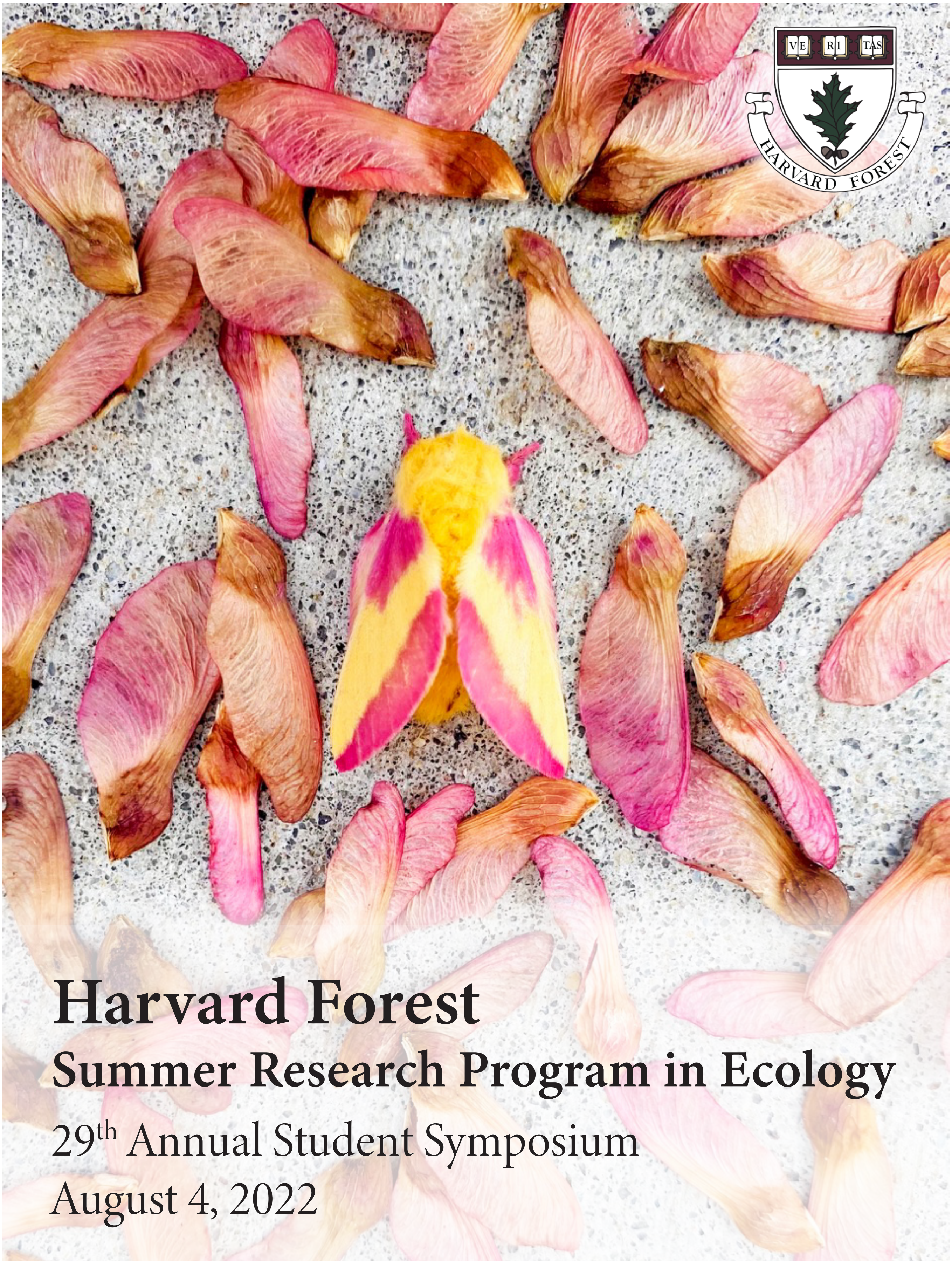


Harvard Forest

Summer Research Program in Ecology

29th Annual Student Symposium

August 4, 2022

29^{th} Annual Harvard Forest Student Symposium

August 4, 2022

cover photo: Savanna Brown

Introduction to the Harvard Forest

Since its establishment in 1907, the Harvard Forest has served as Harvard University's outdoor classroom and laboratory focused on forest biology, ecology, and conservation. Through the years, researchers at the Harvard Forest have concentrated on forest management, tree biology and physiology, community ecology and biodiversity, soil processes, watershed studies, forest economics, landscape history, conservation biology, and long-term ecosystem change.

Today, this legacy is continued by faculty, staff, and students who seek to understand historical, modern, and future changes in the New England landscape. Their research has informed conservation and land management policy as well as enhanced appreciation of forest ecosystems, their histories, and the many ways they sustain communities. This activity is epitomized by the Harvard Forest Long Term Ecological Research (HF LTER) program, which was established in 1988 with funding from the National Science Foundation (NSF) and now supports some of the world's oldest studies of global change in forest ecosystems and hosts year-round science education programs for learners of all ages.

Physically, the Harvard Forest is comprised of more than 3,750 acres of land in the north-central Massachusetts town of Petersham and surrounding areas. These acres include mixed hardwood and conifer forests, ponds, streams, extensive wetlands, and farm pastures. Additional land holdings include the 20-acre Pisgah Forest in southwestern New Hampshire (located in the Pisgah State Park); the 100-acre Matthews Plantation in Hamilton, MA; and the 90-acre Tall Timbers Forest in Royalston, MA. The Facilities Crew undertakes forest management, supports research infrastructure, and maintains facilities.

In Petersham, a complex of buildings provide office and library space, laboratory and greenhouse facilities, experimental gardens, and lecture rooms for seminars and conferences. Ten colonial-style houses provide accommodations for staff, visiting researchers, and students. Extensive records, including long-term data sets, historical information, original field notes, maps, photographic collections, and electronic data are maintained in the Harvard Forest Archives.

Administratively, the Harvard Forest is a department of the Faculty of Arts and Sciences of Harvard University. Faculty associated with the Forest offer courses through the Department of Organismic and Evolutionary Biology, the Harvard Kennedy School, and the Freshman Seminar Program. Close associations are also maintained with Harvard University's Department of Earth and Planetary Sciences, Paulson School of Engineering and Applied Sciences, Chan School of Public Health, and Graduate School of Design; as well as many Harvard centers, including the Arnold Arboretum, Office for Sustainability, Center for the Environment, Herbaria, Museum of Comparative Zoology, and Museums of Science and Culture. The Harvard Forest's affiliations outside of Harvard University include research collaborations with faculty and students from dozens of institutions– in particular, the University of Massachusetts, Boston University, the University of New Hampshire, the Marine Biological Laboratory's Ecosystems Center, Hubbard Brook Ecosystem Study and other LTER research sites, and regional environmental organizations, including Highstead and the New England Forestry Foundation.

About the 2022 Summer Research Program

The Harvard Forest Summer Research Program in Ecology brings a diverse group of students to receive training in scientific investigation and experience in long-term ecological research. Audrey Barker Plotkin and Sydne Record co-directed the 2022 program with the help of incoming program coordinator Ben Goulet-Scott and program assistants Savanna Brown and Nautica Jones. Students worked with mentors on a variety of research projects from field and laboratory experiments to computational science. The program included weekly seminars from scientists, workshops, a career panel, and many field excursions. The Harvard Forest Summer Research Program in Ecology culminates in the Annual Student Symposium held on August 4, 2022, where students present their research findings to an audience of scientists, peers, and family. We are especially grateful of this cohort for bringing so much perspective, joy, and laughter to the Harvard Forest community after two years without an in–person program.

Funding for the 2022 Summer Research Program

In 2022, the Harvard Forest Summer Research Program in Ecology was supported by the following organizations:

National Science Foundation
REU Site: Summer Research Program in Ecology at the Harvard Forest: Diverse data networks for diverse data scientists (DBI-1950364)
LTER: From Microbes to Macrosystems: Understanding the response of ecological systems to global change drivers and their interactions (DEB-1832210)

National Aeronautics and Space Administration
MUREP Inclusion Across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science: Partners Aligned to Heighten Broad Participation in STEM

Harvard University
Faculty of Arts and Sciences
G. Peabody "Peabo" Gardner Memorial Fund
Reuben Tom Patton Scholarship Fund

Bryn Mawr College
The Bryn Mawr College Summer Science Fund
Collaborative Proposal: MRA: Local-to-continental-scale drivers of biodiversity across the National Ecological Observatory Network (NEON) Grant #:1926568

Mount Holyoke College
Lynk Summer Funding Program

Wellesley College
T.T. and W.F. Chao Summer Scholars Program in Natural Sciences

2022 Summer Research Program Students and Mentors

2022 Summer Research Program Students and Proctors

2022 Summer Research Program Seminars

June 23	Many voices, one song: Pathways and discoveries in a career in ornithology. *Scott Edwards, Harvard University*
June 30	From REU to R1 researcher: Stories of a conservation ecologist and the bees she studies. *Laura Figueroa, University of Massachusetts Amherst*
July 7	Seedlings, soil microbes, and tree diversity at Harvard Forest. *Fiona Jevon, Yale University*
July 14	Can we see sick trees from space? *Dan Johnson, University of Florida*
July 21	How does drought influence carbon movement in a plant? *Jess Gersony, Smith College* & Preserving STEM identity through affinity spaces. *Teressa Alexander, University of West Indies, Trinidad*

2022 Summer Research Program Workshops

May 24	Title IX Training. *Rachel DiBella, Harvard University*
May 26	Discussion of the Program Educational Activities & Tick App. *Audrey Barker-Plotkin, Harvard Forest; Isobel Ronai, Harvard University; Pilar Fernandez, Washington State University*
May 25, 27, 31 & June 2	Reproducible Research with R. *Sydne Record, Bryn Mawr College*
June 7	Writing and Peer Review of Research Proposals. *Audrey Barker-Plotkin, Harvard Forest; Emma Conrad-Rooney, Boston University*
June 9	Research Integrity. *Greg Llacer, Harvard University*
June 14	Reading Journal Articles Like a Pro. *Joe Tumber-Dávila, Harvard Forest*
June 28	Field Navigation. *Audrey Barker-Plotkin, Harvard Forest; Charlotte Malmborg, Boston University*
July 5	Science Communication. *Clarisse Hart, Harvard Forest*
July 12	Introducing the LTER Network. *LTER sites*
July 19	Presenting Your Research. *Savanna Brown, Harvard Forest*
July 26	Career Panel. *Nautica Jones, Harvard Forest; Christine Wilkinson, University of California Berkeley; Justin Cummings, University of California Santa Cruz; Stephen Decina, US State Dept.; Danielle Perry, Mass Audubon*
July 28	Data Archiving. *Audrey Barker-Plotkin* & *Emery Boose, Harvard Forest*

29th Annual Harvard Forest Student Symposium Schedule
August 4, 2022

10:00am Opening Remarks

10:15am Student Talks - Session I

Cristina Winters *Humboldt State University*	Forest Carbon Cycling Belowground: Changes in Root-Based Carbon Flux Under Warming Temperatures	24
Miranda Oseguera *Saint Joseph's University*	Non-Structural Carbohydrates' Transition from Starch to Sugar Signals Spring Leaf-Out in *Quercus rubra*	19
Riley Wolcheski *University of Connecticut*	Effects of Anthropogenic Activities on Ground Beetles Diversity: An Approach Using Intraspecific Trait Variation	25
Isha Chinniah *Mount Holyoke College*	[Joint presentation with above]	10

BREAK

11:30am Student Talks - Session II

Sean Fabrega *Mount Holyoke College*	Support for Collecting Data Provenance from RMarkdown Documents	11
Tatiana Perez *Bryn Mawr College*	Past, Present, Future: Seedlings as a Story	21
Aiyana Vazquez *Wellesley College*	March of the Oak: Influences of Eastern Hemlock Decline on Red Oak Seedling Mortality	23
Jordan O'Hare-Gibson *University of Massachusetts*	Examining the relationship between negative density-dependent factors and seedling mortality in *Tsuga canadensis* in a North American research forest	18

12:30pm LUNCH

1:30pm Student Talks - Session III

Lorelei Wolf *Harvard University*	Digging out the Root of the Problem: Understanding Hemlock Tree Mortality through Root Resource Allocation	26
Gabby Martínez *Xavier University*	Artificial Soil Warming Negatively Affects Mycorrhizal Colonization Rates and Root Respiration	17
Grace Shiffrin *Willamette University*	How much mortality is observed in the Quabbin Forest after a *Lymantria dispar* outbreak?	22

	Student Talks - Session III (cont.)		
Miranda Fernandez *Simmons College*		Assessing the Relationship Between Land Protection and Nature Loss in New England Through an Environmental Justice Framework	13
Rachel Carethers *Wellesley College*		Understanding Plant Relationships and Communities: Creating a Framework for Supporting Native Plants in Relation to Multiflora Rose	8
Santiago Alvarado *Rhode Island School of Design*		Understanding And Learning Community Relationships Between And With People: Indigenous Land Stewardship Practices, Methods of Care, and (Plant) People	7
	BREAK		
3:15pm	**Student Talks - Session IV**		
Ellie Kerns *Amherst College*		Forest regeneration: How the rate of forest biomass accumulation and diversity differ in harvested and unharvested plantation plots at the Harvard Forest	14
Maya Chandar-Kouba *Bowdoin College*		Trends of Aboveground Biomass Accumulation Between Different Forest Types at Harvard Forest	9
Jocelyn Fahlen *Columbia University*		Controls on Carbon Sequestration: From Climate to Atmospheric Deposition	12
Courtney Leung *University of Chicago*		Short-term iterative forecasting of carbon fluxes in Harvard Forest: validating and assessing soil respiration forecasts of the SIPNET model	16
Agustín León-Sáenz *Harvard University*		Modeling the Disturbance Effects of Major Hurricanes on New England Forest Carbon Under Varying Disturbance Magnitude Scenarios	15
Matthew Peña *Michigan State University*		Site Conditions Indicative of Successful and Unsuccessful Oak Regeneration	20
4:45pm	**Closing Remarks**		
5:30pm	**Community BBQ**		

Santiago Alvarado

Rhode Island School of Design

Mentors: Clarisse Hart, Nia Holley, Meg Graham MacLean, and Danielle Ignace

Understanding And Learning Community Relationships Between And With People: Indigenous Land Stewardship Practices, Methods of Care, and (Plant) People

We are a team dedicated to amplifying indigenous voices, working within the institution of Harvard. We are working in collaboration with Nipmuc community members, whose land Harvard Forest occupies, to identify land stewardship solutions involving Plant People who are considered invasive. Our pilot experiment's focus is working alongside the Nipmuc community to identify Plant People of cultural significance and learning about the community relationships of newcomers to this region, such as multiflora rose. We are observing plant communities of two native plants in soil conditions occupied by widespread multiflora rose (*Rosa multiflora*), whose ancestral homelands are Japan, Korea, and eastern China. Multiflora Rose was introduced by colonial land managers (in the 19th century), and since– has grown abundantly across Nipmuc territory, homogenizing open landscapes and displacing a diversity of culturally important plants. We collaboratively defined a research method involving planting seedlings of two native plants (which we will not name here out of respect to our Nipmuc colleagues), and growing them in pots containing multiflora rose soil or burned multiflora rose soil. We are coming from a place of understanding that all life is equal to each other and we honor the life of all Plant People, including those considered invasive because of colonial histories. With this understanding, we hope to reintroduce native plant communities, of culturally important Plant People, to live in relationship with non-native species on Nipmuc stewarded land. Nipmuc mentors have been core to the development of this research project and we look forward to sharing our results as we continue our work. Throughout our team's relationship with Nipmuc people, we have put marked emphasis on listening and learning what we can do for the living-resistance against colonial powers that continue to exist.

Rachel Carethers

Wellesley College

Mentors: Clarisse Hart, Nia Holley, Meg Graham MacLean, and Danielle Ignace

Understanding Plant Relationships and Communities: Creating a Framework for Supporting Native Plants in Relation to Multiflora Rose

This multi-year project is meant to center Indigenous knowledges and to proceed in cultivating a continuous and reciprocal relationship between Nipmuc people and the Amplifying Indigenous Voices team at Harvard Forest for the benefit of Nipmuc people. We explore what it means to be in kinship with a contrived category of non-native plants – presently known as 'invasive' in the western science framework – in relation to plants significant to Nipmuc people. The perceived threats/values of invasive plants vary drastically between western and Indigenous groups. In management, 'eradication'/'control' of invasive plants through the use of chemical controls is the most common practice, which is harmful to surrounding beings and the arability of land as chemicals persist. For our study, we created a pilot garden to observe community relationships between two native plants and the 'invasive' multiflora rose. Seedlings of the focal plants – state-listed herbaceous and woody perennials – were potted in soils occupied by multiflora rose: untreated vs. burned (in efforts to denature phytochemicals). We measured growth (height, foliage count, biomass). The final biomass will be measured from the harvested seedlings at the end of the pilot before the plants are returned to the nation. Thus far, plants in the untreated soil present an average foliage increase of 8.7%, and the burned soil 5.4%. These results can help inform how these plants can exist/be planted in relation to the widespread multiflora rose on Nipmuc land. The goal is to make culturally-significant species more abundant on traditional lands, inform land stewardship practices through Nipmuc knowledge and consensual collaboration, and to provide information applicable beyond this project.

Maya Chandar-Kouba
Bowdoin College

Mentors: Tim Whitby and Bill Munger

Trends of Aboveground Biomass Accumulation Between Different Forest Types at Harvard Forest

As global climate change accelerates, understanding the storage potential and future of carbon stocks has become a global priority. Terrestrial ecosystems have been identified as a necessary part of this process, as above-ground biomass (AGB) mediates CO_2 fluxes through long-term carbon storage. However, rates of AGB accumulation in forests can vary due to forest composition and age. Therefore, recent focus has turned towards quantifying the effects of maturation on carbon sequestration in forest carbon stocks. Trends of biomass accumulation in maturing forests appear to be quite general, with the rates of above ground biomass (AGB) accumulation increasing during early growth and decreasing as the forest matures. My research seeks to compare rates of AGB accumulation between different forest stand types at Harvard Forest. This was accomplished using the long-term Harvard Forest dataset, which collects dendrometer data from plots surrounding an Environmental Monitoring System (EMS) tower to construct trends of AGB of plots in mature forests. In addition, I aimed to identify the influence of tree mortality on trends of AGB accumulation in Harvard Forest, and whether mortality drives differences in the AGB trends between different forest stands. Mortality in the system was assessed by counting the tree death in each plot from 1988 to 2022, and supplemented by assessing the amounts and rate of coarse woody debris (CWD) inputs over time. Understanding how forest composition relates to AGB accumulation and the influence of mortality on these trends will allow researchers to better understand the carbon storage potential of Harvard Forest.

Isha Chinniah

Mount Holyoke College

Mentors: Isadora Fluck Essig and Sydne Record

Effects of Anthropogenic Activities on Ground Beetles Diversity: An Approach Using Intraspecific Trait Variation

Past land use disturbances can have prolonged effects on current biodiversity. However, the underlying mechanisms influencing these changes are yet to be understood. Here we used ground beetles (Carabidae) to model the relationship between past logging activities and changes in diversity through the process of interspecific competition. Ground beetle samples were collected using pitfall traps from ten plots at the Bartlett Experimental Forest NEON site. Spatial data were used to retrieve information on past logging activities at these plots. At each plot, body size measurements of every individual in a species were used to evaluate their intraspecific trait variation; overlap among species body size was then used as a proxy for quantifying community-wide competition. In addition, Shannon diversity index values were calculated at each plot. Finally, we fit a simple linear regression model to determine how much variation in interspecific competition (overlap) and richness could be explained by time since disturbance. Time since logging disturbance did not have a statistically significant effect on ground beetle diversity or overlap; however, a larger data set spanning multiple forested sites may provide greater power to detect an effect of time since disturbance on ground beetle diversity. Assessing how interspecific competition and diversity of ground beetles are influenced by past logging activities, can further provide insights into ecology and future conservation efforts.

Sean Fabrega

Mount Holyoke College

Mentors: Emery Boose and Barbara Lerner

Support for Collecting Data Provenance from RMarkdown Documents

Multiple STEM fields are experiencing a “reproducibility crisis” since many researchers cannot reproduce the results of previous work. Sometimes, this is because of lacking software and data availability. Data provenance, the information about how processing alters or uses data during exploration, addresses this issue by recording details about each processing step and the computing environment at execution time. Tools such as rdtLite, an R package developed at Harvard Forest and Mount Holyoke College, support data provenance collection of processes that use R. Two main types of files are used for data exploration in R, R scripts and RMarkdown documents. With RMarkdown, a user can embed code segments into a text document. These segments or “chunks” can be run individually or all at once, allowing for code organization into specific tasks and clearer annotations. Prior to my project, when rdtLite processed RMarkdown documents, they were converted into R Scripts and then provenance was collected on those generated scripts. Thus, the benefits of RMarkdowns, such as the “chunk-style” organization, were not used in provenance collection. In this project, a new method for provenance collection was added to rdtLite. Users can now request detailed provenance collection on specific chunks by adding “details = TRUE” to chunk headers. In addition, rdtLite’s visualization tool for displaying data exploration, provViz, captures chunk information to make the provenance more understandable. This method for collecting provenance from RMarkdowns allows users to specify chunks for detailed provenance collection, decreasing run time and capturing chunk information into the provenance.

Jocelyn Fahlen

Columbia University

Mentors: Emma Conrad-Rooney and Pam Templer

Controls on Carbon Sequestration: From Climate to Atmospheric Deposition

Temperate forests play an important role in the global carbon cycle as a net annual sink through carbon uptake and sequestration. However, temperate forests have varied in their ability to sequester carbon. Therefore it is crucial to understand the future potential of northeastern hardwood forests as carbon sinks. Remote sensing products are effective tools to monitor phenology, quantity, and activity of vegetation, and can be used to understand forest carbon capture. To further explore possible controls on carbon capture and remotely sensed metrics, we performed a series of univariate linear regression to determine whether factors like climate, temperature, and atmospheric deposition are significantly related to forest carbon capture. Throughout the course of the study, we found that the previous five years of atmospheric deposition of total N, SO_4^{2+}, Mg^{2+}, and Ca^{2+} exhibits a positive relationship with net ecosystem exchange. Annual deposition flux of Mg^{2+}, K^+, Cl^-, and Na^+ exhibited a strong relationship with Max EVI2, and annual N in NH_4^+ deposition exhibited a strong relationship to EVI2 area under the curve. Further analysis as to why annual nutrient deposition correlated strongly to remotely sensed metrics is needed to understand the impact of annual nutrient flux on forest greenness. Ultimately, this study contributes to remote sensing analyses, which are becoming an important aspect of ecological research as more satellite data are available for analysis purposes. This study will contribute to our understanding of remotely sensed metrics like EVI2, which hold great potential for future ecological research relating to forest productivity.

Miranda Fernandez

Simmons College

Mentors: Mayra Rodríguez González, Lucy Lee, and Jonathan Thompson

Assessing the Relationship Between Land Protection and Nature Loss in New England Through an Environmental Justice Framework

Access to open space and the development of natural areas are disproportionately distributed across the population according to factors of social marginalization, including income level, race, and levels of English proficiency. Existing data on trends of both forest loss and land protection indicate that individuals with marginalized identities are more likely to live in communities with less access to green spaces that are protected from development and are more likely to live in communities experiencing the highest levels of nature loss. However, less is understood about the relationship between these two phenomena. Understanding this relationship is an essential step in supporting the aims of environmental justice, which is a movement that seeks to address disparate exposures to environmental harms and unequal access to environmental benefits. We investigate (1) trends of nature loss and land protection in New England from 1990 to 2020; (2) how nature loss correlates to land protection (POS) in New England from 1990 to 2020; and (3) how these trends relate to key demographic variables. We used land cover and protected open space data available across New England to quantify nature loss and land protection at the census tract level. This data is joined to census tract level demographic data sourced from the American Community Survey Using a quartile approach, we compare % nature loss and % POS to environmental justice factors in each census tract. We expect that high forest loss and low land protection will co-occur in areas where marginalized communities are concentrated.

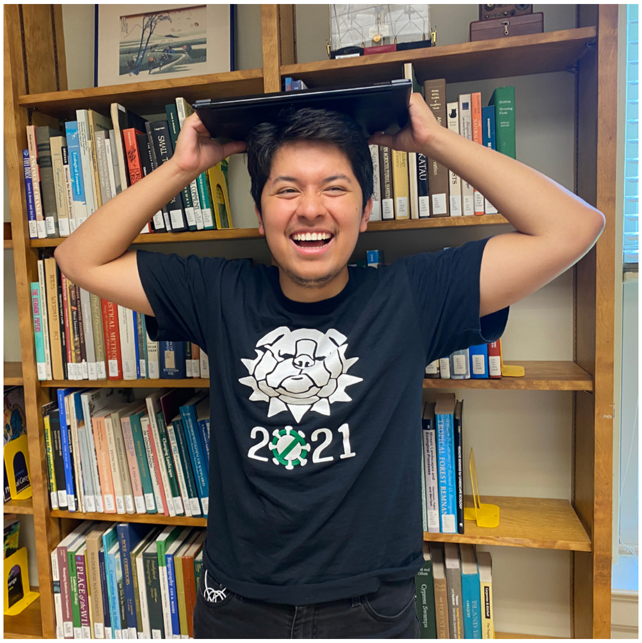
Ellie Kerns

Amherst College

Mentors: Greta VanScoy and Audrey Barker-Plotkin

Forest Regeneration: How the rate of forest biomass accumulation and diversity differ in harvested and unharvested plantation plots at the Harvard Forest

As anthropogenic forces continue to drive land-use change and forest harvest it is important to understand how forests respond to these disturbances. The widespread degradation of forests could have far-reaching impacts on diversity. Decreases in diversity could lead to a reduction in the forests' resistance to natural or anthropogenic disturbances. It is not well understood how rates of accumulation in forest biomass and diversity change as conifer plantations in central New England regenerate. Trends at the Harvard Forest suggest that old plantations are experiencing high mortality as they age. I investigate how biomass accumulation, basal area, and Shannon's diversity index differ in harvested and unharvested plots after 15 years. This is important in order to observe how forest diversity influences productivity across harvested and unharvested plantation plots. This study uses tree diameter at breast height (DBH) data for every tree over 2.5 cm taken at 22 plots 13 harvested and 9 unharvested) at the Harvard Forest Long Term Ecological Research (LTER) site in Petersham, MA. Additionally, this study accounts for the species richness and evenness of trees at each plot which will be used to calculate the Shannon's Diversity Index. My findings suggest an upwards trend of both biomass accumulation and basal area in harvested plots and a downwards trend in unharvested plots. There also appears to be an upwards trend of Shannon's diversity in both harvested and unharvested plots above pre-harvest levels, but harvested plots show a higher diversity overall.



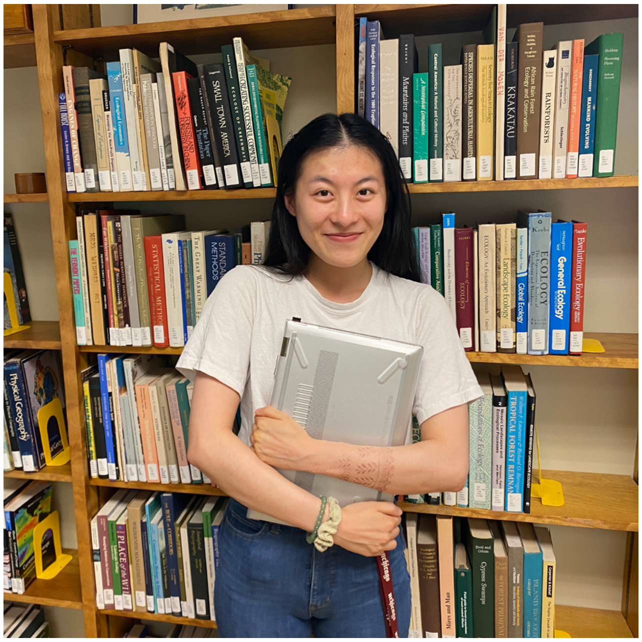
Agustín León-Sáenz

Harvard University

Mentors: Shersingh Joseph Tumber-Dávila and Emery Boose

Modeling the Disturbance Effects of Major Hurricanes on New England Forest Carbon Under Varying Disturbance Magnitude Scenarios

Climate change will likely impact long-term tree mortality patterns through wind disturbance. Thus, using the ten most damaging 20th century New England hurricanes as a baseline, we created models representing plausible hurricane damage scenarios for the 21st century: 1) no change in hurricane intensity; 2) a projected 8% wind speed increase; and 3) a maximum 16% wind speed increase. To model hurricane damage, we used National Hurricane Center data and implemented HurreconR and ExposR to create topographic exposure and hurricane damage maps based on 30-meter resolution digital elevation models. To model the wind susceptibility of trees, we designed a framework based on tree species and height, informed by previous tree mortality observations following major wind disturbances. We employed our tree mortality table to process Forest Service FIA (Forest Inventory Analysis) data and develop an understanding of New England forests based on an imputed FIA map. Finally, we paired the forests data from FIA with the hurricane damage maps to estimate the effect of hurricanes on New England forest carbon. The baseline scenario led to a loss of 1.2 million metric tons of aboveground forest carbon. A projected 16% wind intensity increase led to a roughly 4.8-fold increase in carbon loss compared to the baseline, or the removal of 5.9 million metric tons of carbon throughout the 21st century. Overall, southern New England is the most affected by hurricanes but wind intensity increases led to the heavily forested regions in central New England to have a greater increase in carbon loss.



Courtney Leung

University of Chicago

Mentors: Alexis Helgeson, Dongchen Zhang, and Mike Dietze

Short-term iterative forecasting of carbon fluxes in Harvard Forest: validating and assessing soil respiration forecasts of the SIPNET model

Temperate forests account for the majority of terrestrial carbon dioxide storage, and much of this carbon is stored below ground in the soil. However, there is much uncertainty in the carbon budget of these forest ecosystems, driving modeling efforts to quantify the fluxes of various carbon and water processes. In the past decade, near-term forecasting has become a potential method for performing short-term forecasts that can be readily validated and improved using real-time data. Much work is needed to evaluate these models' accuracy and sensitivity to the variables used to make sure predictions. In this study, I validated 35-day carbon-cycle forecasts generated using the SIPNET model against soil respiration data at Harvard Forest in 2021, comparing the predictions to NEON observations and assessing the model's sensitivity to model parameters and climate variables. I found that uncertainty, measured using RMSE and MAE, remains relatively constant until its observed increase at a lead time of around 18 days, when the model begins to underpredict soil respiration. Using CRPS scores, uncertainty initially decreases with forecast lead time and is generally highest for mid-day predictions of soil respiration. The SIPNET model is most sensitive to soil temperature, base soil respiration, and the soil respiration Q10 value. This suggests that the SIPNET forecast could be improved through a recalibration that includes the respiration data and the soil respiration basal rate and Q10 parameter. Future steps should also seek to include soil respiration observations in the daily data assimilation process to help improve iterative predictions.

Gabby Martínez

Xavier University

Mentors: Nikhil Chari, Thomas Muratore, and Serita Frey

Artificial Soil Warming Negatively Affects Mycorrhizal Colonization Rates and Root Respiration

As climate change increases atmospheric temperature, it is unclear whether soils will continue to act as a carbon (C) sink due to an increase in soil respiration and carbon (C) inputs. Fine roots and their associated mycorrhizal fungi are important drivers of soil C cycling. Mycorrhizal fungi aid roots in attaining nutrients by increasing root tip surface area. This is done either by extending their hyphae into the soil or forming a dense hyphal net on root tips. Once the fungi provide nutrients to the roots, they receive glucose from the plant. Earlier studies have asserted the existence of a mycorrhizal-associated nutrient economy for soils, but do not address the extent to which roots themselves can attain nutrients from soil, as not all root tips are colonized by mycorrhizal fungi. Here, we question how fine root structure and mycorrhizal fungi will respond to simulated soil warming and thereby control root respiration and exudation rates, two important factors of forest C cycling. Samples were collected from Barre Woods Soil Warming Experiment at Harvard Forest LTER. We hypothesize that soil warming will increase root respiration and exudation, but the amount will be managed by mycorrhizal fungi. We therefore predict that the regulators and mechanisms of root respiration and exudation under warming will be mycorrhizal specific. Results show a negative correlation ($R^2 = -0.1907$) between average percent of mycorrhizal-fungi colonized root tips and respiration rates (μmol CO_2 / g*s).

Jordan O’Hare-Gibson

University of Massachusetts Amherst

Mentors: Jackie Hatala Matthes and Sydne Record

Examining the relationship between negative density-dependent factors and seedling mortality in *Tsuga canadensis* in a North American research forest

Tsuga canadensis, Eastern Hemlock, is a coniferous tree native to North America. *T. canadensis* is also experiencing population decline due to a host-specific, negative density dependent factor — Hemlock Wooly Adelgid. This makes it a good model organism for examining the Janzen-Connell hypothesis in northeastern NA temperate forests. This presentation details a study in which the density of conspecific and heterospecific trees surrounding *T. canadensis* seedlings is examined in relation to seedling mortality rates throughout time and space on the Harvard ForestGEO megaplot. This study took place in the Harvard Forest in the northeastern United States, with data collection occurring in the summer months using 1x1m research plots set up along N-S transects. Results are consistent with the Janzen-Connell hypothesis, showing a statistically significant negative correlation between *T. canadensis* seedling establishment and the density of nearby mature conspecific trees. This relationship is likely due to Hemlock Wooly Adelgid spreading from mature trees to seedlings, thus inhibiting survivability. These findings may help inform the future of Eastern Hemlock at Harvard Forest.

Miranda Oseguera
Saint Joseph's University

Mentor: Meghan Blumstein

Non-Structural Carbohydrates' Transition from Starch to Sugar Signals Spring Leaf-Out in *Quercus rubra*

Each year the timing of leaf-out in our temperate forests, or phenology, is a critical transition point for carbon models as climates warm globally. A tree's leaves change the reflectivity of a plant. Thus altering the carbon and water cycle within the tree that connects to photosynthesis. Therefore, accurately predicting the timing of leaf budding in temperate species is essential to understanding climate change. It has been proposed that the movement and subsequent conversion of non-structural carbohydrates from starch to sugar is the initial signal in a tree branch for the tree to bud. Our project uses Northern Red Oak (*Quercus rubra*), as a model organism due to its vast range across eastern North America and abundance. Eight genotypes were selected and twigs were removed post-bud set in January 2022 and placed into twelve different treatments; 3 temperatures, extended chilling period or not, and 2 photoperiods. Twigs were collected at 6 phenophases, stored in a -80°C freezer then freeze-dried and ground to a powder. We extracted sugar and starch using hot ethanol and read samples via colorimetric assays. After, we examined how the percent of total NSC in starch changed with phenophase and treatment using linear models in R. Preliminary data hints the conversion of starch to sugar in warming climates triggers spring leaf-out in *Q. Rubra*. A better understanding of pathways used to move and convert NSC can better understand how genetics and environment contribute to phenology. A comprehensive understanding of the mechanism used for leaf-out can then be used for prediction models in tree phenology and global climate.

Matthew Peña

Michigan State University

Mentors: Charlotte Malmborg and Audrey Barker-Plotkin

Site Conditions Indicative of Successful and Unsuccessful Oak Regeneration

Oaks are one of the most important overstory trees in southern New England, but a recent spongy moth outbreak resulted in widespread oak mortality. The resulting openings in the canopy may allow oaks to regenerate, but viable (>0.5m) oak seedlings are often scarce, and heavy ground cover inhibits oak regeneration. Therefore, to assess regeneration success following the outbreak, I tested the role of canopy openness and ground vegetation on oak regeneration in sites that experienced varying levels of spongy moth damage. Data were collected at the Quabbin Reservoir in central Massachusetts, and 204 plots were randomly selected from a pool of 486 plots originally sampled in 2017. Data collection included tree diameter, oak seedling presence, and estimated percentage of ground cover, along with major species covering the ground. Analysis of the collected data showed that nearly 95% of plots included seedlings in the smallest size class (1.3m). It was also discovered that there is no correlation between oak regeneration and basal area. In regards to groundcover, we found that oaks in the middle size class were more prominent in recent timber harvest sites than anywhere else, regardless of harvest or invasion status. These results provide insight about what oak prominence in the region might look like in the future, and what we can do to manage for it.

Tatiana Perez

Bryn Mawr College

Mentors: Jackie Hatala Matthes and Sydne Record

Past, Present, Future: Seedlings as a Story

Tree seedlings are a window by which we can simultaneously see the past and future of the forest. In the Harvard ForestGEO plot, a long-term ecological research site, patterns of tree composition are heavily tied to land-use history. Because this history has been so well documented at the forest, then, the aim of my work is to connect the dots between this history and current seedling establishment patterns. Here, I invesitgate whether the next generation of trees will match these patterns or depart from them. Using seedling census data collected from 121 1mx1m plots around the 35 ha megaplot, I was able to link land-use history patterns to seedling survival of four major hardwood species (Red Oak, White Pine, Hemlock, and Red Maple). Seedling establishment patterns were consistent with historical land use observed across the mega plot, but seedling mortality was also linked to other environmental factors, including non-native insects and pathogen movement around the forest. Information about the effect of land-use history on the establishment of hardwood trees can be used, then, to understand how forests may continue to develop spatially. This information can also be used to forecast carbon sequestration metrics, allowing for a deeper understanding of how forests interact with climate change.

Grace Shiffrin

Willamette University

Mentors: Charlotte Malmborg and Audrey Barker-Plotkin

How much mortality is observed in the Quabbin Forest after a *Lymantria dispar* outbreak?

The 2016-2018 spongy moth, *Lymantria dispar*, outbreak in southern New England was the most severe outbreak in the region since 1980-1981. Due to the moth's preference for oaks, *Quercus*; these oaks are more heavily defoliated than other species, causing a significant ecological impact on the system as oaks are the dominant species in many New England forests. I analyzed oak mortality data that was collected at Quabbin Forest in Massachusetts from: 1) 204 plots sampled in 2017 and 2022; 2) Continuous Forest Inventory plot data from 1980-2020. The two most recent outbreaks had different forest species compositions and community structures; the 1980 outbreak was more widespread than the 2016 outbreak; however, both outbreaks had similar levels of severity. I predict that in the 2022 Quabbin survey, there will be higher mortality in sites that were more severely defoliated during the 2016-2018 outbreak. I found that Quabbin Forest had a higher mortality loss in the 2016-2018 outbreak compared to the 1980-1981 outbreak. As understanding past spongy moth outbreak damage is key to future outbreak analysis, these results will create a better understanding for future research.

Aiyana Vazquez

Wellesley College

Mentors: Jackie Hatala Matthes and Sydne Record

March of the Oak: Influences of Eastern Hemlock Decline on Red Oak Seedling Mortality

Persistent human interference and climate change are exposing tree species to new vulnerabilities and driving seedling migrations; however, the effect that pest invasions have on soil pH and on the success of migratory seedlings is not well understood. Changes to forest composition, especially due to increased pest infestations, like the introduction of Hemlock Woolly Adelgid on *Tsuga canadensis* (Eastern Hemlock) in northeastern temperate forests can disrupt soil quality regulation. Additionally, as the climate warms, seedlings like *Quercus rubra* (red oak) are migrating northwards where they encounter varying light and soil conditions impacting its success. We compare two Long Term Ecological Research (LTER) sites, Harvard Forest in Petersham, MA, and Hubbard Brook in Campton, NH, to examine (1) how seedling survival rates differ between the two sites with obverse hemlock presence; and (2) what stress, if any, does soil acidity and light availability apply on seedling survival. As a foundational species, *T. canadensis*, is an important regulator for soil, light, and heat in the understory. By using seedling census data collected from plots where seedlings were tagged and identified, we analyzed data to focus on plots with at least one red oak seedling, as well as selected plots with diverse hemlock presence, to sample soil pH. We expected that increasing presence of hemlock creates a more acidic soil environment and restricts incoming light, which may negatively impact the survival of red oak seedlings. This study can help improve our understanding of seedling mortality and its role in predicting future forest recovery.

Cristina Winters

Humboldt State University

Mentors: Nikhil Chari, Thomas Muratore, and Serita Frey

Forest Carbon Cycling Belowground: Changes in Root-Based Carbon Flux Under Warming Temperatures

Terrestrial soils are Earth's largest organic carbon sink; however, the effect that warming temperatures have on soil carbon cycling as it relates to roots and their mycorrhizal (fungal) associates is not well understood. Shifts in plant species composition under climate change, specifically in northeastern temperate forests (a critical U.S. carbon sink) may have significant consequences for soil carbon storage. Plant roots and their fungal associates regulate carbon flux belowground via root exudation (release of organic compounds into soil) and root respiration (release of carbon dioxide), and warming may affect both metabolisms uniquely. We investigate (1) how long-term soil warming alters the relationships between root exudation and respiration; and (2) if roots associated with different mycorrhizal types experience the change in the relationship between exudation and respiration differently. This is important as species composition in New England forests shifts toward a greater proportion of arbuscular-associated trees, especially maples. In forested plots that are warmed using buried heating cables, we took paired root exudation and respiration measurements from arbuscular- and ectomycorrhizal-associated tree species in response to long term soil warming at the Harvard Forest Long Term Ecological Research (LTER) site in Petersham, MA. Additionally, we measured the respiration levels of these fine root systems once exudate collection was complete. We expected the slope of the relationship between root exudation and respiration to increase under warming, indicating a greater proportion of root exudates immediately respired and potentially decreasing the total belowground exudate-based carbon storage. This could have ecosystem-scale consequences for total carbon storage.

Riley Wolcheski
University of Connecticut

Mentors: Isadora Fluck Essig and Sydne Record

Effects of Anthropogenic Activities on Ground Beetles Diversity: An Approach Using Intraspecific Trait Variation

Ecological diversity, the variation of organisms in an ecosystem, is necessary for society's well-being. Diversity can be measured functionally or taxonomically, and previous studies on functional diversity have focused on mean trait values for species. This focus inhibits the ability to consider processes that lead to niche partitioning such as competition. Body size is linked to an individual's use of resources in an ecosystem, thus making it a potential proxy for measuring a species' niche and the degree of interspecific competition. Soil-dwelling beetles can be used as indicators for long term changes in soil quality, which could give environmental scientists insight about the changing climate and increasing anthropogenic effects on the planet. This relationship allows carabids to become a potential proxy for biodiversity as well as richness across the continent during this time. We investigate changes in species functional and taxonomic diversity in response to human activity (distance from roads) using ground beetles (Carabidae) as a model system at the Bartlett NEON site in New Hampshire, USA. The Harvard Forest Hemlock Removal Experiment found that lower soil pH was linked to areas with lower beetle taxonomic diversity. Prior research in New England forests has also shown that soil pH declines with distance from roads. Thus, we expect that as distance from roads increases, beetle taxonomic diversity will decrease. As taxonomic diversity decreases, body size overlap will also decrease because remaining species will be able to more fully partition their niches through less competition for resources.

Lorelei Wolf

Harvard University

Mentor: Sophie Everbach

Digging out the Root of the Problem: Understanding Hemlock Tree Mortality through Root Resource Allocation

Hemlock woolly adelgid (*Adelges tsugae*) is a sap-sucking aphid species invasive to the northeastern United States and is decimating the ecologically important late-successional species eastern hemlock (*Tsuga canadensis*). The range and abundance of non-native herbivores are increasing in response to climate change, and native plants often lack the physiological defenses to survive infestation. Research on the aboveground tree response of eastern hemlock is abundant, but there is a lack of standardized study on belowground root response to infestation. Such research is necessary to document whole tree dynamics and to ultimately understand the mechanisms of tree death due to infestation. This study developed and tested protocols to collect and measure the roots of hemlock saplings and mature trees. We extracted whole saplings and collected square soil cores from four transects around mature trees. In the lab, we separated fine absorptive roots from thicker transport roots. Using the absorptive roots, we measured specific root length (m/g), carbon/nitrogen concentration, fungal colonization density, and starch concentration, comparing measurements across a range of adelgid infestation severity and between saplings and mature trees. We expect that root resource allocation will scale with infestation severity, and that mature trees will be more resource deficient than saplings due to length of infestation. Future studies should consider the use of these protocols to increase replicability and comparability across scales in more comprehensive whole-tree hemlock studies.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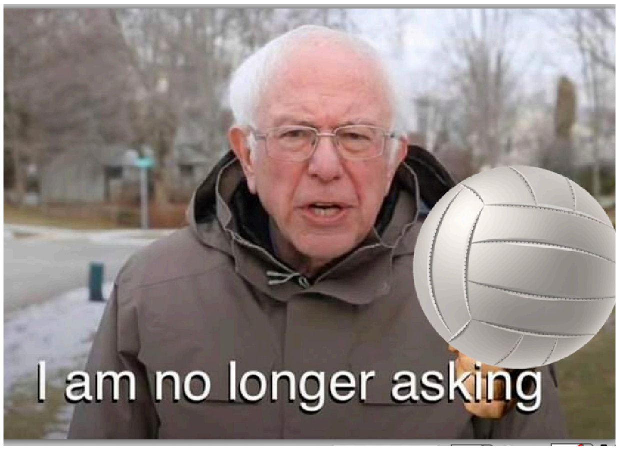

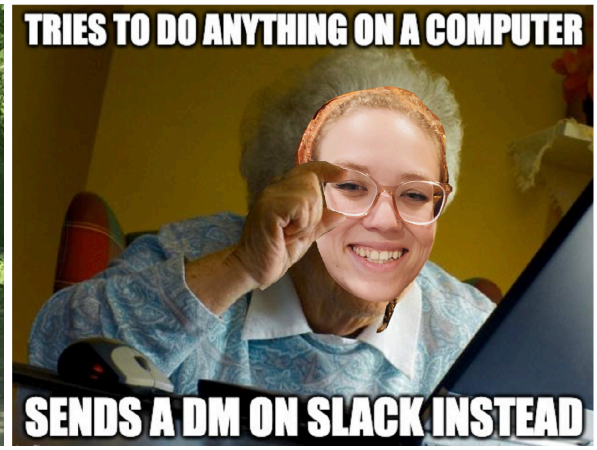

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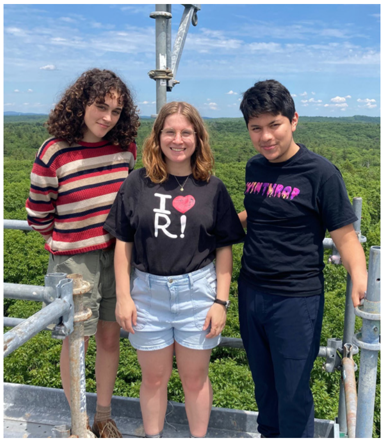



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