Undergraduate Students Research Abstracts

Title: Tree Distributions and Responses in Relation to Soil Characteristic and Topographic Differences in a Premontane Rainforest

Presenter: Jenna Baljunas, Chatham University

Coauthors: A.T. Cahill, Texas A&M University, Department of Civil & Environmental Engineering; A. Dunnebacke, Michigan State University, Department of Forestry; G. Moore, Georgia Southern University, Department of Biology; K. Brumbelow, Texas A&M University, Department of Multidisciplinary Engineering; A. P. Smith, Texas A&M University, Department of Soil & Crop Sciences

Abstract: Future climate changes may have a significant impact on ecosystem composition in montane tropical rain forests. Because of the relationship between elevation and microclimate, potential future impacts can be investigated through the present effects of elevation and topographic gradients on landscape characteristics such as vegetation and physical soil properties. While there is a general understanding of species migration in response to microclimate changes, site-specific analyses are still required, especially given underlying geologic differences. With knowledge that topography influences hydrologic processes and patterns as well as species distributions and traits, this study used geostatistical analysis to discover current elevational impacts on soil and vegetation in an undisturbed premontane tropical rainforest in Costa Rica. A land surface elevation model was generated using azimuth, horizontal distances, and vertical distances between grid points of a 30 x 30-meter gridded plot measured by a clinometer. We performed 25 soil moisture, bulk density, and texture analyses, along with the determination of diameter at breast height (DBH) and locations of previously tagged trees. Soil properties and tree locations were then mapped. Empirical variograms for the soil textural properties were calculated and used to develop a kriging model for the soil characteristics field. Although the spatial intermittency of large trees at the site led to sampling issues, results show associations between the soil field and the vegetation field. Kriging models suggest interactions between trees and soil moisture and bulk density and reveal the influence of moisture on the distribution patterns of *Carapa guianensis*. Overall size distribution suggests an uneven-aged stand which can relate to the topographical changes, such as slope, observed. Some potential implications of the results on future changes in landscape are also discussed, as well as limitations of the modeling approach.

Title: Weather-induced Flower Closure in Spring Ephemeral Forest Wildflowers and its effect on Pollen Viability

Presenter: Megan Gauger, University of Pittsburg, Carnegie Museum of Natural History

Coauthors: Mason Heberling, Carnegie Museum of Natural History

Abstract: This project seeks to understand how temperature, light, rain, and time of day affect day-to-day petal movement in three spring ephemeral wildflower species common across Eastern Deciduous Forests of North America; (*Claytonia virginica* (Montiaceae; spring beauty), *Sanguinaria canadensis* (Papaveraceae; bloodroot), and *Erythronium americanum* (Lilliaceae; yellow trout lily)). Additionally, this project experimentally tests the functional effects of flower opening and closure on fruiting success. Two hypotheses were tested: 1) Species will close their petals at night and reopen only at a certain threshold (temperature, wetness, and/or light levels) in order to protect pollen, and 2) Weather-induced flower petal opening/closing increases pollen viability, therefore improving fruiting success.

At a wildflower-rich field site outside of Pittsburgh, we monitored mature flowers using field cameras programmed to capture images every 30 minutes. Footage was analyzed to determine how each petal opened, which was paired with local atmospheric and abiotic data.

We also experimentally manipulated flower petals to test the effect of permanent petal opening on pollen viability. Multiple organisms of *Sanguinaria canadensis* (Papaveraceae; bloodroot) and *Erythronium americanum* (Lilliaceae; yellow trout lily) were organized into four groups; one group of total petal removal, another of petal cutting, a total control where the flowers were not modified, and a secondary control where petals were lightly crushed to account for the effect of general petal damage.

We found that flowers were at peak openness between noon and 2pm and were never fully open before noon. Flowers never opened when the local temperature was below 9°C or when leaf wetness was greater than 4%. Flowers were fully open at atmospheric temperatures above 13°C, with most fully open around 20°C. From these preliminary results, we can conclude that both moisture levels and atmospheric temperature play a role in the opening and closing cycles of spring ephemerals.

Title: An anatomical analysis of vessel element size and density in shrub willow (*Salix* spp.) stems in response to nitrogen treatments

Presenter: Sara Hallameyer, Alvernia University

Coauthors: Michelle Serapiglia, Alvernia University

Abstract: As technology advances and the human population grows, renewable energy sources and sustainability have become more important to keep the world running and habitable. Plants are one of the largest sources of biomass in the world and the majority of its biomass comes from the cell wall. Cell wall development is a complex process in providing a plant structural integrity and protection against abiotic and biotic stressors. Trees and woody plants, like shrub willow, have the potential to reduce our dependence on fossil fuels by conversion to renewable forms of energy and natural products. Plant biomass consists of manly cellulose and lignin, two of the vital components in the cell wall that respond to changes in the environment. Nitrogen is a critical nutrient to plants and is found in many fertilizers to assist in plant growth. The goal of this project was to examine changes in cell wall development in willow in response to various nitrogen treatments. Cell wall changes were observed using fluorescent microscopy of thin sections of plant stem tissue. Various staining methods were used in order to visualize structural changes in the cell wall. Tissue samples were also analyzed via electron microscopy. Vessel element size and density were analyzed across the treatments. Images, along with these data, will be presented.

Title: Plant and fungi inhibitors of autoinducing peptides in methicillin-resistant *Staphylococcus aureus* (MRSA)

Presenter: Amelia Hanson, The Pennsylvania State University

Coauthors: Teal Jordan, The Pennsylvania State University; Joshua J Kellogg, The Pennsylvania State University

Abstract: Due to the widespread use of antibiotics to treat bacterial infections, pathogenic bacteria like methicillin-resistant *Staphylococcus aureus* (MRSA) are well known to develop resistance to current antibiotic therapies, which poses a serious threat to public health. The peptide signaling system of MRSA, *Staphylococcus aureus* accessory gene regulator (agr), secretes many destructive virulent agents and is activated by cyclic peptides known as autoinducing peptides or AIPs. An anti-virulence approach to bacterial treatment has been proposed that limits toxin production through inhibition of AIP with the goal of lowering the severity of bacterial infections while allowing the body to rid itself of infection without the development of resistance. Natural resources, especially plants, hold possible small molecules capable of combating antibiotic resistance and thus contribute to the development of new classes of antibiotics. In this study we tested 39 plants and fungi, some North American native plants and some widely used plants and fungi of commerce, for their antibacterial and AIP inhibitory activity via a rapid, quantitative liquid chromatography-mass spectrometry (LC-MS) method. Several of the plants surveyed have shown reduction in quorum sensing peptides; two of the most noteworthy being *Inonotus obliquus* at 62.41% AIP inhibition and *Typha* species at 63.19%.

Title: Multi-method sampling of ground and canopy-dwelling insects in temperate deciduous trees

Presenter: Brianna A. Hoffman, Washington & Jefferson College

Coauthors: Jason S. Kilgore, Washington & Jefferson College

Abstract: Individual trees provide a range of niche habitats from the ground into the canopy. Research conducted in temperate forest canopies suggests that biodiverse insect communities exist but remain understudied, especially when compared to tropical regions. We are investigating the change in insect community from the ground to the canopy in temperate deciduous trees.

As part of a developing collaboration called ARBOREAL between primarily undergraduate institutions (PUIs) dedicated to temperate forest canopy research, we developed and piloted protocols to survey canopy- and ground-dwelling insect biodiversity in deciduous trees. In Fall 2022, we used a large pin oak (*Quercus palustris*) on a college campus to practice stationary-rope climbing, to perform diurnal sweep net surveys, and to conduct nocturnal surveys using a suspended blacklight bucket trap. We also selected a large northern red oak (*Q. rubra*) in a mesophytic forest in southwestern Pennsylvania to survey ground-dwelling insect communities using a modified NEON pitfall trap protocol. In Fall 2023, we placed insect flight interception traps, game cameras, and temperature data loggers in the lower, middle, and upper canopy of this tree as part of a one-year ARBOREAL pilot study.

All insects collected in Fall 2022 were identified to the lowest possible taxonomy. Pitfall trap collections consisted of members belonging to the families Carabidae, Gryllinae, and Formicidae, while nocturnal blacklight traps captured insects belonging to the orders Lepidoptera, Orthoptera, and Coleoptera; due to cold weather, no insects were captured during the diurnal sweep net survey. Pitfall traps were the most consistent collection method. Diurnal sweep net surveys require training and supervision in tree climbing; however, lower branches and smaller trees could be more accessible using modified collection methods such as a telescoping net. This Fall, we continue to collect data from the insect flight interception traps, game cameras, and temperature loggers within the three canopy strata.

Title: Using Herbaria to Track Phenology Changes in *E*. *americanum*

Presenter: Peter Kaires, East Stroudsburg University

Coauthors: Emily Rollinson, East Stroudsburg University

Abstract: Climate change is altering environmental conditions for many organisms and ecological communities, potentially leading to changes in the natural history of many species. Many phenological shifts have been documented in response to changing seasonal patterns, including shifts to earlier flowering time in many plant species. Spring ephemeral plant species such as the yellow trout lily are of particular interest in studying flowering time phenology as they are some of the first plants to arise in the spring and their entire life cycle is completed not long after flowering. We assess phenological change in yellow trout lilies by examining herbarium specimens from 1890 to present from the ESU Buser Herbarium and 26 additional herbaria, accessed via The Global Biodiversity Information Facility (GBIF). To explain current-day variation in flowering time among yellow trout lilies in eastern Pennsylvania, we also examined the relationship between flowering time and local temperatures, using iNaturalist observations and PRISM climate models.

Title: Is the widely-cultivated katsura-tree (*Cercidiphyllum japonicum*, Cercidiphyllaceae) an invasion threat in Pennsylvania?

Presenter: Kayleigh Long, Bucknell University

Coauthors: Melody Sain, Bucknell University; Christopher Martine, Bucknell University

Abstract: This project explores the invasive potential of *Cercidiphyllum japonicum* (katsura-tree, Cercidiphyllaceae), a dioecious tree species native to temperate regions of China and Japan. Due to its characteristic heart-shaped leaves and attractive fall color, *C. japonicum* is commonly used as an ornamental and shade tree in temperate regions of North America. While the species has been identified as capable of escaping cultivation and/or becoming naturalized, little research on this has been published so far. A unique opportunity on the campus of Bucknell University occurred as regular landscaping/weeding that normally minimizes the possibility of establishment of unwanted plant species was reduced due to the onset of the COVID-19 pandemic until fall of 2022, allowing early stages of germination of *C. japonicum* to be observed in various locations in the area. For this reason, two surveys were conducted on campus in order to assess the invasive potential of *C. japonicum* when left undisturbed in ideal conditions. Seedling recruitment data was collected utilizing a 1 x 1 m quadrat method alongside buildings with well-draining gravel. Additionally, an incursion of young *C. japonicum* trees discovered in a campus woodland was surveyed for size and potential age-class. These surveys of recruited and established individuals allow us to predict what conditions are most conducive to the escape and possible naturalization of *C. japonicum* in the Mid-Atlantic region of the United States. We suggest that the species be considered “potentially invasive” in this region.

Title: Zinc tolerance of fernleaf bleeding heart (*Dicentra eximia*), a Pennsylvania endangered plant.

Presenter: Shaniah Miller, The Pennsylvania State University - Beaver

Coauthors: Sarah Nilson, The Pennsylvania State University - Beaver

Abstract: Fernleaf bleeding heart (*Dicentra eximia*) is a perennial plant native to the Appalachian Mountains, ranging from Pennsylvania to Georgia. In Pennsylvania, the species is listed as critically imperiled (S1), but two counties have multiple, thriving populations of 10,000+ individuals: Beaver County in western PA (out-of-range) and Carbon County in eastern PA. These counties share a history of industrial zinc smelting, heavy metal emissions, and heavy metal soil pollution. To determine whether *Dicentra eximia* displays tolerance to high levels of soil zinc, we measured soil zinc, foliar zinc, and took photosystem II stress measurements at three sites in Beaver County. Our results indicate that *Dicentra eximia* is capable of thriving in soils with extremely high levels of zinc, up to 2,000 ppm, as well as accumulating zinc in their shoots, up to 1,000 mg/kg dry shoot mass with minimal impact on plant stress. Due to its apparent zinc tolerance, *Dicentra eximia* may be a species of interest for bioremediation efforts throughout Appalachia at zinc contaminated sites.

Title: Determining the Effects of a Changing Climate on Phenology of a Dioecious Shrub

Presenter: Chris Perrone, University of Pittsburgh

Coauthors: Chris Perrone, University of Pittsburgh; Benjamin R. Lee, University of MIchigan; Mason Heberling, Carnegie Museum of Natural History

Abstract: While plant phenology has been an increasing area of study in the context of plant responses to climate change, potential differences between plant sexes are often ignored for dioecious species, plants which have male and female reproductive parts on separate individuals. If males and females respond differently to warmer springs, the period of overlap for pollination, and therefore successful reproduction, may decrease. Here, we combined field observations and herbarium specimen data of common spicebush (*Lindera benzoin*), a common forest shrub found across Pennsylvania. We asked whether males and females respond differently in flowering times in response to changes in mean annual spring temperature. We scored over 500 herbarium specimens from 5 different herbaria. We found males and females seem to have similar phenological responsiveness to increases in temperature. Despite similar responses with spring temperatures, males seem to generally flower earlier than females. We surprisingly found strong sex biases in the herbarium record, with the majority of individuals collected in flower being male. The extent of the sex bias seen in the herbarium varied between herbaria. However, we surveyed local populations in a southwestern PA forest and found most populations exhibited 1:1 sex ratios. Further studies are needed to understand whether the strong sex bias we found in herbarium record is representative of natural populations or reflect bias by plant collectors. Future phenological studies involving dioecious species should consider the possibility of different responses to climate change between male and female individuals.

Title: The Effect of Fire on Northern Red Oak Regeneration

Presenter: Abigail Powell, Duquesne University

Coauthors: Natalie Cleavitt, Cornell University

Abstract: This research project investigates the impact of fire on soil biota and Northern Red Oak regeneration. Oak regeneration is widely recognized to be difficult to execute for numerous reasons, including the presence of soil-fungal pathogens. Previous research has found a decrease in fungal pathogens following fire. This suggests that prescribed forest fire may be a useful tool in regenerating oak though little research has been done previously to fully support this hypothesis. An ex-situ experimental design was used to eliminate the influence that abiotic features of fire (charcoal presence, decreased leaf litter) may have on oak seedling development. Ten acorns were planted in pots containing soil from a burn site, ten acorns were planted in pots containing unburned soil, and five acorns were planted in a potting mix control. All seedlings received equal water and light. A qualitative measurement taken after the first month of development showed that seedlings in the burned soil developed faster than seedlings in the unburned and control soils. Measurements taken after the second and third months show that the seedlings in burned soil developed thicker stems as well. The growth difference between the seedlings in burned soil and the seedlings in unburned soil may be explained by a difference in soil pathogens. Fire may act as a natural sterilization process, eliminating harmful biota from soil. Thus, oaks growing in fire-influenced soil will have more energy to put towards growth than the seedlings in other soils. These findings suggest that fire can be a valuable tool when planning to incorporate oak into forests.

Title: Moss Reproductive Phenology in *Bryum argenteum*

Presenter: Megan Robie, Ursinus College

Coauthors: Denise Finney, Ursinus College

Abstract: Bryophytes are diverse and environmentally tolerant organisms that provide valuable ecosystem services. Despite their ecological importance, little is known about the factors that influence moss reproduction, particularly the timing of sporophyte development. This is a long-term observational study in which we are monitoring phenology and other reproductive traits of *Bryum argenteum* within or near college campuses. The main goal is to determine if sporophyte development time, density, and height differ between built landscapes and natural environments. These traits are measured in ten randomized patches at each site. We expect that differences in moisture and disturbance will lead to divergent patterns in these traits. In the first season of monitoring at Ursinus College, spring 2023, sporophytes developed in one of six sites. Further research is needed to identify the variables responsible for development at this site. This project is designed as a course-based undergraduate research experience (CURE) that can be implemented on campuses in any context (urban, suburban, rural). The universal protocol and a collection of teaching materials are available to undergraduate educators through the Ecological Research as Education Network (EREN), and we are actively recruiting collaborators to join us in carrying out this research. Data collected by undergraduate students throughout North America will build our understanding of moss reproductive phenology while also providing opportunities for students to gain experience in bryology and hands-on field research. Collaborators are not required to have expertise in bryology but must have enthusiasm for introducing students to these often-overlooked organisms and microhabitats.

Title: Tiny Forest Carbon Sequestration

Presenter: Catherine Segada, Mercyhurst University

Coauthors: Christopher Dolanc, Mercyhurst University

Abstract: Urban Nature can be defined as green space, either formal or informal, that is held within an urban setting. These spaces are not only vital to the quality of life of urban residents but also to the greater biosphere. Due to the recent worldwide scientific interest in Urban Nature, more specifically, Miyawaki Forests (Tiny Forests), it is important to determine how much carbon they can sequester. The Mercyhurst University Tiny Forest, planted in the Winter of 2021, is 20 x 11 m and originally hosted 640 trees. We asked, how much carbon can the Tiny Forest sequester in comparison to the amount of carbon emitted from Mercyhurst University? In June-August of 2023, tree diameter and heights were measured on all 580 living trees at the Tiny Forest. We used i-Tree Planting software to calculate carbon (C) sequestered using current dbh and projected future C sequestered at 50, 75, and 99 years using predicted dbh. A comparison between the amount of C sequestered in the Tiny Forest and the amount of C emitted through campus buildings was carried out. From the time it was planted through July of 2023, the Mercyhurst Tiny Forest sequestered 10,987.1 kg of carbon at 3 years, and is projected to sequester 2,204,932.6 kg of carbon at 50 years, 2,658,987.6 kg of carbon at 75 years, and 2,008,632.8 kg of carbon at 99 years. In comparison, Mercyhurst's largest dorm, Warde Hall, emits 300,000 kg of CO^2e annually. It would take 8 years for Warde Hall to emit the same amount of carbon that it will take the Tiny Forest 50 years to sequester. If carbon neutrality is the goal, our findings highlight the importance of increasing tree mass and carbon sequestration efforts on college campuses.

Title: The chemical cue of a parasite accelerates the chemical defense of tall goldenrod (*Solidago altissima* L.)

Presenter: Lily Sudol, The Pennsylvania State University

Coauthors: Robert Witkowski, The Pennsylvania State University; Eric Yip, The Pennsylvania State University; John Tooker, The Pennsylvania State University; Tanya Renner, The Pennsylvania State University

Abstract: Plants rely on environmental information to detect threats. Chemical cues associated with certain herbivores trigger plant chemical defenses in preparation for a later challenge, a phenomenon known as priming. Induced phytohormones including jasmonic acid (JA) and salicylic acid (SA) coordinate defense responses after priming. The relationship between the Pennsylvania native wildflower tall goldenrod, *Solidago altissima* L. (Asteraceae: Astereae), and the parasitic goldenrod gall fly, *Eurosta solidaginis* Fitch (Diptera: Tephritidae), is an example of an interaction mediated by chemical signals. Before mating, male *E*. *solidaginis* emit an airborne sex pheromone that primes *S*. *altissima*, alerting the plant that a parasitic gall attack is imminent. Studies have shown that specialist herbivory and gall formation rate decreases on primed *S*. *altissima*. However, the primed state of *S*. *altissima* is not well described. The reaction of primed *S*. *altissima* plants to generalist herbivory is not known, especially their defense hormone induction over time. We hypothesized that primed plants will rapidly induce JA-mediated chemical defense following insect herbivory and that JA levels will remain higher and last longer during herbivory than in an unexposed plant. We conducted a 48 h generalist herbivory feeding assay on *S*. *altissima* plants exposed to the pheromone of *E*. *solidaginis*. From damaged leaf tissue we quantified the defense hormones JA, SA, and abscisic acid (ABA) from with vapor phase extraction and subsequent gas chromatography-coupled mass spectrometry (GC-MS). Primed plant JA levels peaked 24 h before plants that were not exposed to the priming cue. SA levels were not significantly different across either time points and treatments, nor were ABA levels. Primed plants appeared to have an accelerated defense response to a chewing generalist insect. Interestingly, this indicates that a parasitic specialist's cue influences plant defense against unrelated herbivores. Our results illuminate the complexities of environmental signaling across trophic levels.

Title: Delimiting Varieties in *Cerastium velutinum*

Presenter: Juliana Sweeney, Delaware Technical Community College

Coauthors: Chris Hoess, Delaware Technical Community College

Abstract: Large field mouse-ear chickweed (*Cerastium velutinum*) is a member of the *C. arvense* species complex endemic to the Appalachian floristic province. Goat Hill chickweed (*C. velutinum* var. *villosissimum*) has been described from a mid-Atlantic serpentine barrens, but is difficult to cleanly delineate from the typical variety. A population in northern New Jersey has also been ascribed to this variety, but is clearly distinct in habitat and possibly in morphology. Morphologically and ecologically diverse collections have been made to form the basis of an initial molecular phylogeny using existing nuclear markers. Introns from *Cerastium* RNA polymerase paralogs have been amplified by PCR and cloned for sequencing to determine placement in existing phylogenies of the genus. This will allow us to analyze the likely origins of these populations and help determine an appropriate conservation status.

Title: Factors limiting reproduction in the Pennsylvania endangered dwarf iris, *Iris verna*

Presenter: Leslie Taylor, Shippensburg University

Coauthors: Heather Sahli, Shippensburg University

Abstract: The conservation of local biodiversity has gained importance in recent years as threats from climate change increase. Multiple factors including pollinator decline, inbreeding due to isolated and small populations, irregular and unnatural fire regimes, and more, are potential reasons for why some plant species are decreasing in abundance and quality across the world. *Iris verna*, a state endangered wildflower at the northernmost tip of its range, has been located and studied in Michaux State Forest, Pennsylvania. Since very little is known about the species, research on the factors limiting reproduction was conducted during the spring and summer months of 2023. Hand pollination using pollen from different origins was conducted, as well as pollen viability tests. Additionally, one site had experienced a controlled burn earlier in the year, so that population's fruit and seed production was compared to the fruit and seed production of the other two populations which were not burned. The likelihood of individuals setting fruits only significantly differed between populations ($\chi^2 = 9$, df = 2, P = 0.01), suggesting possible resource inequality. Pollen crosses from the same and different populations overall increased the amount of fruit and seed production, but the origin of the pollen produced no difference, suggesting that bi-parental inbreeding depression likely is not causing low seed production. Effects of the controlled burn were not observed, suggesting fire does not increase fruit and seed production, at least right away. The viability of *I. verna* pollen from numerous individuals varied greatly, but there was no significant difference between the populations ($\chi^2 = 0.97$, df = 2, P = 0.62), leaving a concern for the viability of some individuals. This research improved knowledge and understanding of *I. verna* factors limiting reproduction (pollinator limitations and nutrient and light limitations) and has implications for how best to conserve the species.