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

Wednesday, July 27, 2022
3:30-5:30 p.m.

Thanks to the mentors, labs, and these funding partners for making this an extraordinary experience for students in the Summer 2022 Kellogg Biological Station programs:

National Science Foundation (NSF)

MSU College of Agriculture and Natural Resources (CANR)

MSU College of Natural Science (CNS)

KBS NSF Long-Term Ecological Research (LTER)

KBS USDA Long-Term Agroecosystem Research (LTAR)

Great Lakes Bioenergy Research Center (GLBRC)

MSU Extension (MSUE)

CNS Dept. of Integrative Biology

CANR Dept. of Fisheries and Wildlife

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Noall Scholarship in Biological and Environmental Science (KBS)

Patricia A. Werner Scholarship (KBS)

Residential Opportunities at Kellogg Station (ROKS) Scholarship

Skulnick Endowed Scholarship and Research Fund

Norman Good Endowment Scholarship

Schedule

3:30 to 3:35 p.m.

Opening remarks from KBS Director Dr. Fredric Janzen and Academic Programs Coordinator Dr. Sarah Roy

3:35 to 3:45 p.m.

Student introductions

3:45 to 4:30 p.m.

Open poster session- students stand by posters

4:30 to 5:00 p.m.

Student break to view posters, socialize with attendees

5:00-5:30 p.m.

Open poster sessions- students stand by posters

5:30-7:00 p.m.

Taco bar in McCrary Hall

Sticky Situations: Assessing seed mucilage of Aizoaceae

Olivia Beebe, Michigan State University, URA - Wetzel Lab
Mentors: Vincent Pan, Dr. William Wetzel

Many members of the Aizoaceae family have a succulent growth form and dwell on cliff-sides of the South African and Namibian desert. What is unique about some of these members besides their odd appearance is their seed mucilage, which is abnormally thin and knobby. Seed mucilage has many theorized functions, some of which are means of dispersal and security against predation. To understand the function of Aizoaceae mucilage and how these organisms establish on mountainous terrains, the stickiness of their seed mucilage was assessed using two different methods. We characterized the stickiness of mucilage of 76 accessions of Aizoaceae seeds and related the trait to the climate conditions of their home range. We also examined how well seeds withstand 13 days of periodic misting without dislodgement from a vertical surface. A one standard deviation increase in wind speed was associated with a 37% reduction in the odds of attachment of the seeds. A one standard deviation increase in precipitation was associated with a 41% reduction in the odds of attachment of the seeds. A one standard deviation increase in the probability of the seeds sticking (stickiness) was associated with a 47% reduction in the hazard rate of dislodgement. Because seeds from dryer areas were stickier, a possible function of seed mucilage for Aizoaceae members could be water retention. Seeds from wetter areas don't need to retain water when it is easily available and therefore have less sticky mucilage. A possible explanation for the wind results could be that seeds adapted to favor the dispersal benefits of the wind, hence the need for less sticky mucilage. These results help bring a greater understanding of Aizoaceae members and their mucilage and may aid in the conservation of these plants by identifying what seeds are vulnerable to which climatic characteristics.

The role of local adaptation in agricultural weeds

Shoshannah Blasczak, Suffolk County Community College, REU- Conner Lab
Mentors: Robin Waterman, Dr. Jeffrey K. Conner

Weeds experience various environmental conditions that will impact the fitness of the plant, known as selective pressures. Agricultural weeds face different selective pressures than weeds of the same species growing in non-agricultural settings. We aimed to find genetic differences between agricultural and non-agricultural weeds of the same species. We grew two species of common weeds, lambsquarters (Chenopodium album) and ragweed (Ambrosia artemisiifolia), from both agricultural and non-agricultural environments in a common garden experiment, and plant traits were measured during early development. We found there were significant differences in both the height and canopy area of lambsquarters in one of three regions in Michigan; however, there were no significant differences in these traits for ragweed. Researching the genetic differences between agricultural and non-agricultural populations of weeds can provide an understanding of the rapid adaptation of agricultural populations in response to their novel selective pressures.

Long-term effects of cover crops, tillage, and ecological succession on soil health parameters

Charles Carpenter III, Prairie View A&M University, REU- Robertson Lab
Mentors: Dr. S. Carolina Córdova, Dr. G. Philip Robertson

Soil Organic Carbon (SOC) is an essential part of soil organic matter (SOM), making up more than half of SOM. Measuring the amount of SOC helps conceptualize the amount of organic matter in the soil. An adequate amount of SOM promotes soil health and environmental quality and helps to mitigate climate change. Tracking SOC changes in agroecosystems are complex and occur at a slow pace, which could take at least a decade to be detected. In our research, we collected soil samples at the KBS Long-term Ecological Research Main Cropping System Experiment at 10 cm depth. Seven treatments were sampled, four annual cropping systems (Conventional, No-till, Reduced input, and Biologically based), and three successional systems (Early-, Mid-, and Late successional). We used several methods to quantify the amount of carbon and nitrogen in two pools that vary in mean residence time (active and stable). We quantified the amount of active SOC pool using two methods: Permanganate Oxidizable Carbon (POX-C), 24h aerobic SOC incubation (C-min). For the active SON pool, we ran a 7-day anaerobic incubation study. Additionally, we physically fractionated the soil samples into particulate OC (POC), and mineral-associated OC (MAOC). On June 15, Results showed that at 0-10 cm depth all systems had on avg. 38.5 % of the total SOC was allocated in the MAOC pool (i.e., stable pool), and only Early successional had ~2x higher percentage of POC per total SOC. Both SOC pool stocks vary between systems, where Early and Late successional had the highest (avg. 6 Mg POC and 10 Mg MAOC ha-1; respectively). Annual row crop systems MAOC stocks were significantly correlated with Total SON stocks. Only No-till and Early successional systems had a greater potential to store and stabilize more SOC, whereas Conventional had the greatest potential to mineralize SOC. In conclusion, less aggressive and more diverse cropping systems promote SOC accumulation, and therefore, enhancing soil health in the long-term.

Impact of connectivity on the abundance of pollen collected by moths

Shriya Deshmukh, Michigan State University, REU – Haddad Lab
Mentors: Alice Puchalsky, Dr. Nick Haddad

Generally, moth and insect populations have been declining. One of the main factors that has contributed to this decline is the fragmentation of habitats, which usually occurs with deforestation, habitat destruction, and urbanization. Through an experimental landscape, connectivity between habitat fragments has been shown to cause increases in annual colonization rates and decreases in annual extinction rates for plant species, as well causing an increase in plant diversity when comparing connected habitat fragments to unconnected habitat fragments. This increased plant diversity could lead to increased floral diversity, which may also lead to an increase in the amount of pollen collected by moths. The objective of my project is to determine if connectivity impacts the abundance of pollen collected and the pollination diversity of moths between habitat patches. The hypothesis of this project is that connectivity will cause the diversity of pollen collected by the moths collected in the experimental landscape to increase, but the amount of pollen collected by the moths in unconnected patches will remain consistent with that of moths collected in connected patches. Although results have not yet been determined, data points have started to be collected.

Does increased humidity affect the critical thermal maximum of *Pieris rapae*?

Rachel Downing, Michigan State University, URA- Haddad Lab
Mentors: Stephanie Clark, Dr. Nick Haddad

It is well known that climate change brings fluctuations in temperature, but fluctuations in humidity are also expected. I'm sure if you come from a humid area, you've heard the phrase, "it's not the heat, it's the humidity." Furthermore, all organisms have something known as a critical thermal maximum. That is, the highest temperature that they can survive at; past this temperature, they quickly die and/or experience severe physiological impairment. Little is known about the effect of interactions between humidity and critical thermal maximums in Lepidoptera. *Pieris rapae* adults, commonly known as cabbage white butterflies, were collected and placed in small containers with either 65% relative humidity or 99% relative humidity. They were then placed in a water bath at 23.4 ℃ for 10 minutes before the temperature increased by 0.2 ℃ per minute. They were removed from the bath once they began to lose motor function and were no longer able to right themselves within the container. The temperature at which they were removed was recorded as the critical thermal maximum. To account for any effects from the mass of the butterflies, the critical thermal maximum of each butterfly was divided by its mass and then a t-test was performed. While the t-test showed that the effect of humidity on critical thermal maximum was insignificant, this could be due to too small of a sample size. Furthermore, cabbage white butterflies are generalists and can survive in a wide range of habitats and environmental conditions, so humidity may not have a significant effect on cabbage whites. Further samples should be run on cabbage whites, and further research could be performed with specialist species of Lepidoptera.

Flash drought causes a decrease in the mass of the eggs of Chelydra serpentina during incubation

Paulette Gutierrez, Michigan State University, URA- Janzen Lab
Mentors: Ayley Shortridge, Dr. Fredric Janzen

Climate change has proven to be a rising concern for scientists, impacting the weather, natural processes, and therefore affecting wildlife. Ectotherms, such as reptiles, are greatly affected by the changing climate. For example, a turtle's sex is determined by the temperature during incubation. Climate change has brought an increase of flash droughts in the Midwest region of the U.S.; this means more frequent short periods of intense heat that decrease the moisture of the soil. Turtle eggs, besides being affected by temperature, are affected by the water potential in the soil. Previous research has found that painted turtle eggs' hatching success and size are influenced by the water potential in the last ⅔ of incubation and that the eggs were able to reduce the effects of the dry conditions through compensatory water exchange. In this experiment we investigated if these effects are also present in the eggs of Chelydra serpentina, the common snapping turtle, and see if this can tell us how the species is affected by flash droughts in the wild. Two hundred eggs were collected from a prairie in Thomson, Illinois and incubated in 10 boxes containing 20 turtle eggs each. The treatments are wet to wet, wet to dry and dry to wet; the change was made 3 weeks into incubation lasting to week 6. The data shows that the eggs lost mass in the dry environment (induced drought) and gained mass in the wet environment (typical soil moisture). The eggs in the dry environments were able to recover when switched to the wet environment, which indicates that compensatory water exchange occurred. This is an ongoing experiment where a third switch will be made and we will keep monitoring the eggs until they hatch.

Success in sustainable agriculture research: understanding and achieving stakeholder values

Sarah Rose Hubbard, Michigan State University, Intern- MSU Extension Sustainable Agriculture Internship
Mentor: Dr. Brook Wilke

Previous research in sustainable agriculture has primarily been developed by agricultural and ecological scientists. While great strides have been made, the ultimate goal of sustainable agriculture is to encourage adoption amongst producers. It is our hope that using participatory research methods will help us to obtain that goal. The KBS Long-Term Agroecological Research site seeks to develop strategies for the sustainable intensification of agricultural production using these participatory research methods. As part of this process, we hosted a field workshop to exchange information about current methods and to hear suggestions for improvement from stakeholders. The stakeholders we have included consist of producers, scientists, processors and distributors, agricultural consultants, government agencies, policymakers, extension educators, etc. The purpose of my project is to better understand industry stakeholder values so that we can define and measure success in sustainable agriculture research as well as improve our research to meet stakeholder interests. It is our hope that these improvements will increase the adoption of sustainable agriculture practices among producers. The data collected from the day can be broken down into general values, outcome-based measurements, process-based mechanisms, and big-picture goals. We can use the identified outcome-based measurements as targets and then the process-based mechanisms as guidance for achieving said targets. The general values give us a sense of what stakeholders care about currently and most urgently at the LTAR, and the big-picture goals offer us insight into what questions may need to be answered through future research outside of the LTAR in fields like economics and social science.

Carbon additions can increase plant growth and microbes particularly in well-watered conditions

Sofie Iwamasa, Case Western Reserve University, REU- Evans Lab
Mentors: Dr. Jennifer Jones, Dr. Sarah E. Evans

Rainfall is predicted to become more variable in the Midwest. Because water is required for healthy crops, it is important to research factors that play into plant drought tolerance. Soil microbial communities can aid plant growth and drought tolerance by breaking down organic matter, making nutrients accessible for plants. We predict that food for microbes in the form of carbon additions will increase microbial community size, thus resulting in increased soybean drought tolerance. We grew soybeans in the greenhouse with two irrigation treatments: well-watered and simulated drought, and four carbon additions: no carbon addition, sorghum on top, sorghum mixed in, and early successional plants mixed in. We measured plant growth variables, chlorophyll readings, and soil microbial community size. We found that carbon additions increased plant growth particularly in well-watered conditions; for example, plants were significantly longer in well-watered treatments with any form of carbon addition (Carbon x Irrigation, $p<0.01$). Carbon additions increased microbial community size (Carbon, $p<0.01$), while simulated drought conditions lowered microbial community size (Irrigation, $p<0.01$). We found that carbon additions could increase the size of microbial communities and plant growth, but did not increase plant stress tolerance.

Rain exclusion shelters decrease available photosynthetic light

Maggie Jones, Michigan State University, URA- Robertson Lab
Mentors: Kevin Kahmark, Dr. G. Philip Robertson

Rain Exclusion shelters are widely used in LTER and GLBRC projects to allow more control over water received by the plants underneath. Based on visible shadows underneath the shelters, we decided to compare light levels under the shelters to ambient field conditions. Light was measured in photosynthetically active radiation (PAR) wavelengths in terms of photosynthetic photon flux density (umol photons/m2/s) using an AccuPAR LP-80 ceptomter. The manufacturers suggest an 85% average PAR light transmission through the clear corrugated polycarbonate shelter roofing material when new. At maximum solar radiation around midday, shelters allow 71.4% ± 1.58 of PAR through on average. Throughout a full day, shelters allow 67.17% ± 2.38 of PAR through on average. As shelters age, the percentage of light allowed to pass through the shelter decreases, based on 0, 1, 2, and 6-year-old shelter PAR data. Therefore, the shelter roofing may need to be periodically replaced. We also compared the iPhone application “Photone- Grow Light Meter” to the LP-80 ceptometer and found they differ by 5.04% on average. We concluded that Photone may be used as an accessible alternative to a ceptometer in ambient conditions with low accuracy requirements. Overall, plants underneath shelters receive less light than plants in ambient conditions. This could be a confounding factor in the various projects using Rain Exclusion shelters at KBS.

The effects of warming and pesticides on Cabbage White butterfly clutch size and clutch size mortality

Nikki Knecht, Ulster County Community College, (SUNY Ulster), REU- Haddad Lab
Mentor: Stephanie Clark, Dr. Nick Haddad

As temperatures rise globally insects, specifically lepidoptera, will continue to face increasing challenges. The Cabbage White Butterfly (Pieris rapae) is one of the many organisms that will experience these effects. As temperatures rise, the butterfly’s metabolic and reproductive rates will increase. These increased reproductive rates may lead to changes in clutch sizes. In this study I predict that an increase in clutch size will lead to an increase in survival. One reason for this decrease in mortality is because larger clutch sizes are better at defending against desiccation. Increased metabolic rates are predicted in this study to lead to increased growth rates. Along with warming, insecticide use contributes to the growing stressors on lepidoptera, a stress that will only amplify as time goes on. I predict that insecticide use will increase mortality, but have varying effects on clutch size. Previous findings show that exposure to insecticides increased clutch size, but decreased egg size, which decreased the butterfly’s competitive ability. Growth rate is predicted to be lesser in insecticide scenarios due to the adverse effects that Merit 75 WP, a neonicotinoid insecticide, will have on the caterpillars. In a combined scenario of insecticide exposure and warming, I predict that the physiological effects insecticides have on the butterfly will outweigh warming benefits in the long run. In the short term, however, warming effects on survival rates will likely be stronger. To measure the overall effects that these different clutch sizes have in these different scenarios, artificially sized clutches were created. A “low end” clutch of 3-4 eggs, a “mid-range” of 19-21, and a “high end” of 44-46 eggs were created, with the aim of placing two replicates of each into a control (ambient), warming, insecticide (insecticide sprayed), and an insecticide warming scenario. After three weeks of sampling it was found that for mortality the warming treatment, a low clutch size in control and insecticide treatments, and a high clutch size in controls are significant. For growth rate, the insecticide-warming treatment, medium clutches in control treatments, high clutches in control and warming, and low clutches in control, insecticide, and insecticide-warming were significant. This shows that clutch size has significance and should be further studied due to the fact that there is little to no research on the topic. I’d like to contribute to fixing this knowledge drought.

My KBS Experience: Avian Care Intern

Marie Kroneman, Michigan State University, Intern- Avian Care
Mentor: Lisa Duke

This summer I was the Avian Care Intern at the Kellogg Bird Sanctuary. My poster details my summer project, a typical daily schedule, and interesting facts I learned while working with the avian residents of the sanctuary. I included numerous pictures of the different raptors and waterfowl that I care for on a daily basis. I also included pictures showing the chores and behind the scenes of the job.

Does a drought legacy affect Triticum aestivum growth?

Lisa Leonard, Ohio Wesleyan University, REU- Zarnetske Lab
Mentors: Moriah Young, Dr. Phoebe Zarnetske

Drought is a major abiotic stressor to not only plants, but soil microbes. Plants and soil are inherently interconnected and the relationship between them can determine the health of both the plant as well as the soil. In this study, we looked at the effects of a previous years' drought on the growth of Triticum aestivum, common wheat. Using the Rainfall Exclusion eXperiment (REX) in the LTER at W.K. Kellogg Biological Station, we measured height, greenness, and biomass on wheat. These measurements were conducted in the no till treatments (T2s) and in the drought legacy, irrigated control, and drought footprints with the fungicide and control subplots. A SPAD was used to measure greenness, a proxy for chlorophyll content in leaves. Wheat was harvested in the treatment area, dried, and then weighed for biomass. We expected that drought legacy plots and fungicide subplots would have shorter heights, lower greenness, and less biomass. We found no significant differences between greenness and biomass between each treatment. However, there was a difference in height between the irrigated control and drought legacy fungicide subplots, with the irrigated control plots having lower average heights. This is the opposite of what we expected from our hypothesis. Because the 6-week drought had not started yet, we would not expect an effect from the drought in those footprints. Further, soil microbes could potentially be resilient, resistant, or functionally redundant in their response to the previous years' drought which could be why we did not see any drought legacy effects on wheat greenness or biomass. Soil samples are being collected to compare the fungal and bacterial communities within these same plots in order to explain their responses to the treatments. It is crucial to understand these plant-soil feedbacks as climate change increases and how plants and soil microbes adapt to the changes within the environment.

Assessing differences in butterfly populations between newly planted and established prairie strips

Alyssa Mollema, Michigan State University, URA - Haddad Lab
Mentors: Alice Puchalsky, Dr. Nick Haddad

Agriculture is a main culprit of insect population decline due to its ties to large scale habitat loss, but also pesticides and fertilizers, which either directly kill the insects or threaten their host plants. A way to combat these threats is to implement the use of prairie strips in crop fields. This research aims to estimate the influence of new versus established prairie strips on butterfly populations. Butterfly surveys were conducted in the Long-Term Agroecosystem Research Aspirational Cropping Systems Experiment (LTAR-ACSE) and in the Long-Term Ecological Research (LTER) at the Kellogg Biological Station in Kalamazoo, Michigan. The LTAR-ACSE prairie strips were planted in 2022, and the LTER prairie strips were planted in 2019. Butterfly abundance and species richness data collected from these two sites were compared. The LTER fourth year prairie strips were higher in both butterfly abundance and butterfly richness, which could be linked to the different plant communities between the LTER and LTAR prairie strips. The results of this project could be used to inform farmers of what benefits they should expect within the first years of planting prairie strips as opposed to when the prairie strips are fully established.

Kellogg Bird Sanctuary Visitor Experience Internship 2022

Ezra Montero, Michigan State University, Intern- Visitor Experience
Mentor: Lisa Duke

Science education is often taught in the abstract, with facts and information on biology treated as concepts that are outside of our day-to-day lives. I've learned this summer that good environmental education should help foster the knowledge that the environment isn't an abstract concept, but something core to human existence that we should experience directly as much as possible. Working at the Kellogg Bird Sanctuary, I helped facilitate that environmental experience for sanctuary visitors. I helped answer questions about our native ecosystem, talk about the history of the sanctuary, and deal with countless stressed phone calls about baby birds. While not directly working with the public, I was designing and running activities for our bi-weekly educational programs, or planning for our annual overnight camp. In all my activities, it was important to me to promote observation, question asking, and most importantly becoming comfortable in our native ecosystem. Nothing helps you learn like teaching, and I feel like I've come away with a heightened understanding of not only education and interpretation, but also ecology as a whole.

Differences in plasticity to increased temperature and drought in two native populations of Arabidopsis thaliana

Victoria Nicholes, Shepherd University, REU - Conner Lab
Mentors: Sophie Buysse, Dr. Jeffrey K. Conner

Evidence of climate change surrounds our natural world and poses a serious threat to the fragile balances that maintain life. Current climate projections are expecting up to a 4ºC increase in temperature by the year 2100. The hydrologic cycle, soil microbiomes, suitable habitat disruptions, and endurance of the biotic world all suffer in varying degrees and directions from warming trends. The main cause and accelerator of climate change is the human species. As our climate patterns continue to change worldwide it is crucial we gain an understanding of how it may affect our natural ecosystems. Understanding the ability of species to adapt to different environments through local adaptation, phenotypic plasticity, natural selection, and chance genomic mutations have become ecological and biological focuses. For our experiment, we chose to focus upon plasticity potential of the model species Arabidopsis thaliana due to it being a small, annual species with accessible genomic resources and highly   reproduction. We conducted a growth chamber experiment with 128 plants total, half being Italian (Belmonte) genotypes and half being Sweden (Rodasen) genotypes. We used chamber common gardens to simulate the current and projected future environment for SW to identify differences in plasticity between the Sweden and Italy populations. Italy has a higher single leaf area but a lower dry leaf matter content and relative water content (RWC) than Sweden. Italy also bolted earlier in both environments than Sweden. Given equal investment in below ground biomass, Sweden has more investment in above ground biomass (i.e. rosette leaves); both populations show different plasticity in biomass allocation. Both populations showed different plasticity in number of days to bolting, RWC, and biomass allocation. Plasticity for RWC demonstrates A. thaliana's ability to adjust its balance between transpiration rate and leaf tissue with available water supply in drought conditions. Being plastic towards biomass supports the ability of the plants to invest in either more above ground biomass or less below ground biomass depending upon its environment.

Deer Browse on Michigan Red Pine

Olivia Norris, Kellogg Community College, Intern-Forestry
Mentor: K.J. Kettler

Michigan is among the top producers of red pine forest products in the timber industry. One issue that land managers face is deer browse. Browse can lead to dieback, stunted growth, and undesirable tree form. 465 red pine saplings were planted in June 2022 in an even-aged (clear-cut) unit of Kellogg Forest. 252 red pines were protected by an exclosure that was constructed using natural materials (slash), from the previous timber harvest. The remaining 213 pines were planted as a control without a slash wall to monitor the impact of deer browse. I believe saplings inside of the slash wall will experience less deer browse while saplings in the open will have more deer browse. Another factor considered was if saplings were in direct sun or partial sun. Saplings in the open and along the shade line of mature trees would experience more deer browse than saplings in the middle of the plot. The third and final factor is the average distance the saplings are from other plants. Plants like thistles and switchgrass provide protection for the sapling. Saplings with a farther distance from other plants (stand-alone) were more prone to deer browse.

Plant in a box: The effects of an experimental method on switchgrass biomass and soil microbial function

Veronica Pargulski, Michigan State University, URA - Robertson Lab
Mentors: Dr. Carmella Vizza, Dr. G. Philip Robertson

Panicum virgatum (switchgrass) is a perennial non-food crop being considered for bioenergy. A key to sustainable production of switchgrass is to better understand nitrogen fixation so that fertilizer can be reduced. Nitrogen fixation is a process in which nitrogen-fixing microbes in the soil convert atmospheric nitrogen N_2 into a bioavailable form of nitrogen that plants can also use. This summer, the E-Fix team ran a series of experiments to measure plant-scale nitrogen fixation using mesocosms in the field, which are 75-cm deep steel boxes (25 cm x 25 cm) with whole switchgrass plants. To determine the impact of this experimental design on plant, soil, and microbial properties, I examined how the physical mesocosm impacts soil moisture, plant biomass, greenhouse gas fluxes, inorganic nitrogen, and net nitrogen mineralization. In my experiment, I compared the response variables across depth (0-10 and 10-25 cm), and location (inside and outside the mesocosm). While soil depth had a significant effect for soil ammonium and greenhouse gas fluxes, mesocosm presence never had a statistically significant effect on any measured factor. Plant and soil characteristics were relatively comparable inside and outside the mesocosm to 25 cm in depth, which suggests that our experimental design will hopefully be representative of switchgrass, soil, and microbial interactions at the field scale.

Maturing prairie strips recruit spiders to surrounding agricultural fields

Charlotte Perry, Michigan State University, URA- Haddad Lab
Mentors: Jamie Smith, Dr. Nick Haddad

Prairie strips are areas of native vegetation planted among row crops. They provide benefits to agricultural systems, as well as preserving local biodiversity. By creating both long- and short-term habitat for a variety of species, prairie strips can provide many ecosystem services, including biological pest control. These habitats can support known predators of agricultural pests, such as spiders. The Long-Term Ecological Research site at Kellogg Biological Station has integrated prairie strips into reduced chemical input and organic experimental agricultural treatments. Previous studies have shown that spider richness and abundance are higher in plots with prairie strips than those without. Our experiment investigated the recruitment of spiders into the LTER prairie strips over time, and whether the benefits of prairie strips extend into surrounding crops. We set pitfall traps along three transects within and at multiple distances from the prairie strip. These traps were set in 6 replicates each of reduced chemical input and organic treatment plots. The traps were collected after 48 hours, and spiders were sorted and identified to the family level. We compared our data to spider richness and abundance data collected in May 2019, when the strips were first seeded. We found that spider abundance increased within the crop from 2019 to 2022. Additionally, abundance was higher in the prairie strips than in the crop and was also higher in organic treatments than in the reduced chemical input plots. These results are evidence of prairie strips increasing an ecosystem service, which could incentivize the incorporation of prairie strips into more row crop systems. Farmers will reap the benefits while the natural habitat provided by the strips promotes biodiversity.

Exploring leafhopper dynamics with prairie grasses

Jacob Pressler, Marian University, REU- Malmstrom Lab
Mentors: Katrina Culbertson, Dr. Carolyn Malmstrom

Leafhoppers are a diverse insect family (Hemiptera: Cicadellidae) known to reside on monocots, dicots, or both depending on the species. Leafhoppers are agricultural pests that are also known to vector pathogens, such as Aster Yellow disease. A farming technique under development is including a strip of prairie plants through crop fields to host native plants and pollinators. We compared leafhopper communities across the Kellogg Biological Station’s Long-Term Ecological Research plots. In the Main Cropping system, we compared leafhopper communities in the wheat fields, prairie strips, and the mowed aisles between plots in two different treatments; one with reduced chemical input and one with biologically-based inputs. In the Cellulosic Biofuel Diversity plots, we compared switchgrass with and without added nitrogen, as well as prairie grass stands planted with varying amounts of forbs in correlation with the leafhopper communities.

We collected insects from each plot with a sweep net, sacrificed the insects by freezing, and morphotyped leafhoppers and identified them to the genus or species level when possible. We hypothesized that plots with more plant diversity would have more leafhopper morphotype diversity and higher abundance because a variety of plants would support leafhoppers with both monocot and dicot hosts. We predicted that wheat fields with prairie strips that followed a low chemical input regimen would have higher leafhopper abundance and diversity than those with biologically-based inputs because of the potential benefits to leafhoppers of feeding on plants with added nutrients. In the Main Cropping system, the prairie strips had higher leafhopper diversity and abundance compared to the wheat and aisle, with the prairie and aisle having the least similar leafhopper community compositions. We found that plots with higher plant species diversity had higher leafhopper morphotype diversity, but lower leafhopper abundance. In the switchgrass plots with added nitrogen, leafhopper species with low conservatism were more abundant. Future work would test leafhoppers for plant viruses to determine where vector activity is most prevalent in crop fields with prairie strips, and assess leafhopper communities in comparison with a complete foliar nutrient composition.

Nematode community composition changes with distance from prairie strips in row-crop systems

Abby Rees, Whitworth University, REU- Sprunger Lab
Mentors: Tvisha Martin, Dr. Christine Sprunger

Nematodes have been used to indicate shifts in soil food web functioning within agricultural management practices. However, the influence of edge effects from prairie strips on nematode communities within neighboring agricultural fields has been seldom explored. Our project aimed to 1) Determine how prairie strips impact nematode community composition within row-crop systems that vary in fertilizer inputs and 2) Assess the potential of a spillover effect from prairie strips on nematode communities within neighboring agricultural fields. We collected soil cores within prairie strips and at various distances (1, 5, and 20 meters) away from the prairie strips on reduced input and biologically based treatments at the Kellogg Biological Station’s Long-Term Ecological Research Site Main Cropping System Experiment (LTER-MCSE). Nematodes were then extracted from all soil cores using a Baermann Funnel and counted at 40x magnification using a dissecting scope. Nematodes were identified to family using a compound microscope at 40-100x magnification. We found that distance and treatment had no significant effect on total nematode abundance. However, distance was found to have a significant effect on nematode community composition. For example, fungivores were the only feeding group to have significantly greater abundance within the prairie strips compared to the other distances. In addition, nematode communities that were closer to the prairie strips were found to be more closely related to the communities within the prairie strips. These results indicate that prairie strips may have a potential spillover effect within neighboring agricultural fields, which has important implications for enhanced soil health.

Effects of cropping system management and distance from prairie strips on natural pest suppression

Breh Ruger, Albion College, REU- Landis Lab
Mentors: Dr. Nathan Haan, Dr. Douglas Landis

Predatory and parasitic arthropods provide valuable pest suppression services that benefit agriculture. However, the expanding footprint and increasing intensity of agronomic systems has decreased the abundance and diversity of these service-providing arthropods. Agricultural practices such as prairie strips can be implemented to modify the landscape and include habitat for predatory arthropods to live in. We asked if pest suppression services ‘spill over’ from prairie strips into crop fields, and if so, at what scale. We used plasticine sentinel caterpillar mimics, which record imprints from attacking organisms, to address this question. We placed the plasticine caterpillars in all replicates of two types of wheat cropping systems at the KBS LTER MCSE; ‘reduced input’ (T3), and ‘biologically based’ (T4). They were placed within prairie strips and at 1, 5, and 20m distances into the crop field as well as the turf outside the field. Caterpillars were evaluated for attack marks which we identified as having come from rodents, birds, or predatory arthropods. We detected no difference in overall attack rates between T3 and T4 cropping systems. Attack rates were higher in T4 prairie strips relative to the surrounding crop, but this was not seen in T3 prairie strips. Rodents represented the largest proportion of attackers at all distances in both treatments, and there was no evident pattern of identity of attacking organisms based on the distance from the prairie strips. The data we present are from the month of June only; samples from July are currently being processed. Preliminary observations suggest that in July more of the attacks were by arthropods, but whether ‘spill over’ of services from prairie strips will be evident remains to be seen.

Faces and Spaces of Kellogg Biological Station

Alex Sills, Michigan State University, Intern- External Communications
Mentors: Sarah Carroll and Cara Barnes

As an intern at Kellogg Biological Station this summer, I was able to take in all the science going on and produce ways to represent their experiences. This summer, alongside my mentors, I designed promotional materials that promoted the significance of Kellogg Biological Station research, connected Kellogg Biological Station alumni with current KBS goings-on, drafted, produced and distributed communication pieces and fundraising materials, and assisted with donor related events. I was able to attend many events put on by various parts of Kellogg Biological Station, photograph them, and write blog posts about the events to show to the community. I also made a video this summer to encapsulate our summer and show how KBS positively impacted all of our lives.

Bathing in protein powder: effects of anther position on pollen placement

Sally Song, Wellesley College, REU- Conner Lab
Mentors: Robin Waterman, Dr. Jeffrey K. Conner

Plants and pollinators form a mutualistic relationship in which pollinators feed on pollen from the anthers and/or nectar at the base of the flower. Meanwhile, pollen is often deposited onto pollinator bodies and can then be transferred to the female stigma of another flower, benefiting the plant by enabling ovule fertilization. This study explores how anther position in wild radish (*Raphanus raphanistrum*) affects where pollen is deposited onto the bodies of common, effective pollinators, namely sweat bees and syrphid flies, as they forage for nectar and pollen. Two key traits of anther position is separation, which is the distance between the long and short stamen anthers, and exsertion, the distance between the long anthers and the opening of the corolla tube. Slow-motion videos of the pollinators interacting with radish flowers were recorded and used to measure how long particular body parts of pollinators came into contact with the anthers. Anther position did not affect the duration of contact with most of the pollinator's body parts. However, anther exsertion and separation significantly affected contact with a bee's ventral body and legs/mouthparts, respectively, and anther separation affected contact with a syrphid fly's legs/mouthparts.

Mapping the spatial distribution and evolution of soil carbon and nitrogen accumulations in historic prairie treatments over a thirteen-year period in the Midwestern U.S

Kaitlyn Steeves, Michigan State University, URA- Robertson Lab
Mentors: Dr. Brook Wilke, Grant Falvo

Ecosystem services vary in domain and scale, from the biotic communities of pollinators fertilizing forests and crops to the abiotic filtration of groundwater's impurities before reaching a stream or aquifer. Two such essential ecosystem services paramount to this study are the sequestration and fixation of carbon and nitrogen: essential components affecting atmospheric gas buildup and the current global climate crisis. KBS remains the only LTER site of all 28 current stations to focus on row-crop agriculture. A combination of Conservation Reserve Program (CRP) grassland areas, biofuel switchgrass plots, and restored prairies built on the foundation of traditional cropping systems dating back at least one century provides a breadth and depth of baselines to impose treatment solutions upon. Focusing closely on the latter, the documentation of annual upper-layer soil strata cores (0-25 cm depth) has previously been geo-referenced, but it has never been formatted to include the newest set of samples more than a decade forward in time alongside the baseline samples taken at the implementation of the treatment. Producing a visual reference tool to document the dynamic effects of prairie remediation techniques on carbon and nitrogen stores will serve as a reference tool for short-term benefits of the treatment and a long-term point of interest for future generations of stakeholders as the experiments continue. This experiment and the subsequent research methods, as well as the geospatial modeling procedure, have the primary purpose of contributing to the ongoing research and conduct of the GLBRC Scale-Up Site and the postgraduate works of Grant Falvo. As such, this proposal serves merely as an additional offshoot project and is therefore a single facet in the multi-faceted approach of Falvo's 2022 thesis "Long-term resilience of soil carbon and nitrogen stocks to agricultural land-use change in the U.S. Midwest".

Bullfrog Invasion: Does physiology impact distribution?

Evelyn VanDenBerg, Drake University, REU- Shah Lab
Mentor: Dr. Alisha Shah

Collaborator: Kyle Jaynes

Ecologists have long wondered why species geographic distributions vary. One potential mechanism underlying the differences in species distribution is physiological tolerance. In particular, species with wide distributions are hypothesized to be tolerant of a wider range of conditions than those with restricted distributions. Species that are highly invasive (and thus occupy wider distributions) can provide some insight into the role that physiology plays in species distributions, especially when compared to non-invasive congeners. We tested this hypothesis using anuran congeners: the American bullfrog (Lithobates catesbeianus) and green frog (Lithobates clamitans). Bullfrogs and green frogs have overlapping native ranges and are functionally very similar. Yet, bullfrogs are exceptional at colonizing new habitats and have managed to invade and thrive in much drier and hotter environments in the western United States. We predicted that bullfrogs have (i) higher tolerance to drying (hydric stress resistance), (ii) higher heat stress tolerance, and (iii) greater ability to acclimate to warm conditions than green frogs. We tested our predictions using lab experiments on wild-caught tadpoles. To test hydric stress tolerance, we measured water loss in each species following a 3-hour desiccation period. To measure heat stress tolerance, we measured the critical thermal maximum (CTmax), in each species after allowing them to acclimate to 14 ºC. Finally, we tested acclimation capacity by placing tadpoles in a warm incubator (20 ºC) for 6 days and then measuring their CTmax . We compared this CTmax to that of tadpoles acclimated to 14 ºC. In contrast to our predictions, we found that bullfrogs have lower hydric stress tolerance than green frogs and similar heat tolerance to green frogs. However, in line with our prediction, they showed an increase in CTmax after acclimation to 20 ºC indicating a capacity to acclimate, whereas green frogs showed no ability to acclimate. Our results suggest that acclimation to warmer temperatures may be one way in which bullfrogs are able to invade warmer regions while green frogs remain restricted to cooler climates.

The effects of wetting on greenhouse gas fluxes and denitrification over time

Jorge A. Vázquez Custodio, Resident Mentor/Technician- Robertson Lab
Mentors: Dr. Carmella Vizza, Dr. G. Philip Robertson

Switchgrass is a perennial warm season bunchgrass native to North America and a potential bioenergy crop. Past research has shown that wetting events increase nitrogen fixation and affect greenhouse gas (GHG) emissions in switchgrass soils. The objective of this study is to find out how t GHG fluxes and denitrification change across depth and over time after a wetting event, and to figure out whether N_2O fluxes and denitrification that result in nitrogen losses from the soil could stimulate fixation after wetting. Soil plugs from 0-10 cm and 10-25 cm were collected from a 50 x 50 cm area before, immediately after, 24, 48, and 72 hours following a 30-mm wetting event. Soil plugs were then incubated in a jar for 120 minutes, and the headspace was sampled at 4 intervals (0, 40, 80, and 120 minutes) to measure GHG fluxes. To estimate denitrification rates, acetylene was added to the headspace of a subset of jars to achieve a 10% concentration, which inhibits the conversion of N_2O to N_2, and these jars were sampled at the same intervals as the conventional GHG assay. All gas samples were analyzed using gas chromatography. N2O fluxes did not vary significantly with soil depth or assay type (conventional versus acetylene). In contrast, CO2 fluxes at 0-10 cm were significantly higher than 10-25 cm, while the difference between acetylene and conventional N2O fluxes tended to be higher at 10-25 cm than 0-10 cm, which suggests that microbial processes differ with soil depth after a wetting event. N2O fluxes generally decreased over time after wetting, whereas CO2 fluxes experienced a prolonged increase over three days after wetting. This decrease in N2O fluxes over time after wetting coupled with their very low rates suggests that nitrogen losses may not be the major factor that enhances nitrogen fixation after a moderate wetting event of dry soil. It is possible that the prolonged CO2 fluxes after wetting suggest not only increased microbial activity, but also indicate higher carbon availability that could fuel nitrogen fixation. Understanding how all these factors influence switchgrass soils will shed light on its environmental sustainability as a large-scale biofuel crop.

Chrysemys picta-HA-HA-HA are stayin' alive, and the males thrive

Nina Simone Warner, Spelman College, REU- Fitzpatrick Lab
Mentors: Kyle Jaynes, Dr. Sarah Fitzpatrick

Painted turtles (Chrysemys picta) are the most widespread turtle species in North America, and a common species in Michigan. They exhibit Temperature-dependent Sex Determination (TSD), where individual sex is determined by temperature experienced during egg incubation, with higher temperatures producing females, and cooler temperatures producing males. Given this relationship between temperature and offspring sex determination, organisms with TSD are predicted to be heavily burdened under significant climate change. Yet, despite this developmental constraint under changing abiotic conditions, some turtles, including the common painted turtle, continue to persist across the broad range of climatic conditions they experience. We leveraged a long-term empirical dataset of a periodically monitored painted turtle population in Southwest, Michigan (1964-2022) to study historical demographic patterns. Specifically, we tested for 1) long-term changes in sex-ratios in the historical population (1964-2022; 58 years), and 2) factors that influence survival in the contemporary population (2018-2022; 5 years). We conducted a capture-mark-recapture (CMR) study at a private field site in Southwest, Michigan from 2018-2022 and incorporated sex information from historical field seasons on this system to calculate sex ratios. We analyzed CMR data in program MARK using CJS models to estimate factors impacting survival. Our results show that the population shifted from female-biased to male-biased in the mid-1970s, and has maintained this bias for the last 40 years, which is the opposite of what we'd expect under climate-driven shifts. In the contemporary CMR surveys (2018-present), sex and time were important factors influencing survival, with males having higher survival rates than females. It remains unclear what factors influencing higher male survival rates, such as higher road mortality or emigration in females, have helped to maintain the stable male-biased sex ratio over time, and how the current male-bias in the population sets the stage for predicted female-biased shifts. This study helps continue the long-term monitoring of a wild population expected to be impacted under climate change, with potential insights into understanding their persistence.

Leaf litter as prey for Michigan's carnivorous pitcher plant
Dillon Wheeler, Lee University, REU- Gilbert Lab
Mentors: Sylvie Martin-Eberhardt, Dr. Kadeem Gilbert

Carnivorous plants capture and digest animal prey to acquire nitrogen in nutrient-poor environments. Sarracenia is a North American genus of pitcher plants that has evolved pitfall-style leaf traps convergent with the Southeast Asian genus Nepenthes. In particular, Nepenthes ampullaria is known to utilize nitrogen from captured leaf litter. N. ampullaria has unique adaptations: it is shorter than many congeners, its lid is reflexed away from the pitcher mouth, its pitchers have limited enzyme production and relatively high pH, and it relies on a broad community of digestive mutualists to break down leaves. Sarracenia purpurea, the pitcher plant native to Michigan's bogs, shares many of these traits with Nepenthes ampullaria. Because of these similarities, we hypothesize that Sarracenia purpurea does capture, digest, and utilize leaf nitrogen. To test this hypothesis, we used three approaches: 1) we conducted an observational study in which we harvested pitchers, quantified their prey content, and measured their foliar nitrogen, finding that 81% of pitchers contained leaf biomass and, on average, 56% of the total captured biomass was plant matter. There was not a significant correlation between plant biomass captured and foliar nitrogen concentration. 2) We also conducted an in vitro experiment, assembling model pitchers with inquilines, pitcher fluid and either insect prey, plant prey, or no prey (control). The presence of leaf litter slightly increased ammonia (NH_3) in pitcher fluid. 3) Finally, in an in vivo study, we fed pitchers either insect prey, plant prey, or no prey (control), finding that pitchers fed leaf litter showed a slight increase in foliar nitrogen concentrations over control pitchers. This study offers promising preliminary results that Sarracenia purpurea captures, digests, and utilizes nitrogen from leaf litter, further describing the unique life history of a sensitive Michigan plant.

The effects of climate change treatments on the biomass of plant communities
Jordan Zapata, Michigan State University, URA- Zarnetske Lab
Mentors: Mark Hammond, Dr. Phoebe Zarnetske

A plant's growth can be affected by both biotic and abiotic factors. Available water can help it grow while a drought will slow growth. Warmer temperatures may also increase or decrease growth. Human caused climate change is expected to increase average temperatures and make weather more variable. This project studied how grassland communities and four species in those communities (Solidago canadensis, Symphyotrichum urophyllum, Phleum pratense, Poa pratensis) are affected by warming and drought climate treatments in the KBS LTER Rain Exclusion eXperiment (REX). Biomass was harvested in order to determine annual net primary production (ANPP) for 2021. The irrigated control, ambient control, drought, warming and warmed drought treatment plots were sampled and sorted to species. We found that warmed plots have significantly less biomass on average when compared to the irrigated control plots. Forb species are also shown to have more biomass on average, but experience a reduction in biomass due to warming. Graminoid species, however, had no significant reduction in biomass. When looking at individual species, there is large variation in species' responses to each treatment. These measurements will be completed again in 2022.

This data will help predict the response of ecosystems and specific species to a changing climate.