Harvard Forest Summer Research Program In Ecology

25th Annual Student Symposium

August 3, 2017

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Harvard Forest Fisher Museum
Petersham, Massachusetts

Photographs by Jill Fusco, Jenny Hobson
and 2017 Summer Research Program students
Cover photo by Aaron Ellison

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 and ecology. Through the years, researchers at the Harvard Forest have concentrated on forest management, the development of forest site concepts, the biology of trees, plant ecology, soil processes, forest economics, landscape history, conservation biology, and ecosystem dynamics.

Today, this legacy is continued by faculty, staff, and students who seek to understand historical and modern changes in the forests of New England and beyond. Their research has informed conservation and management as well as enhanced appreciation of forest ecosystems and their histories. 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).

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 spruce and maple swamps, fields, and diverse plantations. Additional land holdings include the 20-acre Pisgah Forest in southwestern New Hampshire (located in the Pisgah State Park), which had been a 300 year -old forest of white pine and hemlock when it was blown down in the 1938 Hurricane; the 100-acre Matthews Plantation in Hamilton, Massachusetts, which is largely comprised of plantations and upland forest; and the 90-acre Tall Timbers Forest in Royalston, Massachusetts.

In Petersham, a complex of buildings that includes Shaler Hall, the Fisher Museum, and the John G. Torrey Laboratories provide office and library space, laboratory and greenhouse facilities, and a lecture room 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 (FAS) of Harvard University. Faculty associated with the Forest offer courses through the Department of Organismic and Evolutionary Biology (OEB), the Harvard Kennedy School (HKS), and the Freshman Seminar Program. Close association is also maintained with Harvard University's Department of Earth and Planetary Sciences (EPS), School of Engineering and Applied Science (SEAS), School of Public Health (SPH), and Graduate School of Design (GSD). The Harvard Forest's affiliations outside of Harvard University include close ties with the University of Massachusetts departments of Biology, Natural Resource Conservation, and Computer Science; the Marine Biological Laboratory's Ecosystems Center; and the University of New Hampshire's Complex Systems Research Center.

The staff and visiting faculty work collaboratively to achieve the research, educational, and management objectives of the Harvard Forest. A management group meets monthly to discuss current activities and to plan future programs. Regular meetings with the HF-LTER science team, weekly research seminars and lab discussions, and an annual ecology symposium provide for an infusion of outside perspectives. The six member Facilities Crew undertakes forest management and physical plant activities.

ABOUT THE 2017 SUMMER RESEARCH PROGRAM

The 2017 Harvard Forest Summer Research Program in Ecology, directed by Aaron Ellison, with assistance from Manisha Patel (coordinator), and Jill Fusco (proctor), attracted a diverse group of students to receive training in scientific investigations and experience in long-term ecological research. All students worked closely with mentors on various research projects from field and laboratory experiments to computer based software and hardware development. The program included weekly seminars from scientists, a career panel, and a field excursion on land-use history. The Harvard Forest Summer Research Program in Ecology culminates in the Annual Student Symposium held on August 3rd, 2017, where students present their research findings to an audience of scientists, peers, and family.

2017 Summer Research Program Students & Mentors

2017 SUMMER RESEARCH PROGRAM SEMINARS AND WORKSHOPS

Seminars

Wed., May 31	Forest Walk *David Foster, Harvard Forest*
Wed., June 7	What is the latitudinal diversity gradient and why should we study it? *Klara Scharnagl, Michigan State University*
Wed., June 21	What to Expect When You're Expecting…Extinction *Michael Reed, Tufts University & Harvard Forest Bullard Fellow*
Wed., June 28	Bambi, Smokey Bear, and introduced enemies: biodiversity collapse within the Eastern Deciduous Forest Biome *Walter Carson, University of Pittsburgh & Harvard Forest Bullard Fellow*
Wed., July 5	Effects of the modern land-use regime on future New England forests *Matthew Duveneck, Harvard Forest*
Wed., July 12	Forecasting Ecology in a Changing World *Mike Dietze, Boston University*
Wed., July 26	Career Panel – Kristin Godfrey, *Field Operations Manager* - Domain 01 Northeast, National Ecological Observatory Network; Julie Marcus, *Director*, SWCA Environmental Consultants; Kyle Welsh, *Fish and Wildlife Biologist*, U.S. Fish and Wildlife Service Northeast Region

Workshops

Thurs., June 1, 8, 15	Programming for Reproducible Ecology in R (parts 1-3) *Matthew Lau and Luca Morreale, Harvard Forest*
Thurs., July 6	Programming for Reproducible Ecology in R Follow-up Session *Matthew Lau and Luca Morreale, Harvard Forest*
Thurs., June 8	Proposal Writing Workshop *Brenden McNeil, West Virginia University & Harvard Forest Bullard Fellow*
Tues., June 13 Wed., June 14	Talking Science with the Public (parts 1 & 2) *Clarisse Hart, Harvard Forest*
Wed., July 19	Scientific Presentation & Poster Workshop *Aaron Ellison, Harvard Forest*

FUNDING FOR THE 2017 SUMMER RESEARCH PROGRAM

The Harvard Forest Summer Research Program in Ecology in 2017 was supported by the following organizations:

National Science Foundation

REU Site: A Forest full of Big Data: the Harvard Forest Summer Research Program in Ecology 2015-2019 (DBI-1459519)

Collaborative Research: EAGER-NEON: Using Intraspecific Trait Variation to Understand Processes Structuring Continental-scale Biodiversity Patterns (EF-1550770).

Collaborative Research and NEON: MSB Category 2: PalEON - a PaleoEcological Observatory Network to access terrestrial ecosystem models (EF-1535623)

HFR LTER V: New Science, Synthesis, and Strategic Vision for Society (DEB-1237491)

SI2-SSI: Collaborative Research: Bringing End-to-End Provenance to Scientists (ACI-1450277)

Bryn Mawr College
Summer Science Research Program

Mount Holyoke College
Miller Worley Center for the Environment Summer Leadership Fellowship

Harvard University
Department of Organismic and Evolutionary Biology
G. Peabody "Peabo" Gardner Memorial Fund
Faculty of Arts and Sciences

25th ANNUAL HARVARD FOREST STUDENT SYMPOSIUM SCHEDULE

THURSDAY, AUGUST 3rd FISHER MUSEUM

	Welcome - Aaron Ellison	
9:15 A.M.	**Session I: Long Data and the Value of Data Provenance**	
Nicholas Patel *Swarthmore College*	White oak recruitment and growth trajectories	19
Caitlin Keady *Bates College*	The complexity of tree response to extreme climatic events in temperate forests	14
Connor Gregorich-Trevor *Grinnell College*	Data Provenance in R and Python Across Multiple Scripts	12
Jennifer Johnson *Middlebury College*	Collecting Provenance in Python	13
10:15 A.M.	**Session II: Science Communication through Installation Art**	
Salua Rivero *Miami Dade College*	The Falling Muse	20
	Break	
Installation Art Site Visit *Prospect Hill Tract*	Tour of Hemlock Hospice: Collaborative field based installation that blends science, art, and design *David Buckley Borden, Aaron Ellison, Salua Rivero*	
	Lunch	
1:00 P.M.	**Session III: From Soils to Trees**	
States Labrum *Columbia State Community College*	The Effects of Long Term Soil Warming on Soil Respiration and Carbon Storage	15
Sarah Pardi *Loyola Marymount University*	The Role of Manganese on Litter Decomposition Along an Oxic-anoxic Interface	18
Valentin Degtyarev *University of Massachusetts - Amherst*	Monitoring Transpiration with Automated Sap Flow Sensor System to Validate Ground-Based Synthetic Radar	11
Corey Carter *University of Minnesota - Twin Cities*	Evapotranspiration Observational Methods: A Comparative Analysis	10

25th ANNUAL HARVARD FOREST STUDENT SYMPOSIUM SCHEDULE

THURSDAY, AUGUST 3rd FISHER MUSEUM

	Session III: From Soils to Trees (continued)	
Jolene Saldivar *Humboldt State University*	Assessing phenological trends of deciduous trees at Harvard Forest and throughout the northeastern United States	21
Johnny Buck *Northwest Indian College*	Explaining what causes the intraspecific variation of phenological events of *Quercus rubra L.* and *Acer rubrum L.*	8
	Break	
2:45 P.M.	**Session IV: Invasion Ecology**	
Karina Martinez *California State University - Dominguez Hills*	Exotic earthworms and invasive garlic mustard (*Alliaria petiolata*) impacts on native plant diversity	17
Alina Smithe *Mount Holyoke College*	Grassland management practices: preserving biodiversity and preventing ecological invasions	23
Jerilyn Jean M. Calaor *University of Guam*	Effects of nitrogen fixers on grassland plant communities	9
3:30 P.M.	**Session V: Carbon Dynamics**	
Kalaina Thorne *Bryn Mawr College*	Body Size Abundance Relationships and Seedling Dynamics at Harvard Forest	24
Colleen Smith *Humboldt State University*	Light availability and size-abundance scaling of saplings at Harvard Forest	22
Molly Leavens *Harvard University*	Post-Harvest Carbon Dynamics: Assessing the climate implications of wood energy	16
4:15 P.M.	**Session VI: Ticks in Massachusetts**	
Aaron Aguila *University of Florida*	Prevalence of ticks in harvested versus unharvested forest plots	7
Aaron Ellison	Tick Study	

Aaron Aguila

University of Florida

Mentors: Audrey Barker Plotkin, Timothy Whitby, & J. William Munger

Group Project: Post-Harvest Carbon Dynamics, Forest Structure and Biodiversity

Prevalence of ticks in harvested versus unharvested forest plots

Climate and land-use change are contributing to the spread of tick-borne diseases such as Lyme disease from its native Northeastern United States range to other parts of the country. Although Lyme disease risk is known to be higher in fragmented forests, less is known about how tick abundance and disease presence responds to the early successional habitats and down dead wood created by timber harvesting. To fill this gap, we sampled ticks and forest structure attributes in partially harvested hardwood forests, fully harvested plantations, and unharvested controls in each forest type (n=8 plots for each of the 4 types). Ticks were sampled using a drag-flag sampling protocol set forth by NEON. Overall tick abundance was much higher in fully harvested plots ($p<0.001$) but this was largely driven by *Dermacentor variabilis* ($p<0.001$) which is not a Lyme disease vector. There was no significant difference in the abundance of the Lyme disease vector *Ixodes scapularis* ($p>0.05$). Further analysis will explore habitat structure variables in fully harvested plots that may correlate with greater tick abundance, and the *I. scapularis* ticks collected will be tested for the presence of the Lyme disease bacteria *Borrelia burgdorferi.* These results will be of importance to foresters and land owners interested in integrating disease prevention with forest management, public health agencies interested in predicting Lyme disease risk, and community members who enjoy spending time outdoors.

Johnny Buck

Northwest Indian College

Mentors: David Basler, Margaret Kosmala, & Andrew Richardson

Group Project: Explaining variation in the seasonal changes of trees

Explaining what causes the intraspecific variation of phenological events of *Quercus rubra L.* and *Acer rubrum L.*

It is important to improve our understanding of individual tree phenology strategies to increase our knowledge of the associations between vegetation canopy and the periodic changes of photosynthetic uptake of CO_2. To gain this insight, we looked at two dominant hardwood species (a ring porous and a diffuse porous) in the Harvard Forest (Petersham, MA), *Quercus rubra L. and Acer rubrum L.* From five different PhenoCam sites, I isolated and created individual masks for 24 *Q. rubra L.* and eight *A. rubrum L.* crowns. Information extracted from these masks were used to produce an individual Green chromatic coordinate (G_{cc}), that was utilized to identify seasonal phenology patterns and length of growing season. The trees masked were located out in the forest, cored and the diameter at breast height was recorded. In the tree lab, the cores were dated and the tree rings measured. Currently, tests are being conducted to measure variation of phenology patterns that will inform us of the range of days when we can expect *Q. rubra.* and *A. rubrum* trees to begin spring leaf out, their mean length of the growing season and range of days when we can expect their senescence to end. We are also testing to see if trees that have a longer growing season will have a greater growth rate, and test whether younger trees leaf out earlier than older trees. Due to the ambition of this project, results aren't currently available and will be shared at the Harvard Forest 2017 Summer Symposium.

Jerilyn Jean M. Calaor

University of Guam
Mentor: Martha Hoopes
Group Project: Invasion Dynamics at Harvard Farm

Effects of nitrogen fixers on grassland plant communities

With the abandonment of heavy agriculture in New England, reforestation threatens the unique habitat grasslands provide. Strategies for decreasing woody incursion remove biomass and may create a battleground for native and nonnative species. This study explores, observationally and experimentally, whether nitrogen fixers, like *Trifolium,* facilitate nonnative plants with negative effects on native species. At Harvard Farm, within a long-term study to assess the effects of cow grazing and mowing on plant communities, we surveyed plant species richness and cover in paired 1x1m plots with and without *Trifolium*. We found higher Shannon-Wiener diversity in *Trifolium* plots, but there were no significant effects on species richness except the addition of *Trifolium* itself. Percent cover of nonnatives decreased in the presence of *Trifolium*, but *Trifolium* appeared to have no significant effect on native species cover or richness. In the greenhouse, we explored the effects of soil type and plant litter by growing *Rumex acetosella,* an invasive plant, and *Oxalis stricta,* a native wildflower, in three soil types (potting, *Rumex*, or field soil) with four litter treatments (no litter, *Trifolium*, *Rumex* or general leaf litter). Growth of both species was highest in potting soil and lowest in *Rumex* soil. As for the effects of litter, growth was highest with no litter and lowest with *Rumex* litter. *Trifolium* litter had a positive effect on *Rumex* and a negative effect on *Oxalis* when compared to leaf litter. Unlike the field results, the greenhouse results suggest *Trifolium* may facilitate invasive species and have negative effects on natives.

Corey Carter

University of Minnesota - Twin Cities
Mentors: Xingjian Chen & Paul Siqueira
Group Project: Forest stand dynamics measured by an above-canopy automated robotic system

Evapotranspiration Observational Methods: A Comparative Analysis

The evapotranspiration moves water through soil, plants/animals and the atmosphere as it passes minerals and nutrients through a forest in its liquid, solid and gaseous forms. Our project involves using low-cost temperate probes to monitor sap flow movement in trees as a controlled comparison to Synthetic-Aperture Radar (SAR), which observes changes in the ambient magnetic field generated by sap/water movement. If successful SAR can replace conventional forms of tree-based sap flow monitoring and will be able to monitor larger areas. We will expand the number of probes deployed compared to last year's two, and build a more robust program to support these operations. Our sap flow sensor will be integrated into the Tram-Sites main tower at Prospect Hill and will allow for easy access to its power and Internet. The new software will allow the user to easily add more probes, edit list containing probes, generate data frames, plot data, back up data frames and export data to excel spreadsheets. This program allows for greater flexible, reproducibility, reliability and easier sharing of information with other communities. The software is holding up and is withstanding the rigors of field conditions and collection. Further use will highlight any minor flaws but no major flaws have been detected yet. More probes, improved hardware and robust software packages will lead to more data correlation and allows scientist to make conclusions on the viability of SAR compared to traditional sap probe methods.

Valentin Degtyarev

University of Massachusetts - Amherst

Mentors: Xingjian Chen & Paul Siqueira

Group Project: Forest stand dynamics measured by an above-canopy automated robotic system

Monitoring Transpiration with Automated Sap Flow Sensor System to Validate Ground-Based Synthetic Radar

Transpiration is a fundamental process which is crucial to a forest's growth and development through its cooling and distribution of nutrients to different portions of the plant. The engineers working with Harvard Forest's aerial tram site have developed two methods of collecting data on the flow of water through a forest's plants, soil, and atmosphere. One technique uses the Ground-Based Synthetic Radar to measure the water content of vegetation based on the dielectric properties of water. The second approach uses a Sap Flow Sensor System which analyzes the flow of sap within tree trunks. The overarching goal is to upgrade the previous Sap Flow Sensor System and enhance the reliability, consistency, and accuracy of both the data and the system itself. The system's power source was redesigned to be more durable and consistent, which will result in continuous data collection over a long period of time. The Sap Flow Sensor circuitry has been enhanced so that connecting multiple sensors over long distances would continue to produce accurate results. Once enough data has been collected, the next step is to find similarities between the two techniques to verify that both are effective ways of measuring the transpiration process within a forest. If the radar data shows a strong correlation to the Sap Flow Sensor data, then the Ground-Based Synthetic Radar could become an effective tool used by other researchers as a simple way of examining water content and forest health.

Connor Gregorich-Trevor

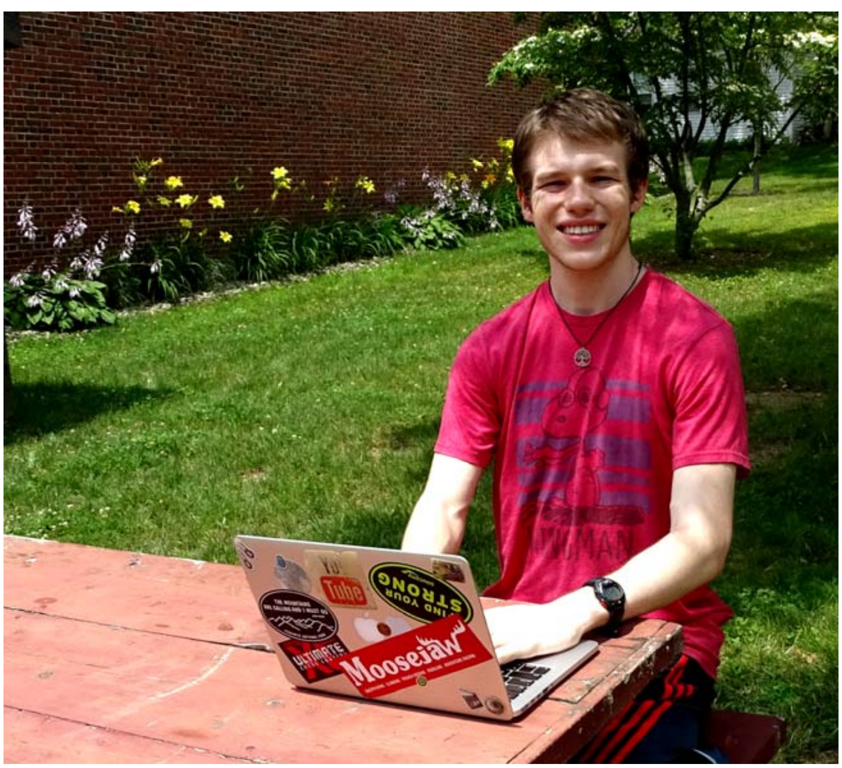
Grinnell College

Mentors: Matthew Lau, Emery Boose, & Barbara Lerner

Group Project: Data Provenance in R

Data Provenance in R and Python Across Multiple Scripts

New research often involves extending a previous scientific study. To do this, a scientist may need to recreate and modify the procedure or methods of an existing study in order to obtain results. Extension is important, since it is one of the foundations for research and increasing scientific knowledge. Scientific studies can contain information that is crucial to their replication and extension, such as how the data in the study were collected, the conditions under which they were obtained, and what processes and transformations they went through. These details and the complete history of data is known as data provenance. Many studies lack information about how their data were collected or processed, yielding little in the way of provenance and making them very difficult to replicate or verify the reliability of. In my research, I worked with Emery Boose, Barbara Lerner, and Matthew Lau on RDataTracker and DDG Explorer. RDataTracker is a program which captures provenance of programs and analyses run in the R programming language, and DDG Explorer creates visualizations of the program flow. I modified these programs so that they can be used to track data through workflows composed of multiple R and Python scripts by matching input and output files. With this new feature, scientists will be able to gather provenance when using a combination of different languages to interact with their data, as well as focus on provenance across multiple scripts, leading to greater transparency and easier replication.



Jennifer Johnson

Middlebury College

Mentors: Matthew Lau, Emery Boose, & Barbara Lerner

Group Project: Data Provenance in R

Collecting Provenance in Python

The reproducibility of results is an essential quality of scientific research. Reproducibility allows researchers to more easily verify results and expand on each other's work. However, data analyses often lack complete and high quality documentation, making them incomprehensible to other researchers, and sometimes even to the author. It is easy to forget the logic of a complex analysis. Data provenance is a detailed record of the processes performed in an analysis and greatly improves its transparency. Tools that collect provenance could help researchers keep projects organized for collaborators, reviewers, and themselves. The package RDataTracker collects provenance for R scripts, and the Java application DDG Explorer displays it as a Data Derivation Graph. However, R is not the only language used for data analysis. Python and R have different uses and strengths in data analyses, and can complement each other when used together. The goal of this project was to collect provenance for Python scripts in a similar manner to RDataTracker. This feature relies on an existing tool for collecting Python provenance, noWorkflow, developed by researchers at the Universidade Federal Fluminense in Brazil and at New York University. Their goal was to provide provenance for projects that do not use a workflow system for organization. In this project, noWorkflow provenance was converted into a format that is compatible with DDGExplorer. Because of the popularity of Python, a tool that collects Python provenance could be a first step to increase awareness of provenance and the value of reproducibility in scientific research.

Caitlin Keady

Bates College

Mentors: Matthew Lau, Emery Boose, & Neil Pederson

Project: Tree Response to Extreme Events Across Scales and the Use of Data Provenance

The complexity of tree response to extreme climatic events in temperate forests

Temperate forests in the northeastern US are experiencing greater temperature and precipitation variability, which potentially increases the occurrence of extreme events that could threaten plant communities. Using daily temperature and precipitation data, we investigate the consistency of tree response to climate across space and time and how it changes during extreme years. We compare climate response from 1964 to 2002 for several species present in central Massachusetts, Southwestern New Hampshire, Southern New York State, and the Adirondacks to identify years when trees are particularly sensitive to temperature and precipitation. Also, we use principal component analysis on narrow and wide ring years to describe climatic factors driving or limiting growth. In southern New York State, climate response reveals significant correlations with current summer temperature and precipitation during the first half of the 20th century, however that signal nearly disappears in the second half of the 20th century. From 1964 to 2002, climate response is weak across all sites, especially Harvard Forest. This is likely due to favorable growing conditions, possibly attributable to global climate change. In our analysis of extreme ring width years, 1991 is the most common narrow ring year across several sites and species, however there is no clear climatic variable limiting growth at that time throughout sites. This is true of several narrow ring years, highlighting the potential for site elevation, soil moisture, light availability, etc. to affect climate response. This study also stresses the importance of using daily data to reveal nuances in monthly climate response.

States Labrum

Columbia State Community College

Mentors: Michael Bernard, William Werner, & Jerry Melillo

Project: Disentangling the Factors Behind Thermal Acclimation of Soil Respiration Observed in a Long-Term Soil Warming Experiment

The Effects of Long Term Soil Warming on Soil Respiration and Carbon Storage

Soil organic matter (SOM) contains the largest carbon pool in the terrestrial ecosystem. As the earth warms, accelerated microbial respiration will increase the flux of carbon released from the soil into the atmosphere. Warming may result in a self-reinforcing feedback loop affecting climate - SOM decay accelerates due to increased microbial respiration, and soil organic carbon is transformed to atmospheric CO_2, which leads to further warming and decreased soil carbon storage. In the Prospect Hill Soil Warming Experiment, warming has increased annual carbon fluxes, but we noted a pattern of decreased soil respiration in the heated plots relative to the control at any given temperature, a phenomenon we refer to as thermal acclimation. To understand what drives thermal acclimation, we incubated soils in the laboratory, using heated and control soils separated by horizon at six temperatures. We observed relationships between temperature and respiration qualitatively similar to field data. We found a decrease in microbial biomass in heated soils explained much of the decrease in respiration relative to control soils. In a second set of incubations, we amended the soils with sucrose to remove potential substrate limitation, which further minimized the difference in respiration between the treatments. We conclude that the reduction in microbial biomass and substrate limitation are primarily responsible for thermal acclimation. Previous studies from the Prospect Hill experiment have provided evidence of functional and structural changes in the microbial community, leading us to hypothesize that those changes could explain the pattern of soil acclimation over the 26-year experiment.

Molly Leavens

Harvard University

Mentors: Audrey Barker Plotkin, Timothy Whitby, & J. William Munger

Group Project: Post-Harvest Carbon Dynamics, Forest Structure and Biodiversity

Assessing the climate implications of wood energy

In response to our conflicting needs to generate energy and reduce current levels of atmospheric CO_2, many have proposed wood biomass as a carbon neutral energy source. While carbon capture through forest regrowth theoretically balances the carbon emissions from burning wood, forest regrown takes time and the emitted CO_2 contributes to atmospheric warming during this delay. In addition, the wood harvesting process leaves many dead tree branches and stumps in the forest, and as this woody debris decomposes, it releases carbon back into the atmosphere. We aim to record the timescale of post-harvest temperate forest biomass accumulation and woody byproduct decomposition across two different forest management practices. We surveyed native hardwood forests with 25% biomass removal, former non-native conifer plantations with 95% removal, and unharvested controls for each treatment type. We used live tree and dead wood (stump, coarse woody debris, and standing dead) survey data from four time intervals: immediately before the harvests, immediately after, several years post-harvests, and 2017. The partially harvested plots grew more quickly than their unharvested counterparts and thus recaptured the removed carbon quickly. Although the clear-cut plantation plots grew at a slower rate than the partially harvested plots, the plantation control plots lost biomass due to canopy tree mortality. Changes in dead wood stocks were small compared to the live biomass, so contributed minimally to the overall carbon flux. These results suggest biomass energy can be sustainable for wood sourced from declining forests or partial harvests.

Karina Martinez

California State University - Dominguez Hills
Mentors: Erin Coates-Connor, Mercedes Harris, & Kristina Stinson

Project: Biological invasions, and plant and soil community responses under global climate change

Exotic earthworms and invasive garlic mustard (*Alliaria petiolata*) impacts on native plant diversity

Invaders in North American forests include a Eurasian duo; exotic earthworms and garlic mustard (*Alliaria petiolata*). Through its allelopathy mechanism, garlic mustard disrupts the relationships between mycorrhizal fungi and native plants. Earthworms facilitate the establishment of invasive species by reducing leaf litter and increasing nutrient availability. The invasional meltdown hypothesis states that positive interactions between two invasive species may facilitate invasions by impacting the success of native plants. Both allelopathic invasive plants and exotic earthworms can interact in the soil, thus intensifying changes in native plant communities. This study aims to answer the following questions: (1) Is there a relationship between plant diversity and earthworm density? (2) Is there a relationship between plant diversity and garlic mustard density? (3) Does earthworm biomass vary between experimental garlic mustard eradication treatments (invaded, non-invaded, hand pulled, and herbicide spraying (glyphosate, triclopyr, 2,4-D)? Preliminary results indicate that invaded control plots have higher earthworm mass than uninvaded plots and plots where garlic mustard has been manually pulled for four seasons. Studying the relationship between above and below ground invasive communities is important as it can enhance a better understanding of the ways invaders can interact and impact forest dynamics.

Sarah Pardi
Loyola Marymount University
Mentors: Morris Jones & Marco Keiluweit
Project: Linking forest soil Mn cycling to organic matter decomposition along oxic-anoxic interfaces

The Role of Manganese on Litter Decomposition Along an Oxic-anoxic Interface

Soils play an important role in carbon cycling, releasing three times more CO_2 emissions into the atmosphere than anthropogenic factors through forest floor litter decomposition. Studies have shown that manganese concentration is positively correlated to the rate of litter decomposition. Using extracellular enzymes such as oxidase and peroxidases, fungi can oxidize Mn^{2+} to Mn^{3+}, a soluble and potent oxidant that decomposes lignin. At present, the environmental factors influencing the rates of Mn^{3+} formation and its use in litter decomposition in soils are not known. Here we examined the oxidation potential and the forms of Mn along a soil moisture gradient. We hypothesized that Mn^{3+} concentrations would be greatest along oxic-anoxic interfaces. To test this hypothesis, we found that soils with intermediate moisture, characterized by clear oxic-anoxic transitions in the A horizon, had the greatest oxidative potential. Our results also showed that this soil layer had the highest concentrations of pyrophosphate extractable Mn^{3+}. Furthermore, the largest quantities of extractable soil organic carbon were generated in this horizon, indicating greater decomposition. Our results suggest that the potential for Mn^{3+} formation is most pronounced in the suboxic zone, where enhanced decomposition may be responsible for the production of soluble compounds. As precipitation and temperature patterns change in New England, soil moisture is gong to change as well. How climate change alters the natural Mn cycle will have to be taken into consideration if we want to estimate the soil carbon balance and predict the release of CO_2 in the future.

Nicholas Patel

Swarthmore College

Mentors: David Orwig & Neil Pederson

Project: Faith in Oak: White Oak Trajectories in the Greater Walden Pond Woods

White oak recruitment and growth trajectories

The prevailing view is that, despite white oak once being a dominant species prior to the arrival of Europeans, it is failing to recruit on most sites across the eastern United States. However, this phenomenon may only be apparent when considered on a short timescale. Understanding the drivers behind this "recruitment crisis" is essential to guiding effective management solutions to this situation. Three of the four sites we sampled in Massachusetts were even-aged, 120-140 year-old stands that are likely still in the stem exclusion phase of stand development, not unlike a majority of Massachusetts forests. We cored white oaks of all canopy classes and assessed local competition. We measured cores and crossdated them using COFECHA. We determined release events and disturbance history with the TRADER R package. Ages of trees with suppressed or intermediate canopy class indicate that these trees have persisted in the understory for an average of 125 years – with one persisting for up to 230 years – under high shade with low growth rates. PCA reveals that competition and disturbance history almost independently account for the majority of the difference in growth trajectories and current canopy position of white oaks from all four sites. Recruitment analysis reveals that 82% of trees were recruited into a canopy gap at all sites, suggesting that overstory gaps are required to stimulate successful regeneration. The "recruitment crisis" may therefore not be as severe in this region because the younger forests lack the large-scale canopy disturbance events that drive white oak recruitment.

Salua Rivero

Miami Dade College
Mentor: David Buckley Borden & Aaron Ellison
Project: Hemlock Hospice: Arts-based science-communication of a declining species at Harvard Forest

The Falling Muse

Eastern Hemlock (*Tsuga canadensis*) is currently on the decline because of the Hemlock Woolly Adelgid (HWA, *Adelges tsugae*). This microscopic insect has infested most of the Hemlocks in the Eastern United States, including the ones at Harvard Forest. This tree is a foundation species, which means that its decline will affect multiple animal, plant and human communities. To gain insight on this species and its decline, I collaborated with designer-in-residence, David Buckley Borden and senior ecologist, Aaron Ellison to create art installations that would represent the research results on the Hemlock and our thoughts about this declining forest stand. While creating these installations, I also created my own smaller, temporary installations which I photographed and wrote accompanying essays and poems to. I thought about our relationship to the Hemlock and our emotions towards its decline and created pieces that could contribute to the idea that we, humans, plants and animals, are connected to and affected by this species. The temporary installations were made with materials found in nature such as leaves, rocks, tree stumps, moss and seedlings while also using man-made materials found in the art studio such as aluminum tape, wooden boxes and spray paint. The materials themselves, put together, illustrate the idea of how we interact with nature and the completed photographed pieces represent how we interact with the Hemlock species and its ecological community.

Jolene Saldivar

Humboldt State University
Mentors: David Basler, Margaret Kosmala, & Andrew Richardson
Group Project: Explaining variation in the seasonal changes of trees

Assessing phenological trends of deciduous trees at Harvard Forest and throughout the northeastern United States

Phenology is the study of biological activities influenced by seasonal environmental changes. These changes drive ecosystem functions and services and have been found to be influenced by climate change. The methods for documenting phenology have expanded from ground observation to more advanced methods including digital repeat camera and satellite imagery. Additionally, citizen science programs have contributed observations to nationwide databases. I utilized Harvard Forest Long Term Ecological Research (LTER) and data provided by the USA National Phenology Network's (USA-NPN) citizen science project Nature's Notebook to examine the phenological trends of five deciduous tree species throughout the northeastern United States. I assessed the accuracy of predicting phenological events and the degree to which various abiotic factors influenced phenology. To predict leaf out dates, an accumulated growing degree day (AGDD) model was developed. The model gave an overall root mean squared error (RMSE) of 25.5% and mean absolute error (MAE) of 12.6%. Canopy position was found to significantly affect the timing of leaf out and leaf fall for trees located at Harvard Forest. Additionally, leaf fall showed less variability than leaf out throughout all USA-NPN sites. Finally, ANOVA and Tukey's HSD revealed varying degrees of significance for the timing of phenological events for species based on urbanization status. Overall, abiotic factors played significant roles in the timing of phenology for all species across all sites. As interest in phenology continues to increase, there is great potential for further integration of scientific and citizen science data to assess trends and predict future changes.

Colleen Smith

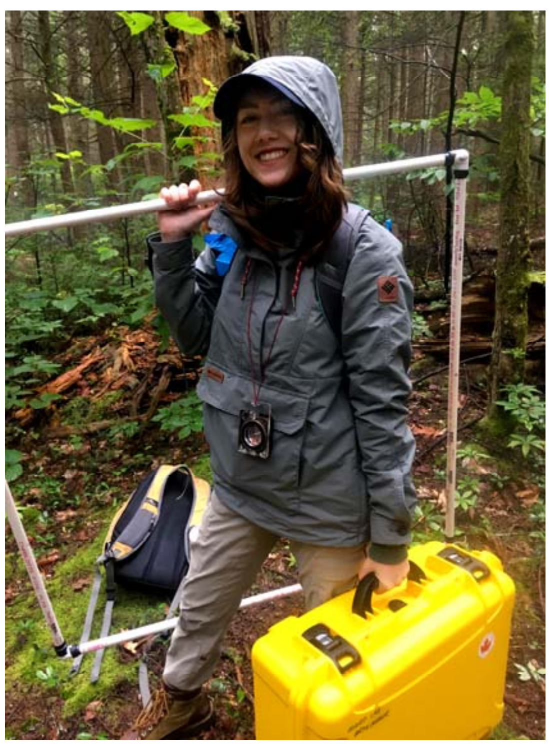
Humboldt State University

Mentors: John Grady & Sydne Record

Group Project: Functional traits and early National Ecological Observatory Network (NEON) data

Light availability and size-abundance scaling of saplings at Harvard Forest

Tree size is one of the most important predictors of metabolic rates and abundance, but many gaps in our understanding remain. In particular, the idea of energetic equivalence and the relationships between body size, abundance, and light availability in forest structures are not yet fully established. Energetic equivalence asserts that collectively small trees use the same amount of energy as larger trees due to their relative abundance. Few have studied energetic equivalence in forests, and there have been no studies to our knowledge that include stems under 1 cm in diameter that may be significantly affected by light limitations. The smallest and most abundant trees are missing from analysis. To address this gap, we censused saplings under 1 cm in diameter across 50 plots within the Harvard Forest Mega-plot and quantified light availability with the use of hemispherical photography. Solar energy is a main limiting factor for the abundance and growth of trees, varying with each species as their shade tolerance differs. We hypothesized that areas with limited light would have a lower total abundance than areas where light was not a limiting factor despite the assumption of energetic equivalence. We found that sapling abundance decreased in sites with lower levels of light availability as predicted. Using preliminary measurements of our most common species, we found an inverse correlation between diameter and abundance, providing support for energetic equivalence in smaller stems. Further research may be applied to various aspects of ecology including carbon storage, succession following disturbance, and beyond.



Alina Smithe

Mount Holyoke College

Mentor: Martha Hoopes

Group Project: Invasion Dynamics at Harvard Farm

Grassland management practices: preserving biodiversity and preventing ecological invasions

Vulnerable to infiltration by the ever-expanding New England forests, grassland ecosystems remaining from the footprint of agricultural land use are rapidly decreasing. Without conservation management, loss of many rare species is inevitable. Cattle grazing and mowing are biomass removal management strategies to protect grassland biodiversity through regular disturbance that prevents the growth of woody species. While mowing cuts plants all indiscriminately, cows have specific dietary preferences that may facilitate proliferation of certain invasive plant species. In the third year of a long-term study at Harvard Farm, we examined the impacts of these practices on plant communities by surveying the species in 10m x 10m plots distributed across three experimental treatments (continuous grazing, rotational grazing, and mowing), with two plot types (greens and fairways). Our results indicate that species richness is increasing in all treatment areas; however, the same is true for the abundance of invasive species and woody species. Because changes in plant community structure happen over time, the distinct effects of the treatments will become more interpretable in future years. To understand the spread of the invasive species, *Rumex acetosella*, we surveyed areas containing a high abundance of the plant and analyzed its potential allelopathic effects. Though we hypothesized that plots containing *R. acetosella* would contain more bare ground and fewer native species than nearby areas without the invader, we detected no significant trends. Because our results may have been limited by the observational design and small sample size, we also conducted a greenhouse experiment to investigate these effects.

Kalaina Thorne

Bryn Mawr College

Mentors: John Grady & Sydne Record

Group Project: Functional traits and early National Ecological Observatory Network (NEON) data

Body Size Abundance Relationships and Seedling Dynamics at Harvard Forest

Energy is used by all organisms to survive and grow, making it essential for life on Earth. Energy equivalence explains that total energy use among individuals of different size classes is the same, due to the relationship between body size and population abundance. Previous studies have found that abundance decreases with increased body size[1], and have proven that energy equivalence holds true for trees[2]. Small trees (<1cm Diameter at Breast Height) have been excluded from these studies, due to their high mortality and abundance, making them more difficult to study. To have a broader understanding of this size abundance relationship, we investigated seedling dynamics within Harvard Forest's 35 (500 x700 m) hectre megaplot. The aim of this study is to test size abundance models, with the combination of our seedling data and previous established tree data. Seedling abundance was found to decrease with increased individual heights, as expected. Combined data with trees of greater and less than 1 cm dbh also showed a negative relationship between diameter and abundance per size class. We have found that the inverse size abundance relationship is true for smaller seedlings, which is promising for future study on energy equivalence in forests, and will be useful for understanding more insights about forest stand dynamics.

[1] Damuth, John. "Population density and body size in mammals." *Nature* 290.5808 (1981): 699-700.

[2] Enquist, Brian J., James H. Brown, and Geoffrey B. West. "Plant energetics and population density." *Nature* 398.6728 (1999): 573.

PERSONNEL AT THE HARVARD FOREST - 2017

Ross Alexander	Lab Technician
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Emery Boose	Information Manager
Jeannette Bowlen	Accountant
Laurie Chiasson	Administrative Assistant
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Elaine Doughty	Research Assistant
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Kathy Fallon Lambert	Director of Science and Policy Exchange
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Brian Hall	GIS Specialist
Julie Hall	Assistant Data Manager
Clarisse Hart	Outreach and Development Manager
Jenny Hobson	Secretary
David Kittredge	Forest Policy Analyst
Oscar Lacwasan	Woods Crew
Matthew Lau	Post-Doc
Ronald May	Woods Crew
Marissa McBride	Post-Doc
Roland Meunier	Woods Crew
Alisha Morin	Accounting Assistant
Luca Morreale	Research Assistant
John O'Keefe	Museum Coordinator (Emeritus)
David Orwig	Senior Ecologist/Forest Ecologist
Julie Pallant	Information Technology and Archives Administrator
Manisha Patel	Lab Manager and Summer Program Coordinator
Neil Pederson	Senior Ecologist/Forest Ecologist
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Greta VanScoy	Museum Coordinator
Mark VanScoy	Field Instrument Specialist
Marissa Weiss	Science Policy Exchange Coordinator
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2017 SUMMER RESEARCH PROGRAM PROCTOR

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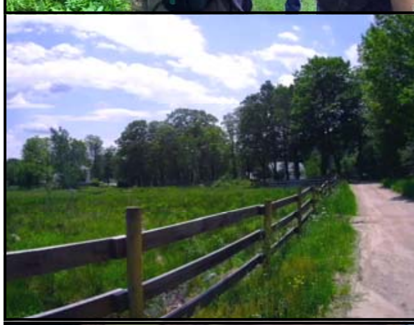
ARMY







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Menu ala Tim
FRENCH TOAST
CHIA PUDDING
EGGS
BACON
HOME FRIES
OATMEAL






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