From our founding over a century ago, research has played a key role at Matthaei Botanical Gardens and Nichols Arboretum. Historically, the pharmaceutical use of plants as well as plant taxonomy, hardiness and ecological relationships were among key research themes. Today, ecological themes continue to dominate much of the research and scholarship carried out at the Gardens and Arboretum, but we also support studies into the role of plants and nature in human health and physical well-being, the testing of ideas/devices used to support sustainability, and the role of art and performance in sharing ideas about nature.

We also share research conducted on our properties with the general public through free lectures with many of our partner community-based organizations, through public workshops, or through displays and special exhibits.

This guide shares a sampling of research conducted during 2015-2016. I know I am impressed with both the range and diversity of topics explored this last year, and I hope you will be as well. We have been delighted to work with all of the scholars represented here and look forward to another robust group in the coming year.

Robert E. Grese, Director
1 Diego Alvarado
Spatial genetics of an agricultural weed: Use of next generation sequencing to explore levels of population connectivity in common morning glory (Ipomoea purpurea)

1 Regina S. Baucom
Ipomoea trifida crosses

2 Jennifer Blesh
Legume cover crop impacts on soil nitrogen cycling and soil fertility on organic vegetable farms

3 Daniel Buonaiuto
The influence of plant mating system on seed germination in wind-pollinated Carex

4 Megan Bushlow
Solar dehydrator testing

5 Sara Colom
Is ecological displacement a driving force in the evolution of root morphologies of invasive weed species?

6 Katherine Crocker
Do wild field crickets (Gryllus pennsylvanicus and G. veletis) use maternally provided hormones to generate phenotypic plasticity in offspring?

6 Leslie Decker
Disentangling the effects of food nutritional and medicinal quality on disease under future environmental conditions

8 Gordon Fitch
Interactions between primary pollinators and natural enemy parasitoids acting as secondary pollinators - pilot study

9 Stephen Graber
How will tree species’ range migration affect Michigan’s wildlife feeding patterns?
<table>
<thead>
<tr>
<th>Page</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Time series of Michigan squamate microbiomes</td>
<td>Iris Holmes</td>
</tr>
<tr>
<td>10</td>
<td>The emergence of novel regeneration niches: Forecasting tree species recruitment dynamics in a time of change</td>
<td>Ines Ibanez</td>
</tr>
<tr>
<td>11</td>
<td>An investigation into the technology and engineering of aquaponics: The implementation of different growing methods</td>
<td>Rosemary Kelley</td>
</tr>
<tr>
<td>12</td>
<td>The impact of natural light on plants grown hydroponically</td>
<td>Nicholas Machinski</td>
</tr>
<tr>
<td>12</td>
<td>Farther along</td>
<td>Clara McClenon</td>
</tr>
<tr>
<td>13</td>
<td>Communicating from below: Can microbial symbionts belowground alter plant smells aboveground?</td>
<td>Amanda Meier</td>
</tr>
<tr>
<td>14</td>
<td>Investigating the effects of nutritional mutualisms on multitrophic interactions</td>
<td>Amanda Meier</td>
</tr>
<tr>
<td>15</td>
<td>Prescribed burn impact on earthworm abundance</td>
<td>Robert Meyer and Rees Blanchard</td>
</tr>
<tr>
<td>16</td>
<td>Effect of temperature increase on the virulence and transmission of a parasite of monarch butterflies</td>
<td>Johanna Nifosi</td>
</tr>
<tr>
<td>17</td>
<td>Transcriptomic analysis of eco-evolutionary molecular adaptations in neotropical tree species.</td>
<td>James Pease</td>
</tr>
<tr>
<td>17</td>
<td>Pest interactions and chemical ecology of Coffea sp.</td>
<td>Lauren Schmitt and Zachary Hajian-Forooshani</td>
</tr>
</tbody>
</table>
Table of Contents

18  Andy Sell
Assessing perceptions of nature play in the Gaffield Children’s Garden: Lessons for inspiring nature play in home landscapes

19  Maria Carolina-Simao
When do floral additions cease to affect pollinator diversity in urban landscapes?

19  Selena Smith
Leaf economic traits in monocots

20  Selena Smith
Seed development in Heliconia

20  Alex Taylor
Independent recruitment of homologous genes in the origins of nodulation

21  Andrew Tluczek
2016 Michigan exotic forest pest research: Early detection of exotic wood- and phloem-boring insects

21  Chatura Vaidya
Effect of urbanization on pollinator survival and reproductive success, and the role of urban agriculture as a refuge for pollinators and pollination services

22  Megan Van Etten
Role of epigenetics in herbicide resistance

23  Nastassia Vlasava
Understanding and conserving genetic diversity of historic and wild herbaceous peonies (Paeonia - Paeoniaceae) in public garden reference collections.

24  Theresa Wei Ying Ong
The stability of urban agriculture: Spatio-temporal flux

25  Yin-Long Qiu
A temporary evolutionary framework for land plants
Research Projects

Project Title: Spatial genetics of an agricultural weed: Use of next generation sequencing to explore levels of population connectivity in common morning glory (*Ipomoea purpurea*).

Investigator: Diego Alvarado-Serrano, Postdoctoral Research Fellow, Department of Ecology and Evolutionary Biology, College of Literature, Science, and the Arts.

Faculty Advisor: Regina Baucom, Assistant Professor of Ecology and Evolutionary Biology, College of Literature, Science, and the Arts.

Abstract: The spread of herbicide resistance is an increasing concern for agriculture, yet its underlying causes remain inadequately understood. In particular, how population connectivity contributes to the spread and evolution of resistance remains an open question. The main goal of this project is to address this question by assessing patterns of inter-population migration via pollen and seed movement through the combination of GIS and genetic analyses. The project is focused on the common morning glory, a problematic crop weed of economic importance, which offers excellent opportunities to study the interaction between evolutionary forces, landscape features, and agricultural management practices.

---

Project Title: *Ipomoea trifida* crosses

Investigator Regina S. Baucom, Assistant Professor of Ecology and Evolutionary Biology, College of Literature, Science, and the Arts.

Abstract: Leaf shape varies dramatically in *Ipomoea batatas*, or the sweet potato. There is currently very little known about the functional influence of leaf shape on sweet potato yield. As such, we are developing sweet potato’s progenitor, *Ipomoea trifida*, as a model organism to understand the genetics of leaf shape variation.
Research Projects

**Project Title:** Legume cover crop impacts on soil nitrogen cycling and soil fertility on organic vegetable farms.

**Investigator:** Jennifer Blesh, Assistant Professor of Natural Resources and Environment, School of Natural Resources and Environment.

**Abstract:** This project explores how cropping system diversification through legume cover crops impacts nitrogen (N) fixation, soil organic matter (SOM) pools, and the sustainability of organic vegetable farms. Specifically, we are studying cover crops as both sources of new N and as winter cover in vegetable crop rotations in Southern Michigan. Despite growing interest in cover cropping (i.e., crops not harvested), there is still a great need for information to help farmers optimize cover crop management in agroecosystems (e.g., species selection, timing of incorporation) to maximize their ecological benefits while maintaining or improving crop yields and farm profitability. We are partnering with small-scale organic vegetable farmers to conduct on-farm research testing different legume and grass species grown in monocultures and mixtures. We will measure cover crop biomass, N inputs from legume N fixation using stable isotope methods, and impacts on soil nutrient cycling and soil organic matter (SOM) pools. We expect that increased reliance on legume N sources will build SOM, increase N in labile SOM fractions, and reduce surplus N and the need for external N inputs. This research will address a key knowledge gap in nutrient management on organic farms, and will help enhance the ecological sustainability of a rapidly growing sub-group of the organic agriculture sector. The greenhouse component, to be conducted at the Matthaei Botanical Gardens, is part of the natural abundance method for measuring legume nitrogen fixation.
**Research Projects**

**Project Title:** The influence of plant mating system on seed germination in wind-pollinated *Carex*

**Investigator:** Daniel Buonaiuto, M.S. Student, School of Natural Resources and Environment and Lecturer in Ecology and Evolutionary Biology, College of Literature, Science, and the Arts.

**Faculty Advisor:** Robert Grese, Theodore Roosevelt Professor of Ecosystem Management, Professor of Natural Resources, School of Natural Resources and Environment and Director, Matthaei Botanical Gardens & Nichols Arboretum.

**Abstract:** *Carex pensylvanica* is an important understory plant in many local ecosystems and, as such, is highly sought after for incorporation in ecological restorations. However, its seeds are difficult to germinate and genetically diverse propagules that are appropriate for use in restoration projects are often unavailable in suitable quantities. This study is intended to examine the genetic mechanisms that may be the cause of the low germination rates found in this species. There is support in the literature for a hypothesis that the reduced seed fitness and low germination rates could be a result of inbreeding depression caused by extensive self-pollination. I will test this hypothesis by performing artificial pollination crosses to induce autogamy (self-fertilization) and allogamy (outcrossed fertilization) and evaluate comparative seed set, seed weight and germination percentages against a control, open-pollinated group. Through this experiment, I will examine the influence of plant mating systems on seed germination and offspring fitness in this ecologically important species.
Project Title: Solar dehydrator testing.

Investigator: Megan Bushlow, B.S.E. Student, Environmental and Civil Engineering.

Faculty Advisor: Steven Skerlos, Arthur F. Thurnau Professor of Mechanical Engineering, Professor of Civil and Environmental Engineering, College of Engineering.

Abstract: The BLUElab Hagley Gap team works with community members and a non-profit organization in Hagley Gap, Jamaica to design and implement sustainable technologies for the community. Over the past several months, our team has developed a design for a solar dehydrator that can be used to preserve fruits. The need for this technology was identified during a trip to the community during August of 2014, when the travelers learned of the large surplus of fruits such as mangoes that go to waste each year. The solar dehydrator includes a chute component that intakes and heats air and an enclosed tower component through which the air is directed to dry pieces of fruit. The majority of the structure is composed of plywood, but the bottom of the chute component is covered in aluminum to absorb sunlight and the top of the chute is Plexiglas. Airflow is primarily driven by natural convection. The air is directed through the chute by wooden baffles to increase the heating time of each parcel of air. The air then flows into the bottom of the tower through three PVC pipes and rises to the top of the tower, passing over trays of fruit, as it exits the tower through ventilation holes. In order to successfully dry the fruit, the tower component must reach a temperature of about 120°F. If this temperature is reached, a single batch of mangoes can be dried over the course of a day. The purpose of the prototype testing is to determine whether or not the current design achieves the required internal temperature and desired airflow. Testing will be conducted by placing mangoes in the dehydrator and leaving the device with the absorption panel facing the sun. Temperature measurements will be taken inside the chute and tower at regular time intervals. Additionally, the percent moisture removal from the mangoes will be measured after one batch is completed.
Research Projects

**Project Title:** Is ecological displacement a driving force in the evolution of root morphologies of invasive weed species?

**Investigator:** Sara M. Colom, Ph.D. Candidate, Ecology and Evolutionary Biology and Lecturer in Biology, College of Literature, Science, and the Arts.

**Faculty Advisor:** Regina Baucom, Assistant Professor of Ecology and Evolutionary Biology, College of Literature, Science, and the Arts.

**Abstract:** Invasive plants disrupt natural community dynamics and threaten local biodiversity and have been estimated to cause over 36 billion dollars in economic losses in the United States per year. Thus, understanding the mechanisms that underlie their ability to adapt and thrive in new areas is key to developing strategies for invasive plant control. Here we will explore the concept of character displacement of root traits as a potential mechanism for explaining co-existence and geographic distribution of *Ipomoea hederecea* (native) and its close relative and weed species, *I. purpurea* (invader). Our study will consist of a greenhouse pot assay with three treatments of non-shared pots (grown alone) and two shared pot with either a interspecific or intraspecific competitor, respectively. *I. hederecea* will be our focal species and for each treatment we will use seeds from populations that co-occur with *I. purpurea* or occur alone against inbred seeds of either *I. hederecea* or *I. purpurea* for its respective shared pot treatment. We will collect plant growth and flowering data as fitness proxies and harvest roots of the mature plants for root phenotyping. If character displacement is a driving force in the evolution of root morphologies we predict to see a pattern between root traits and fitness and greater root trait divergence and higher relative fitness in the *I. hederecea* populations that occur with *I. purpurea.*
Research Projects

Project Title: Do wild field crickets (Gryllus pennsylvanicus and G. veletis) use maternally provided hormones to generate phenotypic plasticity in offspring?

Investigator: Katherine Crocker, Ph.D. Candidate, Ecology and Evolutionary Biology, College of Literature, Science, and the Arts; NSF Graduate Research Fellow.

Faculty Advisor: Elizabeth Tibbetts, Associate Professor of Ecology and Evolutionary Biology, College of Literature, Science, and the Arts.

Abstract: Lab research shows that mother crickets can vary the concentration of hormones they provide to their eggs in response to their environments, and that this subsequently affects their offspring (over multiple generations). This work will investigate whether these hormone-mediated effects occur in 2 species of wild cricket with similar ecology but very different life histories.

Project Title: Disentangling the effects of food nutritional and medicinal quality on disease under future environmental conditions.

Investigator: Leslie Decker, Ph.D. Candidate, Ecology and Evolutionary Biology, College of Literature, Science, and the Arts.

Faculty Advisor: Mark Hunter, Henry A Gleason Collegiate Professor of Ecology and Evolutionary Biology, Professor of Natural Resources and Environment, School of Natural Resources and Environment, and Professor of Ecology and Evolutionary Biology, College of Literature, Science, and the Arts.

Abstract: The surrounding environment profoundly shapes the outcome of disease by altering aspects of host resistance, parasite virulence, and parasite transmission. As humans cause rapid environmental change, an improved understanding of the response of disease to global change drivers is needed. One host-parasite interaction known to vary with changing environmental conditions is that of the monarch butterfly, Danaus plexippus and its protozoan parasite, Ophryocystis elektroscirrha. Infection by this parasite decreases adult monarch lifespan, fecundity, and flight ability. Monarchs are specialist herbivores of plants in the genus Asclepias (milkweed), and larvae become infected by ingesting parasite spores on the surface of plant tissues. Certain milkweed species contain high concentrations of toxic steroids known as cardenolides that confer increased resistance of monarchs to disease. Larvae that feed on plants with high cardenolide
concentrations, or a high diversity of lipophilic (more toxic) cardenolides, suffer lower rates of infection, maintain higher fitness through increased lifespans, and produce fewer new parasites.

My previous work with milkweed grown under elevated CO2 (eCO2) reveals that changes in phytochemistry induced by eCO2 affected the number of spores produced by infected monarch butterflies such that certain species of milkweed grown under eCO2 increased the resistance of monarchs to their parasites. Yet, despite these declines in spore load, there were no species-specific positive effects of eCO2 on infected monarch lifespan. These results suggest eCO2 can decouple the typical relationship between parasite spore load and adult monarch longevity. Recently, phosphorous (P) concentrations have been implicated as an additional plant trait important to the monarch-parasite interaction. Increases in plant P are positively correlated with both infected and uninfected monarch lifespans. Importantly, eCO2 dilutes P concentrations in plant foliage, which may reduce relative plant quality for monarchs and subsequent butterfly lifespan. Therefore, it is necessary to explore the mechanism by which both primary and secondary metabolites interact in this host-parasite system to better predict future interaction outcomes under global change scenarios. For this project I ask how does nutritional and medicinal quality of the larval diet affect both infected and uninfected monarch lifespan? Specifically, can the benefits of decreased spore load conveyed by eCO2 be compromised by reduced monarch lifespan under eCO2-induced P limitation? To answer these questions I will grow plants at Matthaei Botanical Gardens and use them to make artificial diet supplemented with cardenolide compounds and P to mimic levels found in plant tissues grown under eCO2. I will then infect monarch caterpillars with the parasite and observe how both parasite virulence (inverse monarch longevity) and transmission potential (spore load) are affected.

Research Projects
Project Title: Interactions between primary pollinators and natural enemy parasitoids acting as secondary pollinators - pilot study.

Investigator: Gordon Fitch, Ph.D. Candidate, Ecology and Evolutionary Biology and Lecturer in Biology, College of Literature, Science, and the Arts.

Faculty Advisor: John Vandermeer, Asa Gray Distinguished University Professor and Arthur F. Thurnau Professor, Department of Ecology and Evolutionary Biology, College of Literature, Science, and the Arts.

Abstract: Many insects used as natural enemies are parasitoids as larvae, but pollen and nectar-feeders as adults. Little is known about the effect adult stages of natural enemy organisms have on pollinators and crop production. This pilot study will seek to determine whether there is an appropriate natural enemy for further study of this system in cucumber and/or a cruciferous crop. I will manipulate the conditions in mesh enclosures by introducing one or more of the following to an enclosure with three cucumber plants: pest (striped cucumber beetle, collected from Campus Farm), natural enemy (three Tachinid fly species, collected at Campus Farm or elsewhere in the area), and pollinator (bumblebee, collected from Campus Farm). I will check parasitism rates for the three fly species, as well as their effectiveness as pollinators. Time permitting, I will begin the next phase of the project, by examining behavior of the fly and bee when they co-occur with a single floral resource (the cucumber).
Research Projects

**Project Title:** How will tree species’ range migration affect Michigan’s wildlife feeding patterns?

**Investigator:** Stephen Graber, B.S. Student in Environment, minors in Ecology and Evolutionary Biology, and Earth and Environmental Sciences, College of Literature, Science, and the Arts.

**Faculty Advisor:** Lynn Carpenter, Lecturer IV in Ecology and Evolutionary Biology and Lecturer IV in Molecular, Cellular and Developmental Biology, College of Literature, Science, and the Arts.

**Abstract:** I will primarily focus on how forest creatures interact with the nuts of the mockernut hickory, blackjack oak, and the Ohio buckeye. Michigan has habitats suitable for the survival of all three of these species, and they are expected to expand northward into Michigan in the future, according to climate change predictions. The forest animals of Michigan have minimal interactions with these trees, and according to climate change predictions. The forest animals of Michigan have minimal interactions with these trees, and the goal of this experiment is to see which of the three tree species will be eaten preferentially.

---

**Project Title:** Time series of Michigan squamate microbiomes.

**Investigator:** Iris Holmes, Ph.D. Candidate, Ecology and Evolutionary Biology, College of Literature, Science, and the Arts.

**Faculty Advisors:** Alison Davis Rabosky, Assistant Research Scientist, Senior Herpetologist, Museum of Zoology, College of Literature, Science, and the Arts.

Daniel Rabosky, Assistant Professor, Assistant Curator, Museum of Zoology, College of Literature, Science, and the Arts.

**Abstract:** I am looking at the gut microbiome of squamate reptiles across a range of sites. One of the central problems with microbiome studies is that the abundances of microbial taxa can vary widely throughout an individual’s life. In order to understand the magnitude of this variability and the ontogeny of the squamate microbiome, it is very necessary to track individual squamates and repeatedly sample their microbiota. I would like to use Matthaei as my site for long-term monitoring of microbiota.
**Project Title:** The emergence of novel regeneration niches: Forecasting tree species recruitment dynamics in a time of change.

**Investigator:** Ines Ibanez, Associate Professor of Natural Resources and Environment, School of Natural Resources and Environment, and Associate Professor of Ecology and Evolutionary Biology, College of Literature, Science, and the Arts.

**Abstract:** For the last two decades a main goal for ecologists has been to predict the structure and composition of forests in response to climate change. At the same time, land managers are being asked by local governments to follow practices that account for the impact of climate change on the forests they manage. However, the lack of scientific knowledge about short-term forest responses to not only climate change, but also landscape fragmentation and the introduction of invasive species, has made these two tasks very difficult and highly imprecise in their outcomes. In the case of forest, one of the main reasons why our knowledge is limited is because we still lack critical information about the recruitment dynamics of tree species under those novel conditions. This study seeks to cover this research gap by investigating the mechanisms underlying tree seedlings recruitment dynamics of several dominant tree species in temperate forests of the eastern deciduous biome in North America.
**Project Title:** An investigation into the technology and engineering of aquaponics: The implementation of different growing methods.

**Investigator:** Rosemary Kelley, B.S.E. Student in Program in the Environment, College of Literature, Science, and the Arts.

**Faculty Advisor:** Aline Cotel, Arthur F Thurnau Professor, Associate Professor of Civil and Environmental Engineering, College of Engineering and Associate Professor of Program in the Environment, College of Literature, Science, and the Arts.

**Abstract:** Aquaponics is an alternative form of agriculture that combines the best aspects of aquaculture, the growth of fish in a controlled system, with the best aspects hydroponics, the growth of plants in water. The systems make use of a symbiotic growth relationship where the fish produce nutrients for the plants that in turn filter the water for the fish. This technology is up and coming and there is still room for improvements. The benefits of this technology are endless, as it provides a medium for food production in urban societies with limited access to agricultural space. It also decreases carbon emissions, wasteful water use, and minimizes the use of chemical fertilizers. Michigan Aquaponics, otherwise known as M-Aqua, was founded upon the principles that aquaponics can be used to provide food security to developing communities. There are many social impacts that aquaponics can have on communities, such as improving interrelationships and educating about sustainable food practices. M-Aqua plans on implementing methods to cultivate flora and fauna through utilizing established methods of hydroponics and aquaculture, as well as innovating new forms of aquaponics to better demonstrate the possibilities that this technology brings. We will be investigating the effectiveness of each method we employ, both established and new, to determine the best way of tackling the overarching problems of urban blight and food scarcity.
Research Projects

**Project Title:** The impact of natural light on plants grown hydroponically.

**Investigator:** Nicholas Machinski, M.S. Student, School of Natural Resources and Environment.

**Abstract:** The search for sustainable food has led to many different growing techniques to be developed. One technique that is gaining popularity in urban areas is hydroponics. Hydroponics uses soilless media to grow plants while controlling the amount of water that the plant or plants receive. It is argued that hydroponic systems can be efficient in certain areas such as an urban setting because water is more controlled (typically through pumps and timers) than in a field and one can grow plants vertically, saving more space. One issue that persists is that many hydroponic operations rely on grow lights to raise their plants. This control of light may allow one to direct light where it is needed most but in a vertical hydroponic system, light typically does not reach the plants on the lower levels. Having lights hang around the towers or having stronger light bulbs are options but would take up more cubic space and use more electricity. This project will investigate if natural sun will allow better growth for plants on lower levels of a vertical hydroponic system than with grow lights.

**Project Title:** Farther along.

**Investigator:** Clara McClenon, Dual Degree MFA/MSI Student, Penny W. Stamps School of Art and Design and School of Information.

**Faculty Advisors:** Jim Cogswell, Arthur F. Thurnau Professor and Professor of Art, Penny W. Stamps School of Art and Design.

**Abstract:** *Farther Along,* consists of 42 drawings based on a measured investigation of a tree-lined path. Walking one of Matthaei’s nature trails, I took a photograph every 25 feet walking 500 feet down a path, and then returning. Using charcoal, gesso, acrylic paint, matte and gloss media, clear and matte DuraLar, and collaged paper, I then created a drawing for each of the 42 trail photographs. This research was motivated by questions of how we find, use and, ultimately, create meaning out of visual information. In the “Farther Along” series, I employed the path as a structure to address a quest for understanding. This series was first exhibited as part of my MFA thesis exhibition, Farther Along, in Ann Arbor’s Slusser Gallery in March 2016. The show paired the “Farther Along” series with the installation, “680 Leaves,” which is a gridded array of 680 drawing of leaves engaging questions of vision and knowledge. The “Farther Along” series was also exhibited at Matthaei Botanical Gardens in the summer of 2016. Images of the work can be found at claramcclenon.com.
Project Title: Communicating from below: Can microbial symbionts belowground alter plant smells aboveground?

Investigator: Amanda Meier, Ph.D. Candidate, Ecology and Evolutionary Biology, College of Literature, Science, and the Arts.

Faculty Advisor: Mark Hunter, Henry A. Gleason Collegiate Professor, Department of Ecology and Evolutionary Biology, College of Literature, Science, and the Arts.

Abstract: Belowground microbes can have far-reaching effects on aboveground multitrophic interactions. Microbial symbionts that associate with roots belowground, such as arbuscular mycorrhizal fungi (AMF), are ubiquitous in terrestrial ecosystems and associate with the majority of plants. By improving plant nutrient uptake and interacting with plant signaling pathways, AMF can alter plant defensive traits, affecting interactions among plants, herbivores, and their natural enemies. For example, AMF can alter the volatile organic compounds (VOCs) constitutively emitted by plants and induced by herbivores, influencing the ability of herbivores to locate host plants and natural enemies to find herbivores. Despite the prevalence of AMF plant symbioses belowground, little research has addressed how AMF may shape aboveground multitrophic species interactions through altering plant volatile profiles. Therefore, I propose to analyze how AMF communities may indirectly influence insect herbivores and their natural enemies by altering plant VOC emissions. Using two North American milkweed species, their specialist aphid herbivore, and a community of ubiquitous AMF species, I will test the hypothesis that AMF differentially alter the concentration and blend of VOCs produced constitutively and in response to aphid feeding across plant species. I will correlate specific AMF-mediated changes in VOC emissions with rates of aphid colonization and natural enemy recruitment that I recorded in the field at the Matthaei Botanical Gardens in the summer of 2015.

This proposed research will help elucidate the mechanisms by which microbial symbionts belowground may shape multitrophic interactions aboveground. Also, because most plants are colonized by AMF, this work will also add to a more comprehensive theory of plant defense. In addition, my proposed research has applications in agriculture and forestry. For instance, we may be able to account for and manipulate the presence of particular AMF taxa to improve pest management, while increasing nutrient uptake and stress tolerance of crop plants.
**Project Title:** Investigating the effects of nutritional mutualisms on multitrophic interactions.

**Investigator:** Amanda Meier, Ph.D. Candidate, Ecology and Evolutionary Biology, College of Literature, Science, and the Arts.

**Faculty Advisor:** Mark Hunter, Henry A. Gleason Collegiate Professor, Department of Ecology and Evolutionary Biology, College of Literature, Science, and the Arts.

**Abstract:** Multitrophic species interactions are shaped by top down and bottom up forces. In terrestrial ecosystems, multitrophic interactions can be mediated by plants across the soil surface “divide” yet only recently have studies begun to connect above and below ground communities (van Dam and Heil 2011). Microbial symbionts that associate with roots belowground, such as arbuscular mycorrhizal fungi (AMF), are ubiquitous in terrestrial ecosystems and associate with the majority of plants (Smith and Read 2008). By improving plant nutrient uptake and interacting with plant signaling pathways, AMF can alter plant nutritive quality and defensive traits (Smith and Read 2008). These changes in plant phenotype may cascade up to affect higher trophic levels through trait-mediated indirect effects, thereby influencing interactions among plants, herbivores, and their natural enemies (Smith and Read 2008, van Dam and Heil 2011). Microbe-plant symbioses are not always beneficial for plants, and range from parasitic to mutualistic depending on environmental conditions and the particular species involved (Smith and Read 2008). Specific AMF taxa may have differential influences on multitrophic species interactions due to taxon-specific carbon requirements and efficiencies of nutrient transfer (Lendenmann et al. 2011), which may ameliorate or exacerbate the trade-off for plants between growth and defense (Vannette and Hunter 2011). Despite the prevalence of AMF-plant symbioses belowground, few studies have addressed how AMF shape aboveground multitrophic species interactions, or how AMF taxa may differentially influence these interactions. And no study to date has considered in mechanistic detail the potential impacts of AMF taxa and colonization on herbivore population dynamics. Therefore, I propose to investigate how AMF taxa influence multitrophic interactions by altering plant phenotype.
I will analyze how particular AMF species and communities influence the population dynamics of insect herbivores and their natural enemies by altering plant defenses and nutrient quality of different plant species. Specifically, I will examine how nutrient quality and chemical defenses of two North American milkweed species (*Asclepias incarnata* and *A. curassavica*) vary in response to colonization by single mycorrhizal fungal species (*Gigaspora margarita*, *Glomus claroideum*, and *Rhizophagus intraradices*) and a combination of all three. In addition, I will assess the influence of mycorrhizal fungi on the population dynamics between Oleander aphids (*Aphis nerii*) and their parasitoids in the field. In order to perform these experiments in August 2015, I will grow *A. incarnata* and *A. curassavica* inoculated with a single AMF species or all three AMF species at zero, low or high concentrations (N=960) from April 2015 to August 2015. These will be grown in autoclaved soil (3:1 mix of MetroMix 360 and sand) in 600ml Conical Deepots at the Matthaei Botanical Gardens greenhouses. I will then assess the influence of AMF on the interactions between aphids and their parasitoids, by placing aphids I rear on plants, arranging the plants in a common garden at the Matthaei Botanical Gardens, and assessing aphid per capita population growth rates and rates of parasitism.

**Project Title:** Prescribed burn impact on earthworm abundance.

**Investigators:** Robert Meyer, M.S. Student, School of Natural Resources and Environment and M.S.E. School of Engineering;

Rees Blanchard, M.S. Student, School of Natural Resources and Environment.

**Faculty Advisor:** Sheila Schueller, Intermittent Lecturer in Natural Resources and Environment, School of Natural Resources and Environment.

**Abstract:** We will be investigating the impact prescribed burns has on earthworm abundance in both prairie and woodland environments.
Project Title: Effect of temperature increase on the virulence and transmission of a parasite of monarch butterflies.

Investigator: Johanna Nifosi, M.S. Student, Ecology and Evolutionary Biology, College of Literature, Science, and the Arts.

Faculty Advisor: Mark Hunter, Henry A. Gleason Collegiate Professor, Department of Ecology and Evolutionary Biology, College of Literature, Science, and the Arts.

Abstract: In the last century, our planet has been experiencing rapid alterations in climate associated by anthropogenic activity. Rising temperatures can increase parasite virulence and transmission rates and decrease incubation periods. In order to understand the impact of climate change on disease dynamics, it is necessary to conduct research on host-parasite interactions under changing climate regimes. I will study the effects of climate change on disease dynamics using the protozoan parasite, Ophryocystis elektroscirrha (OE for short), and the monarch butterfly, Danaus plexippus. Studies have shown that infected monarchs have a longer lifespan as adults if they were laid on high cardenolide milkweeds than if they were laid on low cardenolide milkweeds. Therefore this research proposes to assess how temperature affects the disease dynamic of monarch butterflies and their parasite. I hypothesize that a rise in temperature will increase the virulence and transmission potential of the parasite Ophryocystis elektroscirrha. A decrease in adult lifespan will denote an increase in virulence, while a higher parasite load will denote an increase in transmission potential. To test the effects of temperature on virulence and transmission potential of OE, I will rear monarch larvae at three different temperatures, 22.6oC, 25.8oC and 28.9oC. I will infect a total of 75 monarch caterpillars per temperature treatment, and I will have 45 caterpillars as uninfected controls for each temperature. Since cardenolides in milkweed act as anti-parasitic compounds that reduce parasite virulence, I will test how the increase in temperature due to climate change interacts with the effects of cardenolides on disease. I will rear the caterpillars described above on three species of milkweed, Asclepias sp., that differ in their cardenolide contents. The three species are A. curassavica, which has high cardenolide content, A. syriaca, which has medium cardenolide content, and A. incarnata, which has low cardenolide content.
Research Projects

**Project Title:** Transcriptomic analysis of eco-evolutionary molecular adaptations in neotropical tree species.

**Investigators:** James Pease, Postdoctoral Fellow, Department of Ecology and Evolutionary Biology, College of Literature, Science, and the Arts;

**Faculty Advisors:** Stephen A. Smith, Assistant Professor, Ecology and Evolutionary Biology, College of Literature, Science, and the Arts; Christopher Dick, Curator and Professor of Ecology and Evolutionary Biology, College of Literature, Science, and the Arts; Director of the U-M Herbarium and E. S. George Reserve; and Associate Chair for Museum Collections.

**Abstract:** Understanding the effects of global climate change on tree species worldwide will require development of new integrated genomic resources not only to enhance the investigation of the molecular mechanisms that underlie response to climate but also how these traits may change over evolutionary time. We will sample Neotropical tree species inhabiting various clines in the Andean-Amazonian region (and appropriate Neo- and Paleo-tropical outgroups) to better understand how tree species adaptation and distributions were affected by the uplift of the Andes.

---

**Project Title:** Pest interactions and chemical ecology of *Coffea* sp.

**Investigators:** Lauren Schmitt, Ph.D. Student, School of Natural Resources and Environment;

Zachary Hajian-Forooshani, M.S. Student, Ecology and Evolutionary Biology, College of Literature, Science, and the Arts.

**Faculty Advisor:** Ivette Perfecto, George Willis Pack Professor, School of Natural Resources and Environment;

John Vandermeer, Asa Gray Distinguished University Professor and Arthur F. Thurnau Professor, Department of Ecology and Evolutionary Biology, College of Literature, Science, and the Arts.

**Abstract:** Coffee is among the world’s most important commodities. As an agricultural product, it supports millions of smallholder farmers, including many in Latin America. Studying the ecological dynamics of shaded coffee
Research Projects

systems has potential to contribute to the body of ecological knowledge and have practical implications for biocontrol. Variability in field studies can make studying specific plant-animal interactions difficult. In this research, we aim to examine the ability of different pests, both natural and introduced, to feed on coffee and alter plant chemistry. In a controlled setting, we can examine the tolerance of pests to defensive chemicals and explore how defensive compounds are induced and allocated. We also plan to use choice experiments to determine the ability of pests to host switch. These greenhouse studies will contribute to the progress of our doctoral work and complement our field work in Chiapas, Mexico and Puerto Rico.

Project Title: Assessing perceptions of nature play in the Gaffield Children’s Garden: Lessons for inspiring nature play in home landscapes.

Investigator: Andrew Sell, MLA Student, School of Natural Resources and Environment.

Faculty Advisor: Robert Grese, Theodore Roosevelt Professor of Ecosystem Management, Professor of Natural Resources, School of Natural Resources and Environment and Director, Matthaei Botanical Gardens & Nichols Arboretum.

Abstract: Botanical gardens and arboreta are constructing children’s gardens as a way of reaching out to families and to address broader concerns about an increasing “nature deficit disorder” in children as described by Richard Louv (2006) and general lack of engagement by children in nature (Kwon, et.al., 2015; Wake, 2008; Wake, 2007). While there is considerable variation in the approaches taken by gardens and arboreta, many have focused on hands-on, interactive activities termed “nature play” as a way of engaging children. What is unclear is how successful these children’s gardens have been in fostering an attachment to the natural world by the families who use them. Do children’s gardens inspire families to adopt “nature play” in home landscapes? The research will utilize focus groups, surveys, individual interviews, and observational studies with parents in the Gaffield Children’s Gardens and managers at children’s gardens across North America to answer this question. While the study will provide valuable insight to the role and importance of the Gaffield Children’s Garden to visiting families at Matthaei-Nichols, I intend to provide useful information for other botanical gardens and arboreta to strengthen the transference of children’s nature play ideas to residential backyards.
Research Projects

Project Title: When do floral additions cease to affect pollinator diversity in urban landscapes?

Investigator: Maria-Carolina Simao, Ph.D. Candidate, School of Natural Resources and Environment.

Faculty Advisor: Ivette Perfecto, George Willis Pack Professor and Professor of Natural Resources and Environment, School of Natural Resources and Environment.

Abstract: It is well known that flowers provide essential food resources for pollinators, and their availability is a fundamental requirement for sustaining pollinator populations. Studies in agricultural settings indicate that only large plantings of flowers effectively enhance pollinator diversity in an area, but the number, size and effectiveness of flower additions in urban landscapes is poorly studied. To date two studies have addressed this question, with one finding floral additions to be ineffective and the other finding floral additions to be very effective in increasing pollinators in urban landscapes. This study explores a hypothesis that in urban landscapes, floral additions increase pollinator diversity until a saturation point, after which additional flowers no longer affect pollinator populations. To test this, levels of flower additions will be experimentally manipulated in an urban landscape to assess effects on urban pollinator abundance, richness and diversity. This work is critical for bee conservation in urban contexts, as floral additions remain a primary recommendation for pollinator conservation, but little direct evidence exists on the parameters of its effectiveness in urbanized landscapes.

Project Title: Leaf economic traits in monocots.

Investigator: Selena Smith, Assistant Professor of Earth and Environmental Sciences, Program in the Environment, College of Literature, Science, and the Arts.

Abstract: Leaf economic traits reflect the function of leaves and various trade-offs between physiology, ecology, and evolution. Leaf economics of monocot flowering plants are understudied and it is not known whether they show the same relationships between traits as dicot flower plants, which have been extensively studied, or are different.
Project Title: Independent recruitment of homologous genes in the origins of nodulation.

Investigator: Alex Taylor, Ph.D. Candidate, Ecology and Evolutionary Biology and Lecturer in Biology, College of Literature, Science, and the Arts.

Faculty Advisor: Yin-Long Qiu, Associate Professor of Biology, Department of Ecology and Evolutionary Biology and Associate Curator, Herbarium, College of Literature, Science, and the Arts.

Abstract: Nodulation is a mutualistic symbiosis in which nitrogen-fixing bacteria are housed in specialized nodule organs on the plant root, where they exchange fixed nitrogen for plant photosynthate. Despite this common definition, the term “nodulation” denotes several distinct associations, which differ substantially in morphology, development, infection mechanism, and the identity and phylogenetic position of both plant and bacterial symbiont. Nodulation appears in several lineages of the Nitrogen-Fixing Clade (NFC) of rosids (Fabales, Fagales, Cucurbitales, and Rosales), but does not occur in any other land plants. This symbiosis appears to have evolved by the repeated, independent recruitment of a “common symbiotic” pathway that mediates interactions with arbuscular mycorrhizae, in a phenomenon known as “deep homology.” This study investigates whether these same homologous genes were recruited in *Elaeagnus umbellata*, a member of a major, unexamined lineage of nodulating plants.
Research Projects

Project Title: 2016 Michigan exotic forest pest research: Early detection of exotic wood- and phloem-boring insects.

Investigator: Andrew Tluczek, Research Technologist, Entomology, Agriculture, and Natural Resources, Michigan State University.

Faculty Advisor: Deborah McCullough, Professor, Department of Entomology and Department of Forestry, Michigan State University.

Abstract: Our primary objective is to collect insects from sites that may be at relatively high risk of exotic forest pest introduction and establishment. We will use a variety of traps baited with artificial lures designed to attract and capture exotic longhorned beetles (e.g., Asian longhorned beetle), bark beetles (e.g., walnut twig beetle) and other defoliators (e.g., *Lymantria monacha* moths). Insect samples collected from traps will be sorted, screened and identified by trained entomologists. If any suspect pests of significance are captured, specimens will be forwarded to federal regulatory officials for confirmation.

---

Project Title: Effect of urbanization on pollinator survival and reproductive success, and the role of urban agriculture as a refuge for pollinators and pollination services.

Investigator: Chatura Vaidya, M.S. Student, Ecology and Evolutionary Biology, College of Literature, Science, and the Arts.

Faculty Advisor: John Vandermeer, Asa Gray Distinguished University Professor and Arthur F. Thurnau Professor, Department of Ecology and Evolutionary Biology, College of Literature, Science, and the Arts.

Abstract: Pollination services are critical for many wild and crop plants. Approximately 35% of all crop production is dependent on pollinators. While many farmers depend on honeybees for crop pollination, bumblebees and other wild bees are responsible for a multitude of pollination services. There has been widespread decline of bumblebee populations across North America over the past decades. Habitat fragmentation, driven by increased land use due
to agricultural intensification and urbanization, is thought to be a major contributor to the decline. Urbanization causes a decline in nesting substrates as well as floral resources, both vital for the survival of pollinators. Many studies across the globe have shown the negative effects of urbanization on the abundance and diversity of insect pollinators. However, green spaces in cities like urban parks and botanical gardens have been shown to harbor diverse wild bee populations. More recently, the burgeoning urban agriculture movement across the United States shows promise to provide refuges for diverse insect species including pollinators and has great potential to support ecosystem services like pollination, pest control and climate resilience. For eusocial insects like bumble bees, availability of floral resources throughout the length of colony development (spring through fall) is important. The spatial and temporal distribution of floral resources can thus have significant impacts on colony growth and survival rates of bumblebee nests. The success of a colony can be measured in the number of reproductives (queen and male bees) produced at the end of the season. The number of reproductives produced is, in turn, dependent on the growth of the colony i.e. the number of workers produced through the season. The effect of urbanization and the possible refugia in urban community gardens on colony success is, thus, key to understanding the long-term prospects of these essential pollinators. For my master's thesis, I will study the potential of urban community gardens as habitat refuges for bumblebees. For this study, I will focus on one particular species of bumblebee: *Bombus impatiens*. A total of 12 *Bombus impatiens* research nests will be placed along the gradient of urbanization—4 each in natural, semi-urban, and urban sites from June–August to answer my research questions.

---

**Project Title:** Role of epigenetics in herbicide resistance.

**Investigator:** Megan Van Etten, Postdoctoral Fellow, Ecology and Evolutionary Biology and Lecturer in Molecular, Cellular and Developmental Biology, College of Literature, Science, and the Arts.

**Faculty Advisor:** Regina Baucom, Assistant Professor of Ecology and Evolutionary Biology, College of Literature, Science, and the Arts.

**Abstract:** Millions of dollars are spent controlling weeds using herbicides. Unfortunately, many weeds quickly become resistant to herbicides, which can cause considerable crop loss. Although genetic changes have been investigated as the cause of herbicide resistance, non-genetic (epigenetic) changes could also play a role. Stresses, such as herbicide application, can result in non-genetic changes
Research Projects

(methylation) that affect plant survival and can be passed on to progeny. These epigenetic changes could allow plants to quickly become herbicide resistant. To examine herbicide resistance, and the relative role of genetic and epigenetic responses, we will use Fast Plants (*Brassica rapa*) to artificially select for herbicide resistance under 2 environments – either unsprayed (only genetic effects) or sprayed (possible methylation + genetic effects). By comparing the response to selection between the two treatments we can determine if methylation contributes to herbicide resistance.

Project Title: Understanding and conserving genetic diversity of historic and wild herbaceous peonies (*Paeonia - Paeoniaceae*) in public garden reference collections.

Investigators: Nastassia Vlasava, Leading Researcher, Department of Plant Biochemistry and Biotechnology, The Central Botanical Gardens of the National Academy of Sciences of Belarus, Minsk, Belarus; David Michener, Associate Curator, Matthaei Botanical Gardens & Nichols Arboretum.

Abstract: The major public peony collections in North American and Belarus together hold over 1,150 herbaceous cultivars introduced between the 1820s and modern times, as well as species of the genus *Paeonia*—many of which are globally endangered. Many of these historic cultivars are commercially extinct—the one to few specimens in living collections are the sole survivors. In this multi-year project, key issues being addressed using a series of molecular markers (i.e. multilocus fingerprinting with RAPD, ISSR, SRAP and SSR systems) include: identifying unique molecular profiles of authentic cultivars; defining the relationships of the cultivars among themselves and with the ancestral species in the absence of breeding records; resolving the identity of unknown or incorrectly named specimens; and finding correlation of specific phenotypes / important breeding traits (e.g., pathogen resistance, stem strength, etc.) with genetic parentage. A long-term outcome is a new model of historic cultivar conservation that maximizes genetic, cultural, and aesthetic diversity with the minimal number of plant specimens, while defining and maintaining critical redundancy across multiple institutions. This model will be useful not only for the institutional partners, but in other living-collection contexts world-wide. This project is being conducted under a Memorandum of Understanding between the two botanical gardens. The project is supported by a grant with the University of Michigan Matthaei Botanical Gardens and Nichols Arboretum and the Belarusian Republican Foundation for Basic Research (No Б15MC-035, for the period 2015-2017).
**Abstract:** Increasingly noted as a rich source of biodiversity and ecosystem services, urban gardens have great potential for further study as dynamic ecosystems that are inescapably linked to the sociopolitical context of their host country. Urban agriculture is a world-wide phenomenon that has arisen several times in history following severe economic crises (McClintock 2010). The stability of these systems has varied greatly from location to location, with some like in the United States occupying strong, yet brief moments in history (Victory Gardens following WWI and II), while others remaining permanent fixtures that in some cases become part of a nation’s identity (Cuba, Germany) (Mougeot 2010). This research proposes to test how basic ecological patterns are altered by the physical as well as socio-political constraints of urban garden ecosystems. Overuse of chemical fertilizers and mechanized tilling has led to the degradation of soil quality in many agricultural systems (Foley et al. 2005). Thus, farms seeking to revert back to ecological soil management must first deal with rebuilding soil quality. Urban agriculture, which converts vacant, urban lots to productive farmland, faces soil quality problems due in particular to compaction and contamination with toxic chemicals (De Kimpe and Morel 2000). This is juxtaposed to the path of the green revolution, which faced few ecological obstacles when converting natural lands with rich soils to high-input, conventional farms (Griffin 1974). These issues are reminiscent of the literature on critical transitions in ecology, where very small changes in management can have dramatic ecosystem consequences, which are not easily reversible (Vandermeer 1997, Scheffer and Carpenter 2003). By adjusting the nitrogen load from organic (earthworm castings) to conventional (CaCO3) sources, I seek to mimic transitions to and from agricultural production strategies and test how this influences the change in biomass of corn seedlings, nitrite/nitrate leaching and water retention. The null hypothesis is that change in either direction would be the same as you switch from one nitrogen type to the other, especially if the total load of nitrogen is kept constant. Alternatively, we may see that the type of nitrogen leaves legacy effects that build in the soil causing transition from one
regime to the other to be sharp, and irreversible. The expectation is that transitioning from organic agriculture to conventional should result in greater biomass, lower rates of nitrogen leaching and greater water retention than the reverse. We expect that the presence of legacy effects could explain why urban gardens (or other less intensive agriculture models) are difficult to stabilize in different cities and political climates.

**Project Title:** A temporal evolutionary framework of land plants.

**Investigator:** Yin-Long Qiu, Associate Professor of Biology, Department of Ecology and Evolutionary Biology, and Associate Curator, Herbarium, College of Literature, Science, and the Arts.

**Abstract:** We attempt to establish a temporal evolutionary framework of land plants through conducting a maximum likelihood phylogenetic analysis and a set of fossil-calibrated molecular clock analyses of two data sets. One includes 616 species, covering 70% of all 675 families of land plants, and five gene genes (cp-atpB, cp-rbcL, mt-atp1, mt-nad5, and nu-18S). The other samples nearly all 136 orders and most of the genes in both chloroplast and mitochondrial genomes. In the molecular clock analyses, different topological arrangements of basal land plant lineages, basal monilophyte lineages, angiosperm-gymnosperm relationships, and mesangiosperm lineages will be experimented. Furthermore, various combinations of rate, substitution, and speciation models will be explored. Finally, different sets of fossil calibration points will be used. All these experiments will allow assessment of robustness of the results, which have been difficult to obtain in molecular clock studies because of uncertainty in data quality and methodological limitations. Establishment of a robust temporal evolutionary framework of land plants will help integrate molecular systematics, paleobotany, morphology, and evolutionary genomics and developmental biology and help us gain a profound understanding of evolutionary history of land plants.

Most of the DNA samples needed for this project are already available in our lab, but new materials for rare plant families, especially those from South Africa, have been acquired recently or are still being acquired. They are all grown at the Matthaei Botanical Garden.