Harvard Forest Summer Research Program in Ecology

27th Annual Student Symposium

August 8, 2019

27th Annual Harvard Forest Student Symposium

August 8, 2019
Harvard Forest Fisher Museum
Petersham, Massachusetts, US

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Photographs by John Tanner Horst, Roberto Carrera-Martínez, Alonwyn Clauser, and 2019 Summer Research Program students.

Cover photo Roberto Carrera-Martínez

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 five-member Facilities Crew undertakes forest management, supports research infrastructure, and maintains facilities.

In Petersham, a complex of buildings that includes Shaler Hall, the Fisher Museum, and the John G. Torrey Laboratory 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 2019 SUMMER RESEARCH PROGRAM

The Harvard Forest Summer Research Program in Ecology attracted a diverse group of students to receive training in scientific investigation and experience in long-term ecological research. The 2019 program was directed by the leadership team: Aaron Ellison, Director of the Program, and Audrey Barker Plotkin and Sydne Record, incoming Co-Directors. The program is managed by Manisha Patel with assistance from Roberto Carrera-Martínez and John Tanner Horst. All students worked closely with mentors on various research projects from field and laboratory experiments to computational science. The program included weekly seminars from scientists, a career panel, workshops, and field excursions. The Harvard Forest Summer Research Program in Ecology culminates in the Annual Student Symposium held on August 8, 2019, where students present their research findings to an audience of scientists, peers, and family.

2019 Summer Research Program Students, Mentors, and Proctors

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HARVARD FOREST

2019 SUMMER RESEARCH PROGRAM SEMINARS AND WORKSHOPS

Seminars

June 5	Exploring the ecological impacts of a novel land use: utility-scale solar fields. *Seeta Sistla, Hampshire College*
June 12	Using next-generation sequencing to understand the ecology and evolution of birds. *Scott Edwards, Harvard University*
June 26	If a rule falls in the forest, does it make a sound? Land systems and institutional ecology in Mexico, Miami and back again. *Rinku Chowdhury, Clark University*
July 10	Ecological Forecasting. *Mike Dietze, Boston University*
July 17 torical	Trace metals in terrestrial environments: ecosystem clues for some and his- problems to others. *Justin Richardson, University of Massachusetts - Amherst*
July 24	Career Panel. *David Boeri, WBUR; Kristin Godfrey, NEON; Stephen Leach, FirstLight Power; Heidi Ricci, Mass Audubon; Emma Sass, Family Forest Research Center*
July 31	Carbon export patterns in relation to diurnal and seasonal carbon and water dynamics in red oak leaves. *Jess Gersony, Harvard University*

Workshops

May 30	Discussion on Summer Program - Educational Activities. *Manisha Patel, Harvard Forest*
May 31, June 6, 13, 20	Reproducible Research with R (3 part series). *Sydne Record, Bryn Mawr College*
June 6	How to Write and Review a Research Proposal. *Meghan Blumstein, Harvard University*
June 13	Basics of QGIS. *Brian Hall, Harvard Forest*
June 18	Case Studies on Matters of Integrity for Undergraduate Researchers *Logan McCarty, Harvard University,*
June 20	Peer Review Panel on Research Proposals. *Summer Students, Harvard Forest*
June 27	Environmental Sign Making. *David Buckley Borden, Artist and Designer*
July 11	Reading Journal Articles like a Pro. *Meghan MacLean, Harvard Forest*
July 18	Communication Moments. *Clarisse Hart, Harvard Forest*
July 25	Field ID Walk. *Aaron Ellison & Audrey Barker Plotkin, Harvard Forest*
August 1	Presentation and Poster Workshop. *Aaron Ellison, Harvard Forest*

FUNDING FOR THE 2019 SUMMER RESEARCH PROGRAM

In 2019, the Harvard Forest Summer Research Program in Ecology 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)

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

HFR LTER VI: From Microbes to Macrosystems: Understanding the response of ecological systems to global change drivers and their interactions (DEB-1832210)

RCN-SEES: Integrating Land-Use Scenarios, Ecosystem Services, and Linkages to Society (Scenarios, Services, and Society - S3) (DEB-1338809)

Collaborative Research:

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

NERC: Addressing the plant growth source-sink debate through observations, experiment, and modeling (DEB-1741585)

Institutions

Bryn Mawr College

The Bryn Mawr College Summer Science Fund

Harvard University

Faculty of Arts and Sciences

G. Peabody "Peabo" Gardner Memorial Fund

Living Diorama Scholarship Fund

Reuben Tom Patton Scholarship Fund

Mount Holyoke College

Miller Worley Center for the Environment

Smith College

Danielle Ignace, Faculty Start-Up Fund

Wellesley College

Frost Endowed Environmental Science Studies Fund

McNair Scholars Program (P217A170092), U. S. Department of Education

27th ANNUAL HARVARD FOREST STUDENT SYMPOSIUM SCHEDULE

THURSDAY, AUGUST 8th FISHER MUSEUM

9:00 A.M.	Opening Remarks	
	Session I: Planning and Conservation	
Anna Therien *Westfield State University*	Focusing Regional Conservation through Local Town-Based Plans	31
Mattea Powers *Plymouth State University*	How land cover change analyses assist in conservation to reach the Wildlands and Woodlands vision	30
	Session II: Species Interactions	
Jaymes Marburger *Kent State University*	The effects of *Alliaria petiolata* (garlic mustard) extract on *Maianthemum canadense* (Canada mayflower) physiology	20
Audrey Kaiser *Keene State College*	Effects of *Alliaria petiolata* eradication on woody native seedling productivity	17
Concetta Ginevra *Florida State University*	Ant Diversity and Global Warming: How Air Temperature Affects Ant Diversity at the Harvard Forest	12
Brianna Alexis Martinez *Rutgers University*	Distribution and nesting characteristics of the thief ant species, *Solenopsis molesta* at Harvard Forest.	21

BREAK

10:45 A.M.	**Session III: Hemlock, Oak, and the Insects of Doom**	
Savanna Brown *Bowling Green State University*	The very hungry, lonely, and sick caterpillar: exploring pathogen occurrence within low-density populations of gypsy moth	7
Sofia Kruszka *University of Michigan*	Quantifying Death: Characterizing patterns of oak mortality in North-central Massachusetts in the aftermath of the most recent gypsy moth outbreak.	19
Emma Conrad-Rooney *Wellesley College*	Does Soil Nitrogen Increase Gypsy Moth Defoliation or Aid Tree Recovery?	9
Nathan Oalican *Harvard University*	Quantifying and Visualizing the Recent Decline in Hemlock Woolly Adelgid Population	27
Samantha Matson *Virginia Tech*	The future of eastern forests without hemlock	23
	Session IV: Data Provenance	
Khanh Ngo *Mount Holyoke College*	provExplainR: why does my R script return different results?	26
Erick Oduniyi *University of Kansas*	provBookR: Visualizing Data Stories	28

LUNCH

27th ANNUAL HARVARD FOREST STUDENT SYMPOSIUM SCHEDULE

THURSDAY, AUGUST 8th FISHER MUSEUM

1:30 P.M.	**Session V: Seedlings of the Megaplot**	
Alonwyn Clauser *Smith College*	Seedlings and energy equivalence: using CO_2 and light curves to find productivity	8
Eleanna Vasquez Cerda *Mount Holyoke College*	How many seedlings does it take to make a tree?	33
Brianna Nicole Martinez *Bryn Mawr College*	The Light of their Lives: Canopy Change and its Effect on the Seedlings of the ForestGEO Plot	22
Dayna De La Cruz *Wellesley College*	Effects of Environmental Biotic Factors on Seedling Survival	10
	Session VI: Forest Productivity	
Wiley Hundertmark *Boston University*	Analyzing Forest Edge Characteristics Using NEON's Airborne Observation Platform	16
Alexis Helgenson *Mount Holyoke College*	Understanding Spectral Reflectance in Deciduous Forests: From Leaves to Canopies	14
Ilana Vargas *Colorado State University*	Varying methods of Leaf Area Index measurements in temperate broadleaf forests of the Northeast	32

BREAK

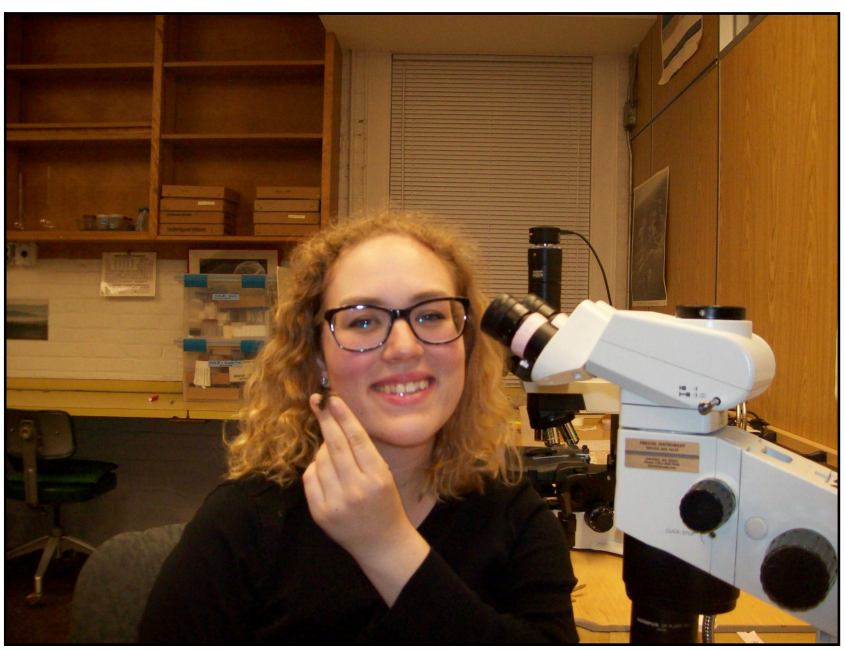
3:15 P.M.	**Session VII: Examining the Past**	
Turtle McCloskey-Potter *Southern Oregon University*	Understanding the impacts of historical land use change through sediment core analysis: Center Pond, Vermont	24
Tania Figueroa Colón *University of Puerto Rico, Mayagüez*	Quantifying flood magnitude from particle size characteristics of flood deposits in Amherst Lake, Vermont	11
Elise Miller *College of Saint Benedict*	Micro-Density Anomalies in White Pine: Distribution and Drivers	25
Elida Kocharian *Harvard University*	Carbon Sinks & Dendro Links: Cross-comparison of dendrometer & tree ring estimates of Net Ecosystem Productivity	18
Sophia Pitney *University of Wisconsin - La Crosse*	Climate Sensitivity in the Transitional Forest: A *Betula* Gradient Study	29
Danielle Holt *Portland Community College*	Limits to growth in *Carya ovata* due to climate and competition	15
	Session VIII: Science Communication	
Elicia Andrews *Quabbin Regional Highschool*	"Telling Climate Stories through Trees and Data Nuggets": An Educators Perspective	34
Shawna Greyeyes *Coconino Community College*	Witness Tree Social Media Project: Can We Increase Science Communication Engagement With A Twittering Tree?	13
Aaron Ellison	Tick Study Closing Remarks	

Savanna Brown

Bowling Green State University
Mentors: Joseph Elkinton, Audrey Barker Plotkin
Group Project: Hemlock, Oak, and the Insects of Doom

The very hungry, lonely, and sick caterpillar: Exploring pathogen occurrence within low-density populations of gypsy moth

Gypsy moth (*Limantria dispar*) has successfully invaded a large portion of North America in a matter of decades, damaging a variety of temperate forest tree species and costing billions of dollars annually in preventative and remediation costs. In 1989 a fungal pathogen native to Japan, *Entomophaga maimaiga*, was accidentally established in North America and may have fundamentally changed the population dynamics of gypsy moth. Although some data exists on pathogen dynamics in high-density outbreak systems, few studies have been done since the introduction of *E. maimaiga* to determine its role in preventing outbreaks and maintaining populations of gypsy moth at low densities. I performed a mortality analysis of gypsy moth larvae in 7 sites at the Quabbin Reservoir in Central Massachusetts in 2019, where after 2-3 years of outbreak populations, larval densities have declined considerably. In spring before neonates hatched, egg mass density was recorded as a proxy of population density at each site. Recording larval mortality and cause of death allowed us to observe if *E. maimaiga* played a unique role among several contemporaneous pathogens and parasitoids in maintaining equilibrium in low density populations. Analysis of larval mortality using marginal attack rates indicated that larval mortality from *E. maimaiga* was proportionally higher in populations with lower egg mass densities. Additionally, of the mortality agents tested, rate of infection by *E. maimaiga* was most strongly correlated with beginning egg mass density of each population.



Alonwyn Clauser

Smith College

Mentor: Danielle Ignace

Group Project: The future of the Harvard Forest - Tree seedlings of Prospect Hill

Seedlings and energy equivalence: Using CO_2 and light curves to find productivity

The global carbon cycle is the movement of carbon between the atmosphere, oceans, land. Human carbon emissions continue to increase the concentration of CO_2 in our atmosphere causing unpredicted repercussions. Global models used to predict these changes to our ecosystems are not yet complete. Forest ecosystems are the least understood and seedlings are generally discounted in carbon models because of their high mortality rate, however seedlings' metabolism and biomass contribute to ecosystem carbon fluxing by photosynthesising and respiring. The energy equivalence theory states that population energy flux is independent of body mass; to test this theory I asked: How do dominant seedling species differ in their photosynthetic capacity? How do seedlings differ compared to older trees? I measured the photosynthetic capacity of seedlings by collecting CO_2 and light curves using the LI-COR 6400XT. These curves were taken at Harvard Forest (Petersham, MA) with four species: red maple (*Acer rubrum*), red oak (*Quercus rubra*), white pine (*Pinus strobus*), and eastern hemlock (*Tsuga canadensis*). We also harvested tissue samples of the individuals for future analysis of carbon and nitrogen content, as well as water use efficiency. I expect there will be significant differences in the photosynthetic capacities of seedlings and mature trees. With my results, I can inform models to include these changing processes and allow for better and more accurate models to be made. These models would be used to help find the global carbon budget and predict the effects of climate change on our ecosystems.

Emma Conrad-Rooney

Wellesley College
Mentors: Jackie Matthes, Audrey Barker Plotkin
Group Project: Hemlock, Oak, and the Insects of Doom

Does soil nitrogen increase gypsy moth defoliation or aid tree recovery?

Trees' critical roles in forest ecosystems are threatened by disturbances such as insect outbreaks. Invasive gypsy moth caterpillars (*Lymantria dispar*), introduced to New England in the mid-1800's, defoliate trees, which can result in mortality. Nitrogen is critical for plant recovery from defoliation and is also critical for the defoliators. I am investigating whether oak leaf nitrogen content correlates to soil nitrogen, whether there a relationship between soil nitrogen and gypsy moth defoliation intensity, and how soil nitrogen contributes to tree recovery from defoliation.

Twelve red oak (*Quercus rubra*) street trees in Amherst, MA were monitored for percent defoliation. In ten plots in the Quabbin Reservoir watershed that had a range of defoliation intensities, trees were assessed for dieback. Soil samples of the organic horizon were collected from around the Amherst trees and in the Quabbin plots, and leaves were collected from the Amherst trees in 2018. Processed samples were run through an elemental analyzer to measure percent carbon and nitrogen in organic soil and oak leaves.

Results indicated a positive correlation between soil and leaf nitrogen content ($p = 0.36$), less herbivory for trees with higher foliar N levels ($p = 0.27$), and more dieback after defoliation in areas with less soil nitrogen ($p = 0.16$). This study suggests that higher nitrogen promotes oak resistance to, and recovery from, gypsy moth defoliation. These results can inform predictions of the northeastern U.S. forests' ability to act as carbon sinks that help to mitigate climate change.

Dayna De La Cruz

Wellesley College
Mentors: Fiona Jevon, Jackie Matthes
Group Project: The future of the Harvard Forest - Tree seedlings of Prospect Hill

Effects of environmental biotic factors on seedling survival

The species identity of neighboring adult trees may affect seedling growth and survival by influencing the level of herbivory or pathogen load that seedlings experience. Our experiment tests the Janzen-Connell hypothesis which states that tree seedlings are more likely to survive under a heterospecific adult tree (HAT) rather than under a conspecific adult tree (CAT), due to the presence of species specific herbivores and pathogens near adults conspecifics. Our goal is to understand mechanisms that connect to patterns in biodiversity and quantify the impact that biotic factors have on seedling survival within the Prospect Hill of Harvard Forest. We tested the effects conspecificity and species evenness have on transplanted seedling survival in White Pine (*Pinus strobus*), Red Pine (*Pinus resinosa*), Northern Red Oak (*Quercus rubra*) and Norway Spruce (*Picea abies*) in 60 plots during the summer of 2019. Overall, 91% of the White Pine, 27% of the Red Pine, 94% of the Norway Spruce and 84% of the Red Oak survived. Seedlings (particularly Red Pine) survived at higher rates under HATs than under CATs. Red Oak seedlings under CATs typically exhibited greater leaf damage than Red Oak seedlings under HATs. Although the differences were not significant, all species had a higher survival under even plots than under uneven plots, suggesting that intraspecific seedling competition may matter for seedling survival over a longer period of time. This study provides useful information about the drivers of mortality in temperate forest seedlings, allowing for better predictions about the future demographics of temperate forests.

Tania Figueroa Colón

University of Puerto Rico, Mayagüez
Mentors: Timothy Cook, Noah Snyder
Group Project: Reconstructing landscape change in New England from lake sediments: interaction of humans, vegetation, climate change, and extreme weather

Quantifying flood magnitude from particle size characteristics of flood deposits in Amherst Lake, Vermont

Clastic sediment layers in lakes are often the result of erosion in watersheds upstream and transport by rivers. This project focuses on the clastic sediment that is deposited in Amherst Lake, Vermont, and is aimed at determining the grain size of the clastic sediment, how it varies through the lake, and whether such deposition is related to flood magnitude and frequency. Sediment cores and samples collected in June from the river delta and across the lake were analyzed using particle size analysis, loss on ignition, and x-ray scan. By conducting GIS-based analysis, the area of active landslides in the watershed has been identified from historical aerial photographs from 1942, 2011, and 2016, indicating an increase from 5,978.12 m^2 to 23,846.93 m^2. Estimates of flood discharges were derived for flood deposits associated with Tropical Storm Irene in August 2011, and events on June 30, 1973 and April 15, 2019. Additional sediment observed in cores collected in 2019 and not present in cores from 2013 reveals continued deposition of clastic sediment related to the 2011 Tropical Storm Irene flood. The difference in max particle size (i.e. D90) between proximal and distal cores appears to provide a reasonable estimate of flood magnitude for the most extreme floods, 271.63 m^3/sec for Tropical Storm Irene, and 217.88 m^3/sec for 1973 flood. However, it appears to overestimate discharges associated with moderate floods since it estimated a discharge of 127.52 m^3/sec for April 2019 flood.

Tania Figueroa Colón (right) and research partner Turtle McCloskey-Potter (left).

Concetta Ginevra

Florida State University
Mentor: Aaron Ellison
Project: The Ants of the Harvard Forest

Ant diversity and global warming:
How air temperature affects ant diversity at the Harvard Forest

This study aims to determine whether there is a correlation between the rising global temperature and ant diversity at the Harvard Forest in Petersham, Massachusetts. Because ants are so abundant and thrive in a wide variety of environments, they are easy to study and provide a vast amount of information about the ecosystems around them. Ant population changes could trigger other species' populations to change as well. This study utilizes data from the Fisher Meteorological Station at Harvard Forest to determine if the climate of Harvard Forest follows the global warming trend. Once determined that the data do in fact follow the same trend, previously collected ant data were analyzed to determine the ant species diversity (number of unique species collected) for each year between 2003 and 2019. The data analysis revealed a positive correlation between air temperature and ant species diversity ($r = 0.27$).

Concetta Ginevra (front) and researcher Sydne Record (back).

Shawna Greyeyes

Coconino Community College
Mentors: Clarisse Hart, Tim Rademacher
Project: The witness tree: telling real-time environmental stories through one wired oak

Witness Tree Social Media Project: Can we increase science communication engagement with a twittering tree?

Social media platforms have strengthened the relationship between science and society by providing easy access to scientific information in a free-choice learning environment. Twitter is a popular science communication platform that encourages communicators to make the often invisible elements of science visible – removing a key barrier to trust in and understanding of science. The Witness Tree Social Media Project uses real-time and historical data to formulate posts sent to Twitter. Multiple sensors (sap-flow sensors, dendrometers, and cameras) are installed on and around the tree and are complemented by research towers to contextualize tree-based sensor data. Combined, the suite of sensors and related datasets tell environmental stories that are contextualized historically for the tree and its environment. The content treatment varies the narrative approach: 1) a data-driven message that incorporates specific sensor-based information (often numeric) from the tree - based on the knowledge deficit model and 2) a narrative message that excludes specific sensor data and is written with an audience-centered science communication approach. An additional multimedia treatment includes or excludes a piece of multimedia assigned to the post. Public engagement analytics will be used to quantitatively analyze the number of clicks, likes, shares, and comments each post – and its associated treatments – receives. We hypothesize that posts with a narrative message will receive a higher engagement than simple data driven messages. Furthermore, we hypothesize that multimedia posts will outperform text-only posts.

Alexis Helgeson

Mount Holyoke College
Mentors: Leticia Lee, Mark Friedl
Group Project: Controls on Forest Productivity

Understanding spectral reflectance in deciduous forests: From leaves to canopies

Forest productivity depends on many different variables including which tree species live in a forest (Humagain *et al.* 2017). Remote sensing technology uses spectral signature analysis to estimate the upper canopy tree demography of a forest (Kotlarz *et al.* 2016). The spectral signature of a tree is the unique reflectance of the tree compared to the known light spectrum (Cerasoli, Costa e Silva & Silva 2016). The spectral signature of leaves is an indicator of biophysical differences between tree species such as size, chlorophyll content, and water content (Zarco-Tejada *et al.* 2000). Other studies demonstrate that the spectral signature of a tree varies depending on the tree species (Zhao *et al.* 2016). However, most of these studies were done using satellite remote sensing data as opposed to field collected data. This study evaluated field spectral measurements of red oak and red maple trees at the Harvard Forest research site in Petersham, MA to compare the spectral signature within and between tree species. This study compared field-collected data within and between the red oak and red maple species using a separability analysis and a principal component transformation in R to better understand the differences in tree spectral signatures. The red oak and red maple spectral differences correlated with the biophysical differences in the leaf properties. Cementing our understanding of tree species spectral signatures will lead to improvements with remote sensing technology and allow researchers to more easily collect and interpret existing data.

Danielle Holt

Portland Community College
Mentors: Tessa Mandra, Neil Pederson
Project: Decades to Centuries: What is Happening Inside Transitional Forests at the Harvard Forest?

Limits to growth in *Carya ovata* due to climate and competition

Both climate change and the ongoing shift in forest composition due to changes in land use can have a dynamic impact on the growth of Shagbark Hickory (*Carya ovata*). While several studies have investigated Shagbark's response to light patches and canopy accession strategies, little attention has been paid to how climate, canopy position, or stand density simultaneously or independently impact growth. In this study I used a combination of field survey data, tree-ring records, competition indexing, and time-series analysis to investigate how these factors impacted two populations of Shagbark Hickory near a poleward limit at the Harvard Forest in Massachusetts. I found that Shagbark Hickory growth is positively correlated to total June, July, and August precipitation, negatively correlated to June and July maximum temperatures, and positively correlated to average minimum February temperatures. While trees in the overstory or understory were both sensitive to summer precipitation, overstory *C. ovata* growth was more negatively impacted by extreme summer temperatures than understory trees. Additionally, the sensitivity to February minimum temperature has decreased in recent years, which is likely caused by increasing winter temperatures due to climate change. 1953 and 1954 were marker rings with extreme damage, followed by a growth release, likely caused by a tornado and late frost event. These rings indicate Shagbark is vulnerable to extreme cold events, and able to respond rapidly to stand disturbance. Understanding how Shagbark Hickory responds to climate, competition, and disturbance will help predict which factors will decide Shagbark Hickory's success in this region.

Danielle Holt (front-right) with mentor Neil Pederson (back-center).

Wiley Hundertmark

Boston University
Mentors: Lucy Hutyra, Jonathan Thompson
Group Project: Controls on Forest Productivity

Analyzing forest edge characteristics using NEON's airborne observation platform

As forests are converted to developed uses, the remaining forest matrix is increasingly fragmented, influencing growing conditions and nutrient cycling towards forest edges. Measuring the resulting edge effects on forest ecosystem properties *in situ* is expensive and time-intensive. Remote sensing may present a more efficient method of characterizing edge effects on a larger scale. This research utilizes hyperspectral data and orthographic imagery from the NEON Airborne Observation Platform, which annually collects 1 m^2 resolution data over the Harvard Forest in Petersham, Massachusetts. Various indices, including the normalized difference nitrogen index, leaf area index, and water band index are computed and compared to soil moisture and productivity data collected *in situ*. The remotely sensed data show some patterns in canopy properties with proximity to forest edge; however, large interannual variability among remote measurements obscures the edge signal and offers a significant challenge in linking calculated indices with *in situ* data. A larger dataset of coincident remote- and ground-based measurements may allow for a more accurate linkage.

Audrey Kaiser

Keene State College

Mentors: Chloe Thompson, Michelle Jackson

Group Project: Invasive plant driven responses to global climate change across a latitudinal gradient

Effects of *Alliaria petiolata* eradication on woody native seedling productivity

Alliaria petiolata is a biennial, noxious weed that is invasive in the United States. This allelopathic plant negatively impacts fungal mutualisms within the soil that aid in plant productivity. Due to lack of post-management monitoring, the effects of *A. petiolata* eradication on native plant communities are unclear. This study examines the effects of *A. petiolata* management methods on community trajectory using the productivity of woody native seedlings. An *A. petiolata* eradication experiment was previously conducted by the Stinson Lab at the McLennan Reservation in Tyringham, MA from 2014 to 2017. Plots were manually and chemically eradicated of garlic mustard, with invaded and uninvaded plots serving as controls. Soils from these plots were sampled, and woody seedlings larger than 2 cm were measured weekly to document productivity. Species within chemically treated plots had a significantly greater average height than species within manually removed and invaded plots ($p \leq 0.05$). Of the functional groups (trees, vines, and shrubs), tree seedlings were the tallest across treatments. Trees in plots treated with chemical application were significantly taller than invaded plots, and plots treated with manual removal ($p \leq 0.05$). In conclusion, chemical application yielded the most productive growth of native species. The findings from this study can be used to influence restoration and management practices in ways that will benefit both the affected ecosystems and native species. Future research should include long-term observation of glyphosate impact on canopy species specifically, to further clarify the implications of garlic mustard management on native plant restoration.

Elida Kocharian

Harvard University
Mentors: Timothy Whitby, J. William Munger
Project: Years to Decades: Cross-comparison of annual tree growth using band dendrometers and tree core ring widths

Carbon sinks & dendro links: Cross-comparison of dendrometer & tree ring estimates of net ecosystem productivity

The Harvard Forest Environmental Measurement Site, the longest running eddy flux tower of its kind, has been measuring Net Ecosystem Productivity (NEP) in the temperate red oak- and red maple-dominant transitional forest since 1992 and has documented it as a strong carbon sink. However, eddy flux measurements of NEP and biomass inventories derived from dendrometer band measurements of above-ground woody increment (AGWI) don't match up perfectly, indicating an unaccounted source of error in measuring annual tree growth. Cross-comparison of dendrometer measurements to annual growth rings offers a robust chronology of inter-annual growth that can be compared against tower data to understand how age and size distributions in the forest impact carbon cycling patterns over time. Monthly dendrometer band increment measurements from 600 trees of varying species, age (42-124 years), and size (10-70 cm DBH) in 34 plots in the Prospect Hill tract of Harvard Forest were compared with ring-width measurements derived from tree cores of a random subsample of 60 trees representative of the distribution of size and species in the plots. Basal area increment from the two methods were linearly correlated with a slope very close to 1 ($p < 0.001$, $R^2 = 0.49$). We intend to compare NEP estimates with environmental variables and carbon sequestration in trees to better understand what drives patterns in tower estimates of NEP. Understanding how carbon is stored inter-annually in forests affected by climate change will inform models of climate response across the terrestrial biosphere and improve knowledge of physiology and phenology of dominant tree species.

Elida Kocharian (front) and Sophia Pitney (back).

Sofia Kruszka

University of Michigan
Mentor: Audrey Barker Plotkin
Group Project: Hemlock, Oak, and the Insects of Doom

Quantifying death: Characterizing patterns of oak mortality in North-Central Massachusetts in the aftermath of the most recent gypsy moth outbreak.

The oak genus *Quercus* is an important species group in the eastern United States, supporting an array of wildlife and contributing nutrients to terrestrial and aquatic ecosystems. Larvae of the invasive gypsy moth *Lymantria dispar* from Europe and Asia defoliate oak tree species, and the weakened oaks are subsequently vulnerable to other forest insects and pathogens. A recent gypsy moth outbreak from 2015-2018 defoliated over 900,000 acres in Massachusetts at its peak in 2017. Despite widespread gypsy moth defoliation in Massachusetts, oak mortality varies among adjacent stands. I investigated the extent of oak mortality in the aftermath of this gypsy moth outbreak. I measured and assessed tree mortality and dieback in ten 0.12-hectare plots in North-central Massachusetts. With this data, I ran linear and logistic regression models to determine the variables that most closely predicted tree condition. I found that a combination of species, plot, canopy exposure, and trunk diameter most significantly predicted mortality of trees of all species (AICc(null) = 670.95, AICc(mod) = 531.88). For oaks, canopy exposure and plot most significantly predicted mortality (AICc(null) = 255.14, AICc(mod) =219.12). Canopy exposure and trunk diameter did not closely relate to dieback for *Quercus* species, which is not consistent with previous findings. These results suggest that the dynamics between gypsy moths, oaks, and forest conditions of this outbreak are different from past events.

Jaymes Marburger

Kent State University

Mentor: Michelle Jackson

Group Project: Invasive plant driven responses to global climate change across a latitudinal gradient

The effects of *Alliaria petiolata* (garlic mustard) extract on *Maianthemum canadense* (Canada mayflower) physiology

Invasive species are thriving under global climate change where nitrogen concentrations and soil temperatures are rising and projected to increase. A limited amount of research has been done on the physiological responses of invasive plants. This knowledge is crucial for making predictions about future biogeographical shifts of invasive species and their potential contribution to changes in community composition/ecosystem services. *Alliaria petiolata* (garlic mustard) is an allelopathic invader dominating forest understories throughout the U.S. This herbaceous plant is believed to be augmented by climate change, thus enhancing its ability to disrupt the arbuscular mycorrhizal fungi (AMF) of native plants. Obtaining a liquid extract from *A. petiolata* that has been subjected to soil warming and nitrogen treatments, we exposed the native perennial *Maianthemum canadense* (Canada mayflower) to these allelopathic chemicals firsthand. Using a LI-6400, we were able to discern that *A. petiolata* extract alone reduces the average photosynthetic rate of *M. canadense* ($p < 0.05$), but *A. petiolata* extract from plants with added nitrogen increased mean *M. canadense* photosynthesis ($p < 0.05$). The result that *A. petiolata* can inhibit the physiology of native plants matches previous research findings. However, the increased photosynthetic rate of *M. canadense* from *A. petiolata* exposed to additional nitrogen may be due to the loss of AMF through this treatment while gaining extra nutrients instead. Our results indicate that further research should be conducted to explore the role of possible AMF loss and clarify the indirect effects of *A. petiolata* on the physiology *M. canadense*.

Brianna Alexis Martinez

Rutgers University
Mentor: Aaron Ellison
Project: The Ants of the Harvard Forest

Distribution and nesting characteristics of the thief ant species *Solenopsis molesta* at Harvard Forest

Ants play an essential role in countless ecosystems, from being crucial nutrient cyclers to aiding in seed dispersal. Many species are adapted to live in very diverse environments, so their impact can be seen worldwide. One of these cosmopolitan species is *Solenopsis molesta,* of which little is known about its ecology. This project aimed to lessen that information gap, through the study of *S. molesta*'s nesting habits. Ten plots were sampled in open field areas, one in a home, and searched through for *S. molesta*. When this species was found, the location and characteristics of its nests were observed for type of shelter, as well as the size of it. *Solenopsis molesta* was found a majority of time under moss and rocks of varying sizes. *Solenopsis molesta* nests were not found under moss or rocks less than 3.5 cm^2 or greater than 27 cm^2. There is a clear favorable shelter size in which *S. molesta* colonies choose to make their home. This factor, in addition to nesting in or near another species of ant habitat from which to steal, are limiting components of nest selection. These environmental conditions limit the abundance and distribution of the species.

Brianna Nicole Martinez

Bryn Mawr College
Mentors: Paige Kouba, Sydne Record
Group Project: The future of the Harvard Forest - Tree seedlings of Prospect Hill

The light of their lives:
Canopy change and its effect on the seedlings of the ForestGEO plot

External conditions such as environmental factors affect any organism's ability to grow and survive. Many biotic and abiotic factors contribute to a tree's growth, such as insect infestation, light abundance, and water availability. Healthy hemlocks (*Tsuga canadensis*) and red oaks (*Quercus rubra)* populations are dwindling because of infestation of harmful insects. Because these trees are abundant in forests, Hemlock wooly adelgid and gypsy moth are a major threat to forest ecosystem dynamics by weakening eastern hemlock and defoliating red oak populations, respectively, over time. Due to these phenomena, the canopy in areas with dense populations of these species are predicted to thin, affecting the competitive environment on the forest floor. Seedling census was conducted in subplots of the ForestGeo plot in Harvard Forest to determine the growth and survivorship of eastern hemlock and red oak seedlings as a result of changes in the canopy. To determine how much the canopy has changed, hemispherical canopy photos were taken in the same plots as the seedling census, and light levels were quantified. Using a Tukey's Honest Significant Difference Test, we found there is significant difference in percent canopy openness across the three-year timespan of our study ($F_{2,316} = 16$, $p < 0.0001$). In the same time period that the amount of eastern hemlock and red oak seedlings, which are light intolerant, decreased. We will use Integral Projection Models to project the future growth and survival rate of seedlings to better understand forest ecosystem dynamics.

Samantha Matson

Virginia Polytechnic Institute and State University
Mentor: Audrey Barker Plotkin
Group Project: Hemlock, Oak, and the Insects of Doom

The future of eastern forests without hemlock

Eastern hemlock (*Tsuga canadensis*) is a foundation species native to eastern deciduous forests that provides ecosystem services including microclimate control, stream stabilization, and biodiversity. The invasive insect, hemlock woolly adelgid (*Adelges tsugae*), is spreading across the Northeast US and Appalachia, killing hemlock trees and stands and subsequently altering the composition and structure of the forest. Prior work in Southern New England has shown that shade intolerant and hardwood species such as black birch are replacing the hemlock forests. Using long term regeneration data and sapling height measurements from the logged and girdled treatments of Harvard Forest's Hemlock Removal Experiment, I examined four emerging understory trees for relative abundance and rate of growth over time. Unsurprisingly and across both treatments, black birch is by far the most numerous and tallest, while pine density is steadily increasing over time. In the girdled treatment, black birch heights are lower than in the logged treatment. The heights of white pine are closer to black birch in the girdled treatment. Annual growth (internode length) measurements in pine show steady rates each year in the girdled treatment while they are declining in the logged treatment. This data supports the idea that pine will take part in the future canopy of this forest, at least in the girdled plots. By continuing with this research, we will be able to test these predicted changes in forest dynamics of New England's forests without hemlock.

Turtle McCloskey-Potter

Southern Oregon University
Mentors: Timothy Cook, Noah Snyder
Group Project: Reconstructing landscape change in New England from lake sediments: interaction of humans, vegetation, climate change, and extreme weather

Understanding the impacts of historical land use change through sediment core analysis: Center Pond, Vermont

The post glacial lakes of New England can provide records of how land use changes have influenced biogeochemical processes through the analysis of lacustrine sediment deposits. This project investigates the sensitivity of the Center Pond watershed in northern Vermont to disturbances associated with land use changes resulting from Euro-American settlement in the 18th and 19th centuries. This research provides insightful information regarding how New England watersheds respond to anthropogenic disturbances. Radiocarbon dates were used to create a geochronology for the cores spanning nearly 2500 years, and changes in the productivity and biogeochemistry of the Center Pond watershed were analyzed across this record to assess the impacts of land use change. Increases in carbon-nitrogen ratios (C:N) and iron-manganese ratios (Fe:Mn) in cores after approximately 1800 suggest environmental disturbances in the watershed, likely related to land clearing by Euro-American settlers. However, a clear increase in erosion as a result of these disturbances is not obvious; clastic sediment layers in cores occur during a period of decreasing human disturbance as revealed by Geographic Information Systems (GIS) analysis. Historical aerial photos indicate a decrease in cleared land from 18.25% in 1942 to 1.67% in 2016. Discrete clastic deposits during this period may correlate to historical floods. Despite a significant decrease in the intensity of anthropogenic disturbances and the widespread reforestation of the region, it appears that the lake has not returned to its pre-disturbance state.

From left to right: Turtle McCloskey-Potter, mentor Timothy Cook, and research partner Tania Figueroa Colón.

Elise Miller

College of Saint Benedict

Mentor: Tim Rademarcher

Project: Seasons to Years: Wood Formation in Trees

Micro-density anomalies in white pine: Distribution and drivers

Wood density determines the amount of carbon absorbed; however, while we are starting to understand normal seasonal variation in wood density, anomalies are common and their drivers are poorly understood. In conifers, wood density normally increases continuously throughout the season, but intra-annual reductions in wood density can occur and have been linked to climatic events. What exactly causes these fluctuations in density at the micro-scale, hereafter referred to as micro-density anomalies, is still debated. Micro-density anomalies are mainly studied in the Mediterranean and boreal forests where their formation has been linked to droughts. Mesic regions are also experiencing more droughts, but micro-density anomalies are rarely studied in these ecosystems. This study examined micro-density anomaly distribution within the bole of white pine (*Pinus strobus*) in central Massachusetts and its relationship with climate. Cores were taken from 41 young white pines at 1.5m in Tom Swamp, a tract of the Harvard Forest with additional samples taken along the bole. Rings were measured using the Tree Ring Index and Analysis Database (TRIAD), cross-dated, and micro-density anomaly presence was recorded. For the first time, we show the existence of micro-density anomalies in mesic ecosystems. Micro-density anomalies were consistently distributed longitudinally but not around the circumference. Even in this mesic ecosystem, micro-density anomalies were related to particular drought events. With predictions of future increases in drought and weather extremes, a mechanistic understanding of the drivers of wood density at the micro-scale is needed for accurate understanding of carbon sequestration in the future and thus climate.

Khanh Ngo

Mount Holyoke College
Mentors: Elizabeth Fong, Emory Boose, Barbara Lerner
Group Project: The Fruits of Provenance

provExplainR: Why does my R script return different results?

One common way for a scientist to increase transparency in their scientific work is to archive their data and scripts, which contain all analytical and computational steps to yield final results. However, this information alone might not be enough to reproduce a result when scripts are rerun on different occasions or shared with other collaborators, for example due to differences in hardware and software. One solution is to collect data provenance, which is the record of all elements that contribute to a piece of data, including its intermediate values, operational dependencies, and computing environment. In this project, we support reproducibility by helping scientists find differences between two provenance collections using a package we built called provExplainR. The package inspects provenance collected by rdtLite, reports changes to the provenance, and then offers suggestions or explanations for why the results are different. Factors under examination included the hardware and software used to execute the script, versions of attached libraries, use of global variables, modified inputs and outputs, and changes in main and sourced scripts. Based on detected changes, our tool can be used to study how these factors affect the behavior of the script and generate a promising diagnosis of the causes of different script results. This in turn should help scientists reproduce scientific analyses and provide rewards for those who collect data provenance.

Nathan Oalican

Harvard University
Mentor: Audrey Barker Plotkin
Group Project: Hemlock, Oak, and the Insects of Doom

Quantifying and visualizing the recent decline in hemlock woolly adelgid population

The persistence of eastern hemlock as a major constituent of eastern North American forests is currently threatened by hemlock woolly adelgid (HWA), an invasive sap-feeding insect native to East Asia. HWA infestation results in complete or near complete mortality of affected hemlock stands. However, fluctuations in HWA density may affect hemlock survival. This study assesses the current population of HWA through a rigorous census of over 3,000 hemlock trees in nine plots at the Harvard Forest in Petersham, Massachusetts. In addition, this study utilizes ground-based hemispherical photography and aerial imaging from Landsat 8 to determine if plot-level findings can be scaled to a regional level. The census found that HWA is present in significantly fewer trees in 2019 than in 2014. The decline in HWA coincides with the spread of elongate hemlock scale, an invasive insect which similarly feeds on hemlock needles and may compete with HWA for needle space. As part of the census, hemlocks were visually assessed for vigor. Between 2014 and 2019, average change in tree vigor was statistically insignificant. However, during this time period the most frequent category of tree vigor measurements improved from 25-50% foliage loss to less than 25% foliage loss. This suggests that over the time period, Hemlock mortality due in-part to HWA infestation still occurred, though there was a widespread foliar recovery for mildly afflicted hemlocks in response to decreased adelgid presence.

Nathan Oalican (left) and research team member, Greta VanScoy (right)

Erick Oduniyi

University of Kansas

Mentors: Elizabeth Fong, Emory Boose, Barbara Lerner

Group Project: The Fruits of Provenance

provBookR: Visualizing data stories

How scientific results come to be is the product of various domain-specific, economic, historical, social, and technical factors. As a consequence, information about how these factors shaped and produced these results is essential to both artistic trade and scientific reproducibility. Whether these results are material or digital, provenance provides the historical accounts of objects: paintings, bones, essays, scientific tables, and plots. Using the idea of provenance and the associated tools that collect provenance, we develop an R package that presents visualizations of provenance for R scripts. This tool is called provBookR, and it allows users to get the history of single R data objects (e.g., plots, scientific tables, variables). provBookR accomplishes this by utilizing previously developed R provenance tools. In particular, provBookR relies on RDataTracker (rdtLite) to record provenance generated from scripts in R, provGraphR for querying the collected provenance, and provParseR for processing the provenance. As a result, provBookR is capable of recording and generating presentations of data provenance from individual R data objects, which users specify through a browser interface. The presentation done by provBookR is in the form of digital booklets called provbooks — interactive web pages created from R. The motivation for provBookR's booklet interface is to produce a document with familiar appearance containing the data provenance and animations of the data provenance. The animations and visualizations represent the various data manipulations of the respective data objects. In doing so, provBookR affords scientists and programmers a visual aid for understanding and reproducing scientific analyses and results in R.

Sophia Pitney

University of Wisconsin - La Crosse
Mentors: Tessa Mandra, Neil Pederson
Project: Decades to Centuries: What is Happening Inside Transitional Forests at the Harvard Forest?

Climate sensitivity in the transitional forest: A *Betula* gradient study

The forecasted impacts of climate change in the Eastern U.S. are highly variable, including shifts in species composition, significant dieback and mortality, or little to no change. This uncertainty is especially prominent at the Harvard Forest in New England, which is located in the tension zone where two major forest types meet. Three *Betula* species- *B. papyrifera* and *B. alleghaniensis* prominent in the north, and *B. lenta* prominent in the south- coexist in the Transitional Forest. This provides a unique opportunity to study climate sensitivity within one genus. In this study, I used dendroecology and PRISM climate data to investigate two different landscapes (flat and mesic; slope and dry) in order to understand how these species are responding to climate and competition. Trees from different canopy positions ranged in age from 60 to 140 years. While cross-dating, all three species exhibited missing and false rings, which made dating a problem. *Betula* species have highly individualistic responses to climate. We found that *B. papyrifera* in the flat, mesic site is negatively correlated with summer temperatures minimums, while in the dry, slope site is positively correlated with march precipitation. *B. lenta* on the slope site is negatively correlated with June temperature maximums, and *B. alleghaniensis* on the mesic site is positively correlated with summer PDSI (Palmer Drought Severity Index). Gaining a deeper understanding of *Betula* species' climate sensitivity will improve predictions about the future challenges experienced by the New England forests due to climate change.

Sophia Pitney (left-front) and Research Experience for Teachers participant, Elicia Andrews (right-back)

Mattea Powers

Plymouth State University
Mentors: Brian Hall, Emily Johnson, David Foster
Project: Advancing Wildlands and Woodlands through Collaborative Conservation

How land cover change analyses assist in conservation to reach the Wildlands and Woodlands vision

The Wildlands and Woodlands (W&W) vision is to protect 70% of land as forests and 7% as farmlands in New England by 2060. The best way the vision can be achieved is through collaboration among conservationists, regional planners, government agencies and private landowners. This summer's research was focused on the Pioneer Valley of Massachusetts where our partner land trust seeks to create a conservation partnership and downscale the W&W vision to a three-county region. Using GIS, I sought to provide a context for this effort by examining land cover changes in the region from 2001 to 2016 and quantify how new development intersects with prime agricultural soils and state-defined Core Habitat and Critical Natural Landscapes. The results were presented to land trusts and planners for the Pioneer Valley, sparking conversations regarding the regional extent of conversion of forested and agricultural land to development. One graph showed that in Kestrel Land Trust's 19-town sub-region, 993 acres that were previously forest in 2001 are now developed with residential subdivision patterns, and of those 993 acres, 655 acres were developed on prime agricultural soils. This analysis can assist conservationists on where development should be located in the future and how to avoid compromising productive prime soils for farmland with development.

Anna Therien

Westfield State University
Mentors: Brian Hall, Emily Johnson, David Foster
Project: Advancing Wildlands and Woodlands through Collaborative Conservation

Focusing regional conservation through local town-based plans

Wildlands and Woodlands (W&W) is a conservation vision for New England that calls for protection of 70% of forests and 7% of farmland. This is a regional goal for New England, but the actual success of this vision will depend on decisions and objectives of landowners and communities. I studied these issues in the Pioneer Valley, which is located in the western part of Massachusetts and is made up of three counties; Franklin, Hampden, and Hampshire. In total there are 69 towns and most of them have Open Space and Recreation Plans (OSRPs) which are created from input and feedback from townspeople. These documents provide a comprehensive explanation of each community, the natural resources they have, community surveys and opinions, goals, objectives, and a seven-year plan to complete the objectives they outline. We collected 63 OSRPs and obtained data from them, mainly focusing on their goals and objectives and their seven-year action plans. These data were combined into an excel sheet with different categories. I then took the text we had collected from the OSRPs and quantified it. By doing this I was able to quantify and analyze town goals. The resulting Excel sheet and maps made from the data are tools that can help inform land trust, planning, and community partners in a developing regional conservation partnership to advance their conservation work in a way that makes sense for different regions and towns.

Ilana Vargas
Colorado State University
Mentors: Leticia Lee, Mark Friedl
Group Project: Controls on Forest Productivity

Varying methods of leaf area index measurements in temperate broadleaf forests of the Northeast US

Leaf area index (LAI) is a commonly used measurement to detect changes in forest canopy density. It measures canopy density by calculating the amount of leaf area in square meters for every square meter on the ground. Variations in canopy cover directly impact light transmission, the fraction of absorbed photosynthetically active radiation (PAR), and available light for plants and trees below the top of the canopy. Using data collected from the Harvard Forest Walk-Up Tower, we were able to identify the relationship between LAI and intercepted PAR. The relationship between LAI and light transmission, as described in the Beer-Lambert Law, is used in modeling photosynthesis rates and atmosphere-ecosystem interactions such as carbon exchanges. The accuracy of LAI readings is imperative to the success of future models. The consistency and accuracy of different LAI measurements were compared to find the best method. LAI data were collected at 18 plots by the Licor-2200C plant canopy analyzer. Hemispherical photos were taken at each plot as well and processed through RStudio and Winscanopy for comparable LAI measurements. Typically, LAI measurements are taken in diffuse light. Different factors were considered, but measurements were taken in varying light conditions including direct sun, dusk, and dense cloud cover to compare techniques. Although there is a translucent filter to simulate diffuse lighting during full-sun conditions, measurements taken under dense cloud conditions and at dusk tended to result in more consistent and precise LAI readings. Using accurate LAI measurements with intercepted PAR data we further analyzed the relationship of forest atmosphere exchanges. Extending this study by continuing LAI sampling in varying light conditions and through different methods could determine the best way to measure canopy density.

Eleanna Vasquez Cerda

Mount Holyoke College
Mentors: Paige Kouba, Sydne Record

Group Project: The future of the Harvard Forest - Tree seedlings of Prospect Hill

How many seedlings does it take to make a tree?

Tree seedlings are under-studied in forest ecology. However, power-scaling theory states that size is inversely related to abundance, and energy use increases with size. This could mean that tree seedlings as a size class contribute as much energy as trees in larger size classes, meaning we would be underestimating the contribution seedlings have to carbon cycling. While the power-scaling theory is not species specific, it alludes to the importance of seedlings within the ecosystem. This study focuses on the population dynamics of specific species to document demographic transitions and patterns amongst seedlings, which determine tree species richness and composition over time. We assessed growth and survival for the species *Acer rubrum* and *Pinus strobus*. We predicted that the generalist species *Acer rubrum* would exhibit a higher growth rate than *Pinus strobus*, which is less resilient in high shade conditions. But we expect that *Acer rubrum* will have lower survival probability because of the low number of adult *Acer rubrum* individuals in the overstory and the high observed seedling mortality. Contrary to our expectations, linear regression models indicate that the growth rate of the two species are similar from 2017-2018 and 2018-2019. Another surprising result was that the abundance of *Pinus strobus* increased significantly in 2018, but declined the following year. In spite of this, the survival probability of *Pinus strobus* in 2018 was higher than that of *Acer rubrum*. Our continued analysis will shed light on how these species' life histories will determine the future of the forest.

Elicia Andrews

Teacher at Quabbin Regional Highschool, MA
Mentors: Tessa Mandra, Pamela Snow, Clarisse Hart, Neil Pederson
Project: Decades to Centuries: What is Happening Inside Transitional Forests at the Harvard Forest?

"Telling Climate Stories through Trees and Data Nuggets":
An Educators Perspective

Data nuggets are a free and worldwide educational resource that allow scientists to share their "science stories" while engaging students in research. Data nuggets were originally created to address teachers' concerns about using scientific research in the classroom. Some of these concerns included the lack of time for full inquiry and the complexity of research data. Using a worksheet, students are introduced to a scientific concept, connected to a scientist and exposed to real quantitative data to analyze. The purpose of my experience was to create a data nugget relating to dendrochronology and climate studies.

My research entailed sampling 20 tamarack trees from a true bog in Harvard Forest. The results indicated that the tamarack were extremely stressed, making the analysis take longer than expected. Transitioning from the original plan, we decided to use data from a previous study on Atlantic white cedar in the Northeast United States. Once we obtained the data, we: (1) constrained the growth index and temperature anomalies to fit the scope of the lesson; (2) summarized content; (3) aligned content to federal and state standards; (4) created a learner guide; and (5) peer reviewed the data nugget.

The major things that I have learned from being involved in dendrochronology research and from creating the data nugget are: (1) science takes time; (2) data is messy; (3) we need more peer reviews; (4) climate education standards are nearly nonexistent in non-environmental science classes; and (5) just because a tree is big does not mean it is old.

2019 PERSONNEL AT HARVARD FOREST

Barker Plotkin, Audrey - Senior Research and Site Manager

Boose, Emery - Information Manager

Bowlen, Jeannette - Sponsored Research Administrator

Chiasson, Laurie - Department Coordinator

Colburn, Elizabeth - Aquatic Ecologist

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Cutler-Russo, Anne - Archives Assistant

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Meunier, Roland - Woods Crew

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O'Keefe, John - Museum Coordinator (Emeritus)

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Patel, Manisha - Lab and Summer Program Manager

Pederson, Neil - Forest Ecologist

Plisinski, Joshua - Research Assistant

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Robbins, Hannah - Regional Conservation Communications Manager

Russo, Thomas - Woods Crew

Snow, Pamela - Schoolyard Program Coordinator

Snyder, Noah - Bullard Fellow

Thompson, Jonathan - Landscape Ecologist

VanScoy, Greta - Education Coordinator and Field Technician

VanScoy, Mark - Field Instrument Specialist

Weiss, Marissa - Science Policy Exchange Coordinator

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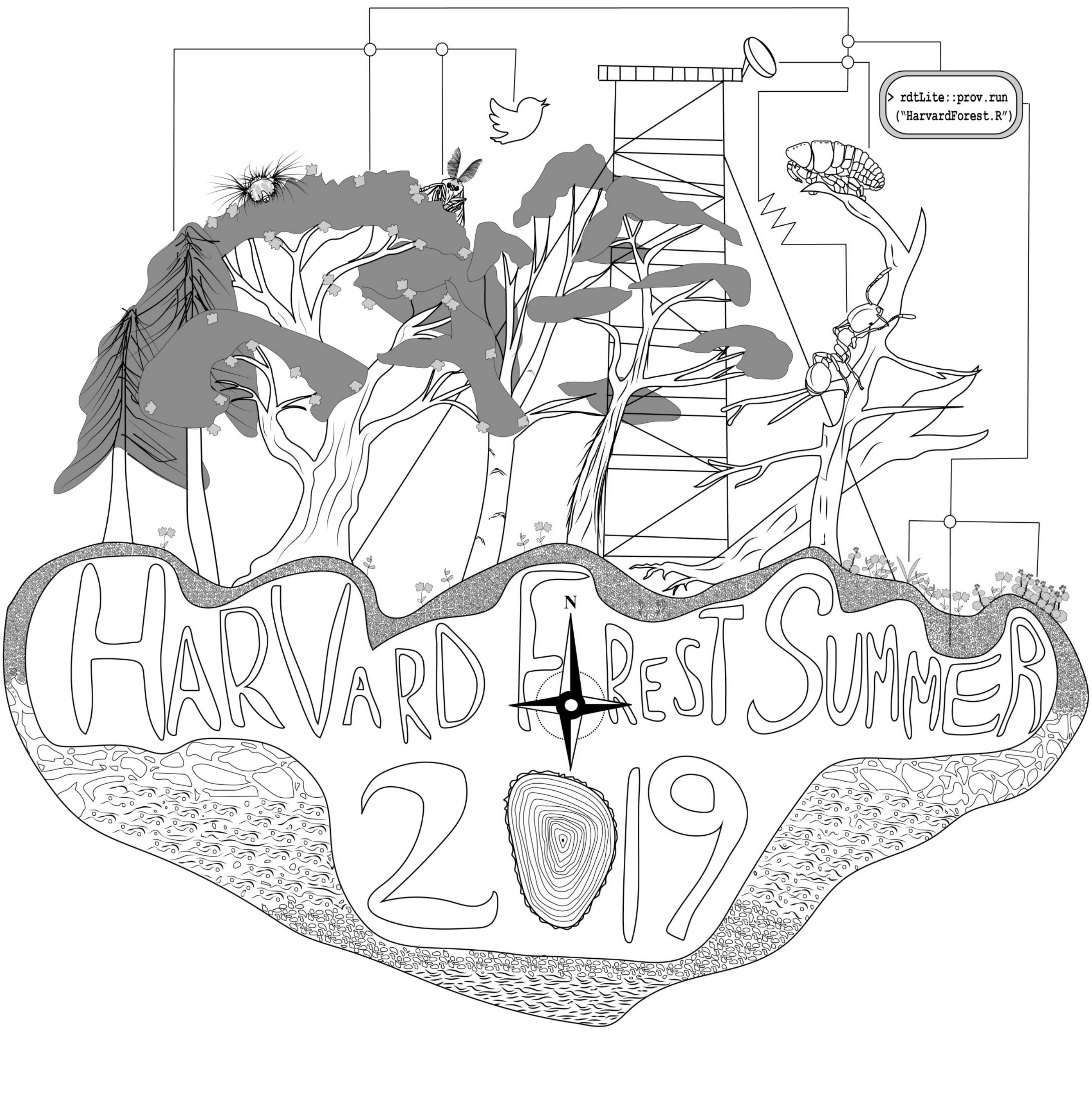
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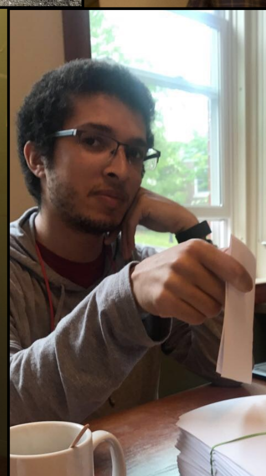




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