W.K. Kellogg Biological Station Undergraduate Internship and Research Symposium

Wednesday, Aug. 4, 2021
3:30 to 5:30 p.m.

Schedule

3:30 to 3:35 p.m.

Opening remarks from KBS Director Fredric Janzen.

3:35 to 3:50 p.m.

Student introductions.

3:50 to 5 p.m.

Open poster session.

5 to 6 p.m.

Refreshments in the atrium just outside of the auditorium.

Project Abstracts

Abstracts are listed in alphabetical order by student last name.

1. Fire Breathers or Insect Eaters? Dragonflies in and around the LTER
Benjamin Adams, REU – Haddad Lab
Mentor: Jamie Smith

Crop loss to herbivorous insects is a well-known and ubiquitous issue in agricultural systems and is conventionally mediated using chemical interventions that cause harm to non-target organisms. Predatory arthropods provide an ecosystem service by feeding on herbivorous insects, to the extent that they are sometimes introduced to habitats as a biological alternative to pesticide use. These predators can, however, simultaneously cause an ecosystem disservice by consuming beneficial insects like pollinators. Dragonflies are voracious insect predators in both their larval and adult stages, but their abundance and diversity are not well documented in agricultural systems. Adult dragonflies are likely to become increasingly abundant in the LTER with the recent introduction of prairie strips, which are known to increase insect diversity and abundance. Our goal was to determine if dragonfly abundance and species richness varied across agricultural treatments, and if they decreased as distance to the nearest aquatic habitat increased. We also evaluated differences in dragonfly community composition between the LTER and surrounding aquatic habitats. We conducted dragonfly surveys in the LTER utilizing the Pollard walk method and captured 135 adult dragonflies within the LTER and surrounding aquatic habitats to identify to the species level. This project characterizes the adult dragonfly community in the LTER and is the first step in investigating their ecological impacts within the LTER insect community. Further research will analyze the gut contents of adult dragonflies using DNA sequencing to identify arthropods in their diet.

2. Anther position in wild radish (Raphanus raphanistrum) affects position of anther contact with pollinator bodies and varies across taxa
Nicholas Bhandari, URA – Conner Lab
Mentor: Robin Waterman

Natural selection drives adaptation to conditions in the natural world and is responsible for the immense diversity of flowers extant today. Flowers in wild radish (Raphanus raphanistrum) have four long and two short stamens (Conner et al. 2009). Studies in the past have found evidence for stabilizing selection on anther exsertion - the distance between the long-stamen anthers and the corolla tube - and disruptive selection on anther separation - the distance between the long-and short-stamen anthers - in wild radish (Conner et al. 2009, Waterman et al. in prep). Yet, we lack information on how differences in anther position affect pollen placement on pollinator bodies, which is expected to have major impacts on individual fitness. Artificially selected lines of wild radish were brought to the field for pollination. Low anther separation, high anther

exsertion, and a control line were represented in this study. By taking slow motion videos of pollination events and using ImageJ to analyze the anther position of pollinated flowers, we were able to determine what parts of pollinators' bodies made contact with anthers and how that relates to the varying levels of separation and exsertion. Although results have yet to be fully analyzed, we hope they shed light on the functional mechanisms behind the observed selection.

3. Effects of rainfall frequency on nitrogen mineralization rates
Claire Bott, URA – Robertson and Roley labs
Mentor: Dr. Carmella Vizza

Microbes convert organic forms of nitrogen into inorganic forms that are more bioavailable, such as ammonium and nitrate. This process is known as nitrogen mineralization, and it is an essential component of the nitrogen cycle. Better understanding how mineralization and nitrogen availability are impacted by environmental conditions can lead to optimized use of nitrogen fertilizers and improved plant growth. We examined the effects of rainfall frequency on net nitrogen mineralization rates in switchgrass soils after a re-wetting event. We excluded rainfall with rainout shelters and added water at different intervals via irrigation systems: 1) Constant moisture plots (n = 4) received a small wetting event (~10 mm each) twice a week, 2) extended drying plots (n = 4) received a large wetting every 20 days (~60 mm), and 3) severe drying plots (n = 4) received a large wetting every 30 days (~60 mm). Soil samples were taken from all 12 plots before and after the wetting event on the 60th day of the experiment and were analyzed for ammonium and nitrate concentrations before and after a 14-day in-situ net nitrogen mineralization assay. We found an increase in net nitrogen mineralization rates after rewetting the severe drying plots, but not in the other two treatments, which suggests that longer periods of drought lead to enhanced microbial activity upon rewetting. However, this pulse of microbial activity in the severe drying plots was short-lived; net mineralization rates reverted to the lower before wetting magnitude and also mirrored those of the other treatments within two days following the wetting event. Nevertheless, this brief pulse of microbial activity could be critical for plant nitrogen uptake and plant growth after a month of drought. We plan to investigate this relationship in future studies.

4. How crop rotations impact butterfly abundance and richness
Cameron Brown, URA – Haddad Lab
Mentor: Lindsey Kemmerling

Butterflies are diverse pollinators, herbivores, and indicators of ecosystem health. A recent study found that total butterfly abundance in the Midwest USA is declining by 2% every year. This decline is due to climate change, habitat destruction, and agricultural practices. Methods for mitigating the loss of butterfly biodiversity in agricultural landscapes include reducing the use of pesticides, restoring habitat in farms, and implementing crop rotations. One method for restoring habitat in farms is sowing a strip of native vegetation within row crops, called prairie strips, which increase biodiversity and ecosystem services in farms. Implementing crop rotations has shown to increase

the biodiversity of above-ground arthropods as well. In this study, we measured butterfly biodiversity over three years across three different crop rotations: wheat, corn, and soy. We measured butterfly abundance and species richness across a gradient of agricultural management intensity including prairie strips. Across agricultural treatments, we found that the wheat year (2019) had the highest butterfly abundance and diversity, the corn year (2020) had lower abundance and diversity, and the soy year (2021) had the lowest abundance and diversity. However, we found that butterfly abundance and richness increased in the prairie strips from the wheat year to the corn year, but decreased in the soy year. These results support past studies that show the benefits of prairie strips to biodiversity.

5. Creating connections: Building community through KBS communications
Abigail Comar, External Communications Intern – KBS Community Relations
Mentors: Cara Barnes and Sarah Carroll

As an external communications intern, my summer at KBS involved exploring my strengths and weaknesses as a communicator. My main summer project was highlighting the experiences of other undergraduate summer students through interviews. I conducted some of these interviews through video, practicing my recording skills. After completing the interview, I wrote blog posts detailing the experiences of my peers and their summer projects. I also used the video footage from the interviews to create promotional videos for the summer academic programs and the PLB 418: Plant Systematics course. I used iMovie to edit the videos and included photos of various summer research, class, or recreational activities. Another important aspect of my internship was designing a thank-you postcard for donors that fund the summer programs. My mentors and I created this postcard in InDesign, where I practiced my graphic design skills. A smaller project that I completed for my internship was monitoring the KBS LinkedIn page and researching ways to engage our audience and reach our alumni network. I also used a DSLR camera to take photos at events and around KBS, generating an album of stock images of KBS. My summer at KBS provided many opportunities for me to enhance my skills in communication through written, visual, and social media forms.

6. Visitor Experience Internship at the Kellogg Bird Sanctuary
Cheyenne Cope, Visitor Experience Intern – W.K. Kellogg Bird Sanctuary
Mentor: Lisa Duke

My name is Cheyenne Cope and I am currently a rising senior at Michigan State University majoring in Environmental Biology/Zoology. After I receive my bachelor's degree I plan on obtaining more experiences that may help further my ecological education. At Kellogg Bird Sanctuary I was the Visitor Experience Intern. This means I was responsible for opening and closing the store, greeting customers, answering questions regarding birds and the facility, creating signage, and self-guided educational activities. In addition, I performed internship projects such as digitizing the memorial directory, renovating the bee condo, and taking care of the monarch caterpillars. Having this internship allowed me to get a greater understanding of bird sanctuaries and how

they are operated while also creating connections, learning new educational techniques, and doing public outreach. I was also able to aid in a weigh-in and health check which granted me the ability to view what healthy waterfowl looks like and what to look for.

7. Host plant preference of the Small Cabbage White Butterfly (*Pieris rapae*) among Brassica oleracea cultivars
Rachel Downing, URA – Haddad Lab
Mentor: Stephanie Clark

Pieris rapae or The Small Cabbage White Butterfly is an invasive pest species originating in eastern Europe. Introduced to North America in the 1860's, Cabbage Whites quickly became abundant across the continent stretching from Northwest Mexico to Central Canada. They are attracted to host plants high in glucosinolates, a group of sugar based molecules used for metabolism and commonly found in the Brassicaceae or mustard family. Also found in this family is the species Brassica oleracea, which is comprised of many well known agricultural cultivars, such as broccoli, cabbage, cauliflower, brussels sprouts, kale, collards, and kohlrabi. Thus, Cabbage Whites present an immense threat to agricultural fields and farmers, causing thousands of dollars of damage to major crops. By capturing fertilized female Cabbage Whites and placing them in enclosures with broccoli, cabbage, brussels sprouts, collards, and tomatoes, this experiment tests Cabbage White host preference among several different cultivars of Brassica oleracea to help determine which crops are at the most risk of damage. Experiments like this one are vital in order to understand host plant preference, which in and of itself is the key for preventing crop damage from pests like the Cabbage White. Further research could test host plant preference between the favored Brassica oleracea plant and a highly preferred naturally occurring host plant such as Brassica nigra, also known as black mustard. Should Cabbage Whites show a large proclivity to lay eggs on Brassica nigra over Brassica oleracea, this could raise the possibility of using groupings of black mustard to remove pressure on agricultural crops by drawing away Cabbage White individuals laying eggs.

8. Evaluating trends in multi-year winter barley variety trial
Rachel Drobnak, Sustainable Agriculture Intern – W.K. Kellogg Farm
Mentors: Drs. Dean Baas and Brook Wilke

The craft beverage industry is increasingly becoming an important part of Michigan's economy; in fact, the craft beer value chain in 2016 was estimated to contribute over $500 million to the Gross State Product (Miller et al., 2019). Currently, a goal in the sector is to provide local sources of malting barley to craft brewers and maltsters. Understanding winter barley varietal performance is important for Michigan producers, since varieties can differ widely in yield, disease resistance, phenology, and quality measurements.

MSU Extension, in collaboration with MSU AgBioResearch and the LTAR (Long-Term Agroecosystem Research) Project at W.K. Kellogg Biological Station, has conducted a Winter Barley Variety Trial since 2017 at Hickory Corners (Kalamazoo County) and

Kawkawlin (Bay County). Over the course of five years, 85 varieties of winter barley have been tested for agronomic and malting quality data, and about 40 have been tested for at least two years. This long-term research is valuable because it is difficult to conduct multi-year, multi-location varietal studies and gather quality data. These data are crucial in helping producers, maltsters and brewers make decisions about varieties that produce optimal yields and quality in Michigan's climate.

In this analysis, I investigated which varieties are best performing (i.e., highest yield, highest quality metrics), how varieties differ in phenology (i.e., heading and maturity date), and which varieties are most susceptible to disease and extreme weather. I used quality data thresholds provided by the American Malting Barley Association to judge performance. To organize the data, I referenced tables from the MSU Wheat and Soybean Variety Trial publications to formulate methods for multi-year comparisons.

9. Bromide tracer uptake in switchgrass: Finding balance between quantification and toxicity.
Katherine Egeler, URA – Hamilton Lab
Mentor: Dave Weed

Tracers can be used to help identify and understand processes. Bromide solutions are inexpensive and have been shown in previous experiments to be readily taken up by roots and incorporated into plant biomass. The objective of this experiment was to find at what concentration a sodium bromide tracer used in switchgrass would be both easily detectable and nontoxic. Four bromide tracer solution levels were created using deionized water and sodium bromide for use in the experiment. The concentrations of the solutions were the following : pure DI water, 100 mg/L Br-, 500 mg/L Br-, and 1000 mg/L Br-. A strip of switchgrass reserve plot G607 in the GLBRC was selected and four 28.5cm x 23cm open stainless steel cylinders (LTER gas chambers) were inserted into the plot, then assigned a concentration. Each chamber was watered triweekly with 500 mL of their designated solution for a four week period. Leaves from each chamber were then collected and dried. The bromide tracer was extracted from the leaves and the concentration was analyzed via ion chromatography. Results and conclusions are shown on my poster.

10. The effect of inbreeding on extrafloral nectaries and community interactions
Luana Fenstemacher, REU – Fitzpatrick Lab
Mentor: Isabela Borges

Chamaecrista fasciculata is an annual prairie plant that has been severely affected by habitat loss and fragmentation caused by human intervention and climate change. With prairie sizes continuing to decrease every year, inbreeding and genetic drift increase in remaining plant populations . C. fasciculata, as many other plants, have extrafloral nectaries (EFNs), which help to foster a symbiotic relationship with arthropods. This mutualistic relationship increases plant fitness and may increase their ability to persist in degraded habitats. More specifically, Chamaecrista fasciculata makes use of EFNs to attract ants, which keep insect herbivores from destroying the entire plant. Over the

course of 6 weeks, we quantified EFN presence, ant abundance, and herbivory for sixty four Chamaechrista fasciculata plants that vary in their amount of inbreeding. This allowed for a comprehensive analysis on how the EFNs were affected as inbreeding levels increased. I counted the number of EFNs and ants present on plants, measured plant height, and calculated a proportion of leaves damaged to quantify herbivory. I predicted that the more inbred plants will have a below average amount of EFNs, which in turn would lower the ant presence, and would increase the amount of herbivory. We found support for our hypotheses, with high inbreeding increasing herbivory through a decrease in ants and EFNs.

11. Got salt? Local adaptation to coastal salt spray in *Mimulus guttatus*
Milagros Jimenez, REU – Lowry Lab
Mentor: Dr. Nate Emery

A wide variety of plants inhabit coastlines and face diverse challenges to survive, with one of the major constraints being oceanic salt spray. Mimulus guttatus, a widespread wildflower species in western North America, is an ideal model species to assess salt spray adaptation mechanisms given its local adaptation to a variety of habitats, including the Pacific coastline. Our objective is to examine how coastal and inland populations of Mimulus guttatus differ in their response to foliar salt spray. Recent work shows latitudinal differences in plant height as well as coastal and inland communities' differences in salt tolerance. For these reasons, we studied two pairs of populations, each containing an inland and coastal variety, one pair from north of their range (shorter plants) and the other from south of their range (taller plants). In order to acquire a deeper understanding on how salt enters the leaf and moves within the plant, we measured water droplet contact angle, leaf thickness, tissue electroconductivity, and stomatal density and size. We sprayed leaves with 100mM NaCl solution or DI water (control) three times in 12-hour intervals prior to processing. To determine how plants possibly reallocate salt we divided salt-exposed leaves into three regions, center, tip, and edges. Preliminary electroconductivity results show increased salt concentration in the leaves' edges between treatments within coastal populations. On the other hand, only the southern inland population's leaf tips exhibited differences between treatment and control which could indicate that minimal amounts of salt are entering the tissue. Future analysis on contact angle, leaf thickness, and stomatal density and size will permit us to answer broader questions on how coastal and inland populations differ in their responses to oceanic salt spray.

12. The effect of switchgrass cultivar and fertilizer application on soil microbial communities
Lauren Kelly, URA – Robertson Lab
Mentors: Drs. Samantha Mosier and Ekrem Ozlu

Switchgrass production for biofuel has the potential to produce high crop yields and above ground biomass without large fertilizer inputs. Switchgrass has multiple cultivars and two main ecotypes that have different traits and are adapted to different soil types and environmental conditions. Microorganisms interact with these plant communities

and are important for nutrient cycling. The objective of this study is to compare soil microbial communities across different fertilizer applications in multiple switchgrass cultivars. Soil samples were conducted at 0-10 cm depth from fertilized and unfertilized plots under nine different switchgrass cultivars. Soil samples were incubated aerobically for 21 days to measure nitrogen mineralization rates. Net nitrification, ammonification, and mineralization rates were measured to determine soil bioavailable nitrogen and estimate microbial function related to nitrogen cycling. Biolog EcoPlates were also used to perform community-level physiological profiling, which shows how microbial communities utilize different carbon sources in their environment. This can be used to assess function and compare soil microbial communities across treatments. Average well color development, species richness, and Shannon diversity index values were calculated for each fertilization treatment and switchgrass variety. Results showed that fertilization had no significant effect on the microbial function in switchgrass. There was also no significant difference in the microbial function between different switchgrass varieties. This study adds to the understanding of microbial function and soil carbon and nitrogen cycling in switchgrass communities and shows that nitrogen fertilization of switchgrass does not negatively influence microbial community function.

13. Bridging the gap: A KBS virtual experience
Aditi Kulkarni, Online Visitor Experience Intern, W.K. Kellogg Manor House
Mentor: Nicole Kokx

To experience the Kellogg Biological Station's grandeur virtually was previously impossible but through my research alongside Nicole Kokx, I am bridging the accessibility gap. My internship focused on developing a virtual tour that is expected to launch in early October. This immersive experience will focus on the Kellogg Biological Station's past, present, and future with an emphasis on W.K. Kellogg's history and legacy. The tour is created through Story Maps, an online mapping platform, and will allow viewers to engage with the campus and explore the area. I set up interviews with a group of Manor House volunteers named The Ambassadors who shared Manor House readings, facts, and stories with me. Using this information, the tour will allow my target audience of students, educators, those with an interest in history, and nature enthusiasts to enjoy the Kellogg Biological Station's information despite distance. This tour, which provides resources for further information and informs communities about the Kellogg Biological Station's initiatives, is accessible to all with internet access which promotes KBS to a more diverse and inclusive group of people. In addition to my virtual tour, I have also been in charge of the Kellogg Manor House's Facebook and Instagram accounts. Through these social media accounts, I shared W.K. Kellogg history facts through "Throwback Thursday" posts and informed our followers about news, events, and KBS updates. It is important to note that throughout this summer, I did not reside on campus. This means that my experience was virtual which offered me a unique perspective and allowed me to empathize with my target audience better. W.K. Kellogg wished for the estate to be a playground for all of Battle Creek; now it will be shared with those around the world.

14. Phytoplankton dispersal from a high-resource lake harms predators on a low-resource lake

Bjorn Larson and Joseph Savage, REUs – Klausmeier and Litchman labs
Mentor: Dr. Jonas Wickman

Phytoplankton are one of the biggest players in the carbon cycle. Additionally, the high diversity of phytoplankton that have evolved in a system with a limited range of resources—the so-called 'Paradox of the Plankton'—make them an important study system in community ecology. Trait-based modelling has become an important tool for analyzing ecological and evolutionary dynamics by focusing on only the most important functional traits in a community, reducing model complexity. In phytoplankton, higher cell volume has been shown to result in higher predator defense, while lower cell volume results in more efficient resource acquisition. However, it is unclear how phytoplankton cell volume would evolve under the selection pressures of both resource competition and consumption by predators. We used a theoretical model of phytoplankton that allowed cell volume to evolve in a system with a resource and a predator, and incorporated phytoplankton dispersal between two lakes to investigate patterns of evolution when changing the proportion of resources on each lake. In a single lake, we found that as the resource supply was lowered, phytoplankton evolved towards better resource acquisition, while higher resource levels led to more predator defense. When nutrient levels were decreased in a single lake, predators were unable to survive without phytoplankton evolving towards smaller size, meaning that phytoplankton evolution had a "rescue" effect on predators. This explains a similar effect in the two-lake system. Because phytoplankton evolved towards predator defense in the high-resource lake, dispersal into the low-resource lake shifted the mean size of phytoplankton in the lake to be larger, which led predators to fare worse than in unconnected lakes. Further analyses of model inputs and outputs will help to give insight into the community ecology of connected lakes, and could be used to better understand the knock-on effects in connected lakes when one lake is enriched.

15. The diversity and abundance of butterflies and caterpillars in prairie strips

Derek Luecker, URA – Haddad Lab
Mentor: Alice Puchalsky

Prairie strips are a new conservation management system that has created new opportunities for diverse organisms to exist in an agriculturally influenced environment. A variety of insect species can be found in these strips, most notably Lepidopterans, which are key pollinators. The difference in diversity between larval and adult stages found in prairie strips is still unknown. If the diversity of species is drastically different between the life stages, this could have implications on how butterflies and caterpillars are responding to the different treatments. We wanted to know if treatments with prairie strips had similar levels of abundance and diversity between butterflies and caterpillars. Our hypothesis was that the abundance and diversity would be the same between adult and larval stages. In the summer of 2021, we collected data on larval and adult populations in the prairie strip treatments (T3 and T4) within the LTER. We performed visual searches and used beat sheets and nets to survey both life stages along a

determined path through the treatments. The individuals were identified and data was taken on the species richness of adults and larvae. This study has implications on the value of prairie strips in regards to biodiversity, and can lead to further research on how effective prairie strips are at holding a high level of biodiversity across various taxa.

16. Does past herbivory amount predict plant-herbivore interaction diversity within a plant neighborhood?
Sofia Maass, REU, Wetzel Lab
Mentor: Luke Zehr

Most biodiversity studies focus on the richness and abundance of species themselves, rather than the diversity of interactions between species. Using a metric of interaction diversity, such as the number of links in a quantitative food web, may be a more ecologically informative and tractable approach in diverse communities, such as those of herbivorous insects on plants. Quantifying the interactions of insects on plants can also increase our understanding of key ecological processes, such as herbivory. We sought to quantify plant–herbivore interaction diversity in plots focused around individuals of five species of prairie plants in both their natural prairie communities and in a common garden. In general, we wanted to learn how the diversity of herbivore interactions in the local plant community relates to the amount of herbivory that has occurred on focal plants over the past growing season. Specifically, we predicted that focal plants that had lower levels of herbivory last year would have lower plant–herbivore interaction diversity in their immediate plant neighborhood. We additionally predicted that interaction diversity would be lower in the younger, smaller, and more simple common garden ecosystem than in the prairies. Consistent with others' results, we found that distributions of herbivorous insects on plants are highly skewed, with most individual plants harboring few or no herbivores, and few individual plants host a high abundance of herbivores. We did not find a clear pattern between the diversity or composition of herbivore communities and the level of past herbivory sustained by the focal plants. During the first round of observations, we found marginally higher herbivore morphospecies richness on plants within 1m of the focal plants that had the highest amounts of herbivory in the previous season.

17. Quantifying novel soil health metrics to inform nitrogen cycling across a management and plant diversity gradient
Christian Mammana, REU – Sprunger Lab
Mentor: Dr. Christine Sprunger

Nitrogen (N) is critical for plant growth and crop productivity but has immense environmental consequences. Steps for reducing N loss from agricultural landscapes are twofold and include reducing the amount of fertilizer applied and providing farmers with better metrics that quantify soil N. Traditionally, soil N status has been quantified by assessing inorganic pools of N. However, metrics that measure the organic pool of N could prove to be an important indicator of soil N and soil health. For example, soil protein is a promising new soil health indicator that reflects the organic pool of N. This study aims to assess how N cycling and organic N storage are affected by a gradient of

management intensity and plant diversity. This study investigated N cycling on four soybean systems under a conventional, no-till, reduced input, and biologically based management; two perennial monoculture perennial crops (switchgrass and miscanthus); and two unmanaged successional communities including an early successional and a mid-successional system at the Kellogg Biological Station Long Term Ecological Research Site (KBS LTER). Soil cores (15) at a depth of 10 cm were collected in May 2021. Laboratory analyses that were conducted consisted of soil ammonium and nitrate, soil protein, and N-Acetyl-β-glucosaminidase (NAG) enzyme. Results indicated that cropping systems with greater perenniality and diversity had increased N mineralization, organic forms of N storage, ammonium. Additionally, nitrate decreased as crop diversity and perenniality increased. Furthermore, sensitive indicators of N did not detect differences across the annual systems. In conclusion, crop perenniality and diversity were found to be essential components for the enhancement of N cycling. Additionally, metrics that represent N mineralization and organic N pools were found to provide novel insights into N cycling within complex agricultural landscapes.

18. The effects of prairie strips on permangante oxidizable carbon
Ceco Maples, URA – Evans Lab
Mentor: Corinn Rutkoski

Agricultural systems have the potential to sequester soil carbon through regenerative land management practices. However, because soil carbon requires decades to centuries to form and stabilize, it is difficult to measure short-term effects of management practices on soil carbon accrual. Active carbon, a labile C pool that is accessible to soil microbiota, has been shown to respond quickly to changes in management and serve as an early indicator of long term C sequestration. In this project, we examine the influence of in-field prairie plantings (prairie strips) on soil active carbon. Soil samples were collected in 2019 and 2020 from Neal Smith National Wildlife Refuge (Prairie City, IA), where prairie strips were planted in 2007. Soils were analyzed for permanganate oxidizable carbon (POXC) as a measure of the active C pool. After 13 years of prairie strip establishment, there was no evidence of POXC accrual in or near prairie strips. Prairie strip soils contained the same amount of POXC as row crop soils at the same landscape position. Whereas crop POXC decreased from 2019 to 2020, prairie strip POXC was unchanged. Prairie strips appear to retain - but not increase - soil active C relative to crop soils after more than a decade of establishment.

19. Intensity of agricultural management impacts butterfly abundance and richness
Annabelle McCarthy, Resident Mentor – Haddad Lab
Mentor: Lindsey Kemmerling

Addressing pollinator decline is quickly rising in importance, as insects are declining globally due to habitat loss, habitat fragmentation, pesticide use, and climate change. Reluctance to protect pollinator populations threatens crop quality and yield, in addition to the immense loss of biodiversity. Farmers have the opportunity to preserve biodiversity of pollinators through the implementation of informed agricultural

management. Scientists are researching regenerative agricultural practices — such as reduced tillage, restoring native habitat in farms, and reduced pesticide use —to understand how these practices can benefit insects in and around agricultural land, and to best inform stakeholders and policy makers. One method of restoring habitat in row crop agriculture is to sow strips of native perennial vegetation within row crops called prairie strips. In order to determine how agricultural management impacts butterfly abundance and species richness, we surveyed butterflies from May-October 2020 in the KBS Long-Term Ecological Research Site. Our research sites spanned a gradient of agricultural intensity — from conventional farming to restored prairie, including reduced tillage, reduced pesticide use, and prairie strips. We found that butterfly abundance and species richness were greatest in the prairie strips within plots, which adds to the mounting evidence of the benefits of prairie strips for biodiversity. In addition, there was significantly higher abundance of butterflies in reduced input and organic treatments than in no-till or conventional treatments. This indicates that altering agricultural management and adding prairie habitat to farms is of utmost importance for butterflies. In the future, we look forward to examining the effect of prairie strips on butterfly presence, as the three-year-old strips continue to mature.

20. The location of pollen on Hawkmoths' bodies
Jessica Meister, URA – Haddad Lab
Mentor: Alice Puchalsky

Hawkmoths are the best-known moth pollinators, but we do not know where they most often carry pollen on their bodies. In this study, we sought to determine where hawk moths carry pollen on their bodies. I predicted that the moths would carry significantly more pollen on their proboscis and palpi than the rest of their body. Hawkmoths' proboscis and palpi come into contact with the pollen of the flower when hovering. Using a pre-dyed jelly, we swabbed pollen off each moth's antennae, legs, face, abdomen and thorax, and proboscis and palpi. We mounted this jelly to microscope slides and counted the number of pollen grains found on each body part. We used an ANOVA to determine the difference in pollen abundance across body locations. This study further elucidates the mechanisms by which hawk moths transfer pollen between flowers.

21. Artificial selection for early flowering in the native radish
Lauren Norwood, REU – Conner Lab
Mentor: Ava Garrison

Agricultural weeds cost the U.S. agricultural industry more than $26 billion annually, due to decreased product yield and herbicide costs. To find out more about these agricultural weeds, we look at Raphanus raphanistrum ssp. raphanistrum, or wild radish. Wild radish exists in both native and weedy variations. The most significant difference between the two is flowering time. Weedy radish is found in agricultural fields, and has evolved to grow and complete its life cycle rapidly (less than 2 months), in order to reproduce in between harvesting seasons. This can lead to fewer, larger leaves, in contrast to the smaller, more numerous leaves of the native radish. Native

radish plants are winter annuals endemic to the Mediterranian, which germinate in the fall, flower in the spring, and sometimes require a cold period before flowering. In order to understand how the weedy radish gained such an accelerated flowering time, two native populations (DEES and MAES) underwent two generations of artificial selection for earlier flowering. Because native and weedy radish plants have such different leaf shapes, we also included leaf measurements in search of potential correlated responses. We hypothesized that there would be some correlation between our collected data, and our findings show that we were correct. See the poster “Artificial Selection for Early Flowering in the Native Radish” for a more in depth analysis.

22. Evaluating goldenrod gall midge fitness in response to climatic stressors
Emily Parker, URA – Zarnetske Lab
Mentor: Mark Hammond

Canada goldenrod (Solidago canadensis) has several parasitic gall makers, one of which is the goldenrod bunch gall midge (Rhopalomyia solidaginis). These midges deposit eggs into the apical leaf bud of goldenrod, forming characteristic rosette or bunch galls. While the effects of warming and drought are well studied in plants, little is known about how these stressors - which are becoming more prevalent with climate change - affect insects. Using the Rain Exclusion eXperiment (REX) in the LTER, drought and warmer temperatures are being simulated. Plants with and without rosettes were measured for their height, and if a gall was present, for their gall diameter and height. Gall frequency within the plots was also measured, to see if the midges had a preference on plant hosts. While warming increased plant height, there was no apparent effect on the gall size. Galling did not have an effect on the plant height at the time of measurement, nor did plant height affect gall size. Midges may have a preference for non-warmed plants, but further evidence is needed to support this claim. The effects of drought will be measured later in the summer and into the upcoming fall semester. After harvest (typically done early in the fall), the galls will be dissected and the number and size of larvae will be measured. Investigating how extreme environmental stressors alter life cycles and fitness of these midges may give predictions of their survivability in future climatic conditions. These midges serve as a food source for numerous birds, and are also parasitized by wasps. Disrupting this tri-trophic interaction may have serious implications for all three organisms at play, which may lead to a change in community dynamics.

23. The future is ‘foggy’: Experimental tests of mist and fog-mediated aerial dispersal in the amphibian fungal pathogen *Batrachochytrium dendrobatidis*
Samantha Pendrick, URA – Fitzpatrick Lab
Mentor: Kyle Jaynes

Batrachochytrium dendrobatidis, or Bd, is a zoonotic fungal pathogen that causes the deadly skin disease chytridiomycosis in amphibians. First described in the late 1990s, Bd has caused global amphibian declines in a matter of decades. Despite its ubiquitous prevalence across the globe, its persistence in ecosystems outside amphibian hosts remains poorly understood. Previous research has found Bd DNA in rainwater samples,

suggesting aerial dispersal events may be possible. However, it is unknown whether this result represents the presence of environmental DNA (eDNA) or if spores can viably colonize new environments via aerial dispersal. In this study, we experimentally tested whether Bd zoospores may aerially disperse through mist and fog environments. Each experiment included a Bd source with ~10 million zoospores and sterile 1% tryptone petri dishes lined on two shelves in a self-constructed fog chamber. We generated mist using a spray bottle and fog using an ultrasonic atomizer. We incubated the plates at 20°C for eight days, or two Bd life cycles after experimental runs. We first determined dispersal success qualitatively by presence of plate growth. We then tested relationships in successful runs quantitatively by assessing the relationships between spore counts and distance from source (mist), amount of source water (fog), and humidity (mist and fog). Our results show that mist can disperse Bd zoospores, but fog does not. The future remains 'foggy' or unclear for how this transmission mechanism happens in nature. Our study has vital implications for predicting long-term environmental persistence of Bd and for conservation management efforts to protect amphibian populations from future declines caused by Bd spread to new regions.

24. The accrual of carbon stocks in soil fractions under different biofuel cropping systems

Sophie Perry, REU – Robertson Lab
Mentors: Dr. Samantha Mosier and Grant Falvo

Soil organic matter (SOM), as the largest terrestrial pool of carbon (C), must be understood in the context of bioenergy cropping systems to effectively manage soils for climate change mitigation. Applying the mineral-associated (MAOM) and particulate (POM) organic matter framework to SOM analysis is important in differentiating the ways that SOM is formed, distributed, and stored in soil. This study examined how bioenergy cropping systems influence the abundance and composition of MAOM and POM in soil over the course of 13 years. Soils managed under annual monoculture (corn), perennial monoculture (switchgrass), and perennial polyculture (native grass mix) cropping systems from 2008, 2013, and 2021 were analyzed using physical soil fractionations to see how the treatments influence SOM abundance and distribution over time. Soils from 2021 were also analyzed using aggregate wet sieving to determine if aggregate stability is positively correlated with POM abundance. We found that total carbon stocks in 2008 and 2013 were equal across treatments. In 2021, however, carbon stocks were higher under the mixed native grasses treatment compared to the corn treatment. In 2021, soils under the mixed native grasses treatment also had higher levels of POM C stocks compared to corn. Conversely, the MAOM fraction's carbon stocks stayed the same across treatments and years. These findings show that the difference in total carbon stocks between 2021 mixed native grasses treatment and 2021 corn treatment can be attributed to differences in soil carbon stocks in the POM fraction. Aggregation was not found to have an obvious correlation with POM abundance. Understanding how changes in specific soil fractions determine changes in total soil carbon is imperative for creating effective climate mitigating agricultural systems.

25. Gibberellic acid's role in the evolution of weedy radish
Elijah Persson-Gordon, URA – Conner Lab
Mentor: Ava Garrison

Weedy radish (Raphanus raphanistrum) is an agricultural weed that is native to the Mediterranean but found in fields all over the world. Accelerated life cycles of weedy radish are commonly induced in spring annual growth cycles in agricultural fields; spring annual environments provide cues for faster reproduction, and in a field, weeds have to flower quickly in order to reproduce before harvest. These morphological changes are analogous to the effects of the plant hormone Gibberellic Acid (GA), which suggests that GA could be a mechanism for radish's weediness. To evaluate this hypothesis, we grew weedy radish in spring and winter annual environments using growth chambers and treated half with GA. Our study will add to the limited knowledge of initial rapid evolution of agricultural weeds. I am wearing a crop top if you want to find me and see my results.

26. Effects of neighbor-induced microbe conditioning on switchgrass growth
Emma Reeves, URA – Evans Lab
Mentor: Tayler Ulbrich

Plants recruit soil microbes to help them access water and other resources, especially in stressful, abiotic conditions. Studies have found that these microbes carry on this beneficial conditioning even when applied to new plants. Comparatively little research has been done on the effects of biotic factors on soil microbes, despite the fact that competition is another stress on plants' resources. Our experiment is meant to test whether such effects can be found in plants exposed to the microbes of another plant grown in a highly competitive environment. In order to do so, we grew switchgrass (Panicum virgatum) conspecifically, with Rudbeckia hirta or with Lespedeza capitata, and extracted the microbes from the focal switchgrass. We applied these microbes to a plant growing with one of the three focal species and allowed them to grow for several months. The plants from this half of the experiment were split into root and stem portions before being weighed and assessed for total biomass or for their root-to-shoot ratio. Results taken from this data demonstrated very little difference in the biomass or root-to-shoot ratio of the plants, regardless of treatment--indicating that the microbes had no direct impact on each plants' competitiveness. From this, we can conclude that plant competition does not condition microbes in a way as to affect the competitive ability of switchgrass. This may imply the need for longer growing periods, that more microbes need be applied in future experiments, or demonstrate that soil microbe recruitment is more complicated than is taken into consideration for this study, or that it is contingent only upon abiotic stress.

27. The effects of rainfall frequency on switchgrass growth and phenology
Karina Rodríguez Pérez, REU – Robertson and Roley labs
Mentors: Dr. Carmella Vizza

Accurate and precise measurements of plant growth and drought stress are indispensable in research involving perennial grasses. The aim of this study was to

determine the effects of rainfall frequency on switchgrass (Panicum virgatum) growth and phenology during the growing season. We evaluated plant height, phenological stage, leaf water content (LWC), and leaf water potential (LWP) as indicators of plant growth, seasonal development, and drought stress. Rainfall frequency was manipulated with rainfall exclusion shelters and irrigation systems. Constant moisture plots (n = 4) received a small wetting event (~10 mm) twice a week, extended drought plots (n = 4) received a large wetting event (~60 mm) every 20 days, severe drought plots (n = 4) received a large wetting event (~60 mm) every 30 days, and ambient plots (n = 4) were unmanipulated and therefore experienced the natural rainfall patterns. Switchgrass leaves were dried and weighed to calculate the water content of the leaf, and a 3000-psi (207-bar) pressure chamber was used to find the leaf water potential. We found a weak, negative relationship between LWC and LWP, which means that leaves with a lower water content were more likely to hold on tightly to that water. However, while rainfall frequency affected LWP, our treatments did not significantly affect LWC, which suggests that LWP may be a better indicator of drought stress. Additionally, we found that switchgrass plants in constant moisture plots were taller than switchgrass plants in the ambient plots due to the long drought early in the growing season, but switchgrass height did not vary between the extended drought and severe drought treatments.

Interestingly, the switchgrass phenological stage did not vary by rainfall frequency. Switchgrass is considered more valuable in the market as feed for livestock than as cellulosic raw material, but we can change the game, understanding all the variables that can affect the growth of switchgrass and influence the biological processes essential for its development. Understanding more about the care and development of switchgrass will allow the construction of a sustainable future with more ecological and favorable processes for the conservation of natural resources, reducing the greenhouse gases.

28. Heat wave events affect developmental trajectories of trichome density in common milkweed

Jake Ruggiero, REU – Wetzel Lab
Mentor: Dr. Olivia Cope

Plant trait expression is a dynamic process that changes with development and in response to various environmental cues. Shifting environmental cues due to climate change may alter trait expression in plant populations, either directly or through effects on development. In common milkweed (Asclepias syriaca), trichomes are a defensive trait that can protect against water loss, reduce the heat load of the leaf, and protect against insect herbivory. Though there are increasing instances of heat wave events due to climate change, their potential effects on trichome expression of milkweed are not yet known. Here we show that heat wave events do not affect trichome density directly, but do affect developmental trajectories of trichome density. These results suggest that the effects of increasing heat wave events occurring due to climate change may depend on their timing relative to plant development and existing trait trajectories. These changes in trait development could have broader implications for communities

associated with a given plant, such as insects that feed on plant leaves or use the plant for reproductive purposes.

29. Phytoplankton dispersal from a high-resource lake harms predators on a low-resource lake

Joseph Savage and Bjorn Larson, REUs – Klausmeier and Litchman labs
Mentor: Dr. Jonas Wickman

Phytoplankton are one of the biggest players in the carbon cycle. Additionally, the high diversity of phytoplankton that have evolved in a system with a limited range of resources—the so-called 'Paradox of the Plankton'—make them an important study system in community ecology. Trait-based modelling has become an important tool for analyzing ecological and evolutionary dynamics by focusing on only the most important functional traits in a community, reducing model complexity. In phytoplankton, higher cell volume has been shown to result in higher predator defense, while lower cell volume results in more efficient resource acquisition. However, it is unclear how phytoplankton cell volume would evolve under the selection pressures of both resource competition and consumption by predators. We used a theoretical model of phytoplankton that allowed cell volume to evolve in a system with a resource and a predator, and incorporated phytoplankton dispersal between two lakes to investigate patterns of evolution when changing the proportion of resources on each lake. In a single lake, we found that as the resource supply was lowered, phytoplankton evolved towards better resource acquisition, while higher resource levels led to more predator defense. When nutrient levels were decreased in a single lake, predators were unable to survive without phytoplankton evolving towards smaller size, meaning that phytoplankton evolution had a "rescue" effect on predators. This explains a similar effect in the two-lake system. Because phytoplankton evolved towards predator defense in the high-resource lake, dispersal into the low-resource lake shifted the mean size of phytoplankton in the lake to be larger, which led predators to fare worse than in unconnected lakes. Further analyses of model inputs and outputs will help to give insight into the community ecology of connected lakes, and could be used to better understand the knock-on effects in connected lakes when one lake is enriched.

30. Long-term trajectory of stable soil organic carbon in conventional and no-till agricultural systems

Sophia Schlenz, REU – Robertson Lab
Mentors: Drs. Carolina Córdova and Ekrem Ozlu

Changes in soil organic carbon (SOC) driven by land management affects ecosystem net global warming potentials. Sequestering SOC in terrestrial agroecosystems buffers climate change impacts. The use or absence of tillage could compromise different SOC sequestration rates in agricultural soil. No-till could preserve soil aggregates that can physically encapsulate carbon and make it non-available for microbial attacks, as opposed to conventional tillage that disturbs soil aggregates. The quantification of sequestered SOC can be done by physical fractionation as particulate organic matter (POM; > 53um) and mineral associated organic matter (MAOM; <53um). Here we

quantified changes in SOC stocks after 33 years of management at the Long-term Ecological Research site Main Cropping System Experiment. Our work focused on two systems of corn-soybean-wheat rotations under tilled and no-till treatments, three replications, and four stations. Here we studied management effects on total soil carbon, nitrogen, POM, MAOM, total bulk density, gravel-free bulk density, soil pH, and soil texture. Soil samples were taken at 0-10 and 10-25 cm depths. We also included archived samples from conventionally till systems collected at similar blocks and depths. Preliminary results showed that the conventionally tilled system exhibited greater clay content and lower bulk density, carbon, and nitrogen. The no-till system showed an increase in SOC stocks, most of which was allocated in the MAOM fraction. We found that POM, C:N and soil pH were not affected between tillage systems. The dominant soil particles showed significant relationships with carbon fractions. For instance, silt content was positively correlated with SOC stocks, C:N, and the POM fraction. Moreover, the no-till system had higher SOC stocks, and greater MAOM-C at the 0-10 cm depth. Future experiments might consider investigating impacts of tillage of microbial communities' ability to mineralize N and impact C stocks.

31. Influence of fungicide and nematicide on plant responses to drought and rainfall variability

Madaris C. Serrano Perez, REU – Evans Lab
Mentor: Dr. Jennifer Jones

Because increased drought and rainfall variability are affecting natural environments in the Midwest and across the globe, it is imperative to study how plant interactions with other organisms influence drought tolerance. Microbial organisms, such as fungi and nematodes, can have both symbiotic and pathogenic interactions with plants. Nevertheless, studies have shown there is a gap of information and understanding of how these microbial interactions are beneficial to plants. For this REU project I leveraged a new large-scale rainout shelter experiment with manipulations of fungal and nematode abundance to ask how fungi and nematodes affect plant growth and success during drought and rainfall variability. I measured plant growth in control, fungicide and nematicide treatments in irrigated, drought, and variable rainfall shelters on early successional vegetation. I recorded plant height, specific leaf area and leaf dry matter content (LDMC) on Red Clover (Trifolium pratense) and Goldenrod (Solidago canadensis) . Finally, I measured percent ground cover and percent flower cover for the whole plant community. I found that LDMC for red clover was lower in nematicide subplots than in fungicide subplots($p=0.02$). For the community measurements, I found that between the two sample times percent flower cover decreased in fungicide subplots more than nematicide subplots ($p=0.04$). I showed that fungi and nematode abundance altered plant phenology and physiology in ways that could influence plant drought tolerance. With continued sampling, I will be able to test the impact of fungi and nematode abundance on plant drought tolerance.

32. Cereal rye cover crop effects on soybeans and weeds
Allison Smith, Sustainable Agriculture Intern – W.K. Kellogg Farm
Mentors: Drs. Dean Baas and Brook Wilke

As farmers move towards more sustainable practices such as no-till and reduced chemical inputs, research can provide evidence and give farmers confidence to improve production and ecosystem services. Cereal rye is a common cover crop used before spring planting of soybeans in a corn-soybean rotation. Rye can provide benefits to the soil by reducing nitrate leaching, suppressing weeds, and having a strong root system that prevents erosion [1]. Producers commonly terminate cereal rye with herbicides or tillage at least two weeks before soybean planting, but progressive farmers are starting to “plant green”, which is defined as waiting to terminate the cereal rye with herbicides or with an implement called a “roller-crimper” until immediately before or after the soybeans are planted. Experiments starting in 2020 at the Kellogg Biological Station (KBS) have evaluated how different rye termination strategies and timing affect soybean growth and weed control.

33. My time at Kellogg Bird Sanctuary
Ashlynn Toles, Avian Care Intern – W.K. Kellogg Bird Sanctuary
Mentor: Sara DePew-Bäby

During my time at the Kellogg Bird Sanctuary, I have learned a lot about animal husbandry. Most of my day-to-day activities included feeding the birds, cleaning their pens and dishes, and answering guests ‘questions. While I wasn’t doing those duties a lot of my summer involved building and designing enclosures for the birds. I would do this with my mentor Sara Depew-Baby and avian care technician Brendan. Some of the projects included putting together a pen for our new pair of Red-tailed Hawks Dottie and Kit, re-doing the Bald Eagle enclosure for Liberty and Patriot, and expanding the Tassel pens for our gamebirds. Along with the projects, I also assisted in giving some of the birds their yearly health exams. This included our resident Trumpeter Swans, Canada Geese, Bald Eagles, Red-tailed Hawks, Great Horned Owl, and Screech Owl. It was interesting to learn more about what goes into being an animal caretaker. How it is more than just feeding and cleaning but also giving exams and building habitats. I would like to thank my mentor Sara for teaching and showing me what it takes. With this knowledge I hope to apply it to future careers in animal husbandry.

34. The effects of rainfall frequency on carbon dioxide and methane emissions in switchgrass soil
Jorge Vázquez, REU – Robertson and Roley labs
Mentor: Dr. Carmella Vizza

Rainfall frequency and drought may affect carbon and nitrogen cycles, thereby altering greenhouse gas emissions. The objective of this study was to examine how carbon dioxide and methane fluxes in switchgrass soil respond to rainfall frequency, which was manipulated with rain exclusion shelter and irrigation systems. Constant moisture plots (n = 4) received two small wetting events (~10 mm) a week, ambient plots (n = 4) were

not manipulated, extended drying plots (n = 4) received one large wetting event (~60 mm) every 20 days, and severe drying plots (n = 4) received one large wetting event every 30 days (~60 mm). We collected a 10-cm plug of soil from each plot (n = 16) on the 60th day of the experiment and we also collected soil plugs from the extended and severe drying plots 2, 5, and 10 days following the wetting event. Soil plugs were incubated in a jar for 3 days and the headspace was sampled at 4 intervals (0, 24, 48, and 72 hours). All gas samples were analyzed using gas chromatography. The response of these soils to rainfall will give us a better understanding of how these rainfall events affect GHG emissions.

35. Leaf greenness varies by climate stressors and gall formation in *Solidago canadensis*

Kristin Wolford, URA – Zarnetske Lab
Mentors: Kara Dobson and Moriah Young

A plant's health is dependent on the conditions of its environment. When faced with stressors such as increasing temperatures, drought, or insect disturbance, a plant must alter how its resources are used in order to survive. This project studied the effects of warming, drought, and goldenrod bunch gall midge (Rhopalomyia solidaginis) rosette gall formation on leaf greenness in Canada goldenrod (Solidago canadensis) in the KBS LTER Rain Exclusion eXperiment (REX). A SPAD meter was used to measure leaf greenness, which is an indicator of chlorophyll content and plant health. Measurements were taken from plants with and without galls from all combinations of warming, drought, and control treatments. Pre-drought measurements showed significantly higher greenness in plants with galls than those without galls across all treatments, but we did not see significant differences between climate treatments. I plan to repeat these measurements at peak drought, which will show the effects of long-term exposure in each set of climate conditions. Preliminary results from another long-term warming experiment show that warmed plants have lower greenness than ambient plants, so I expect to see similar results in future measurements in the REX. Due to climate change, plant species are being forced to adapt to ever increasing temperatures and extreme weather conditions, as well as shifting insect habitats, therefore it is important to understand how plants respond in order to predict future impacts on their health.

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