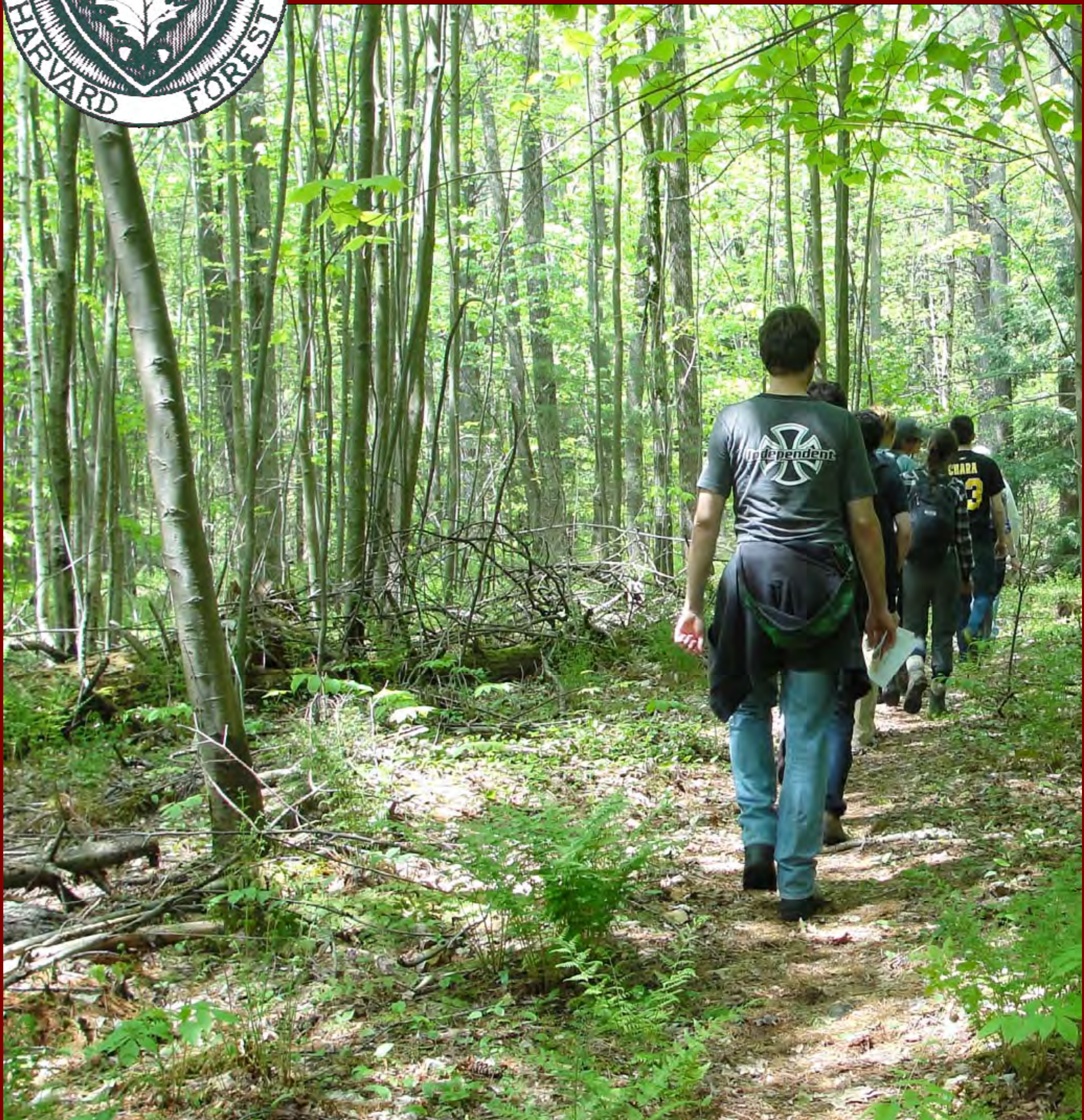
Harvard Forest
Harvard University



21st Annual Student Research Program Symposium

21st Annual Harvard Forest Summer Research Program Symposium

July 31—August 1, 2013
Harvard Forest
Fisher Museum
Petersham, Massachusetts

Photography by Monica Davis, Trynn Sylvester, Harvard Forest Staff, and 2013 Summer Program Participants

Introduction to Harvard Forest

Since its establishment in 1907, the Harvard Forest has served as Harvard University's rural laboratory and classroom for research and education in forest biology and ecology. Through the years, researchers have focused on forest management, soils and the development of forest site concepts, the biology of temperate and tropical trees, plant ecology, forest economics, landscape history, conservation biology, and ecosystem dynamics.

Today, this legacy of activities is continued as faculty, staff, and students seek to understand historical and modern changes in the forests of New England and beyond resulting from human and natural disturbance processes, and to apply this information to the conservation, management, and appreciation of natural ecosystems. This activity is epitomized by the Harvard Forest Long Term Ecological Research (HF LTER) program, which was established in 1988 through funding by the National Science Foundation (NSF).

Physically, the Harvard Forest is comprised of approximately 5,000 acres of land in the north-central Massachusetts town of Petersham. These acres include mixed hardwood and conifer forests, ponds, streams, extensive spruce and maple swamps, fields, and diverse plantations. Additional land holdings include the 25-acre Pisgah Forest in southwestern New Hampshire (located in the 5,000-acre Pisgah State Park), a virgin forest of white pine and hemlock that was 300 years old when it blew 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 experimental space, computer and greenhouse facilities, and lecture room for seminars and conferences. Nine 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 the Department of Earth and Planetary Sciences (EPS), the School of Engineering and Applied Science (SEAS), the School of Public Health (SPH), and the Graduate School of Design (GSD) at Harvard and with the Departments of Biology, Natural Resource Conservation, and Computer Science at the University of Massachusetts, the Ecosystems Center of the Marine Biological Laboratory and the Complex Systems Research Center at the University of New Hampshire.

The staff and visiting faculty of approximately fifty 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 under take forest management and physical plant activities. Funding for Harvard Forest operations is derived from endowments, whereas major research support comes primarily from federal and state agencies (e.g., National Science Foundation, Department of Energy, Commonwealth of Massachusetts Department of Conservation and Recreation), private foundations, and individuals.

Funding for the Harvard Forest is derived from endowments and FAS, whereas major research support comes primarily from the National Science Foundation, Department of Energy (National Institute for Global Environmental Change), U.S. Department of Agriculture, NASA, Andrew W. Mellon Foundation, and other granting sources. Our summer Program for Student Research is supported by the National Science Foundation, the A. W. Mellon Foundation, and the R. T. Fisher Fund.

Summer Research Program

The Harvard Forest Summer Student Research program, coordinated by Manisha Patel and assisted by Monica Davis and Trynn Sylvester, attracted a diverse group of students to receive training in scientific investigations and experience in long-term ecological research. All students worked closely with researchers while many conducted their own independent studies. The program included weekly seminars from resident and visiting scientists, discussions on career issues in science, and field exercises on navigation and land-use history. An annual field trip was made to the Museum of Comparative Zoology and to Harvard University's Herbarium in Cambridge, MA where students learned about museums' contributions to science. Students practiced conveying science through blog writing and pencil sketching at two workshops this summer. The student blog is located at: http://harvardforest.fas.harvard.edu/blog

The summer culminated with students presenting major results of their work at the Annual Summer Student Research Symposium in mid August. They had prepared for this with workshops on creating scientific posters and writing abstracts. Students' presentations were informative and inspiring.

2013 Educational Programs
Harvard Forest Summer Research Program in Ecology

Most evening programs started at 7:00pm and ran for one hour.

Date	**Topic**	**Speaker(s)**
Wed., May 22	Talking Ecology with the Public (START TIME is 6:30pm. 1.5 hours)	Clarisse Hart, *Harvard Forest*
Tues., May 28	Science Check-in	Manisha Patel, *Harvard Forest*
Thurs., May 30	Forest Walk (START TIME is 6pm. 2 hours)	David Foster, *Harvard Forest*
Mon., June 3	Human disturbance and birds of the Northeast: What makes some species decline, while others are just fine?	Leone Brown, *Harvard Forest*
Wed., June 5	Graduate School Panel	Amanda Northrop, *University of Vermont*, Josh Rapp, *Harvard Forest*, & Shannon Pelini, *Bowling Green State University*
Thurs., June 6	Behind-the-Scenes Tour (ALL DAY)	*Harvard Museum of Natural History, Herbaria and Botany Libraries*
Mon., June 10	Regeneration dynamics of western Amazonian forests: the impact of contemporaneous defaunation	Varun Swamy, *Harvard Forest Bullard Fellow & Duke University's Center for Tropical Conservation*
Wed., June 12	The PEcAn Project: Putting ecosystem model-data fusion in your pocket	Mike Dietze, *Boston University*
Mon., June 17	Elevator speeches, I	Student presentations
Wed., June 19	Elevator speeches, II	Student presentations
Thurs., June 20	The relationship between trees and human health (START TIME is 4pm.)	Yvonne L. Michael, *Drexel University*
Mon., June 24	Make conservation forests robust for the 23rd century and beyond	Duncan Stone, *Harvard Forest Bullard Fellow & Scottish Natural Heritage*
Wed., June 26	Navigation Workshop (START TIME. Part I - 4:30-5:30pm. Part II – 6:30-8pm)	Sydne Record & Audrey Barker Plotkin, *Harvard Forest*
Mon., July 1	Scientific Poster Workshop	Aaron Ellison, *Harvard Forest*
Wed., July 3	Career Panel	Russell Davis, Tom Lautzenheiser, Sarah Wells, Joe Doccola, Don Grosman
Tues., July 9	Challenges in managing a multi-functional Mediterranean ecosystem	Liat Hadar, *Ramat Hanadiv - iLTER Network*
Mon., July 15	Scientific Presentation Workshop	Dave Orwig, *Harvard Forest*
Wed., July 17	Scientific Abstract Writing Workshop	Allyson Degrassi, *University of Vermont* & Richard MacLean, *Clark University*
Mon., July 22	In a nut shell: cache management by rodents and mechanisms of oak dispersal	Michael Steele, *Harvard Forest Bullard Fellow & Wilkes University*
Wed., July 24	Nature Sketching (START TIME is 6pm. 1.5-2hours)	Elizabeth Farnsworth, *New England Wild Flower Society*
Wed., July 31 Thurs., August 1	21st Annual Student Research Program Symposium (ALL DAY)	

Funding for the Summer Research Program

The Harvard Forest Summer Research Program in Ecology in 2013 was supported by the following organizations:

National Science Foundation

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

REU Site: Harvard Forest Summer Research Program in Forest Ecology 2010-2014: Ecological data-model fusion and environmental forecasting for the 21st Century (DBI-1003938)

FSML: Walk-up towers for research, education, communication, and outreach at the Harvard Forest (DBI-1224437)

How Important Is ‘Colored’ Stochastiticy for Plant Population Dynamics (DEB-1020889)

CNH-Ex: Shifting Land Use and Forest Conservation: Understanding the Coupling of Social and Ecological Processes along Urban-to-Rural Gradients (BCS-1211802)

US Department of Energy and University of North Carolina - Impacts of elevated temperature on ant species, communities and ecological roles at two temperate forests in eastern North America (DE-FG02-08ER64510)

United State Department of Agriculture (USDA) and University of Rhode Island, A Foodweb Approach to Native Plant Protection in a Forest (2011-67013-30142)

US Environmental Protection Agency, Predicting Regional Allergy Hotspots in Future Climate Sce-narios (RD-83435901-0)

National Aeronautics and Space Administration, Langley Research Center, Data-model fusion and forecasting 21st-Century environmental change in northeastern North America (NNX10AT52A)

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

Harvard University, the Faculty of Arts and Sciences and Harvard Forest endowment gift funds including the **G. Peabody “Peabo” Gardner Memorial Fund.**

21ST ANNUAL HARVARD FOREST
SUMMER RESEARCH PROGRAM SYMPOSIUM
FISHER MUSEUM
31 JULY 2013

	Speaker	Title
10:00 a.m.	Aaron Ellison	Welcome
Session I.	**The New Cutting Hedge**	
10:15 a.m.	Lowell Chamberlain	Are all clearcuts created equal? An analysis of species variability
10:30 a.m.	Rebecca Walker	Spatial analysis of early successional, temperate forest community structure
11:00 a.m.	Break	
11:15	Devin Carroll	Designing and assembling an aerial tram to collect data in remote and treacherous terrain
11:30 a.m.	Faith Neff	Expanding the boundaries of data collection: Construction and application of an aerial tram at the Harvard Forest
11:45 a.m.	Lake Boddicker	Estimating net energy absorption of vegetation using an aerial tram
12—1 p.m.	Lunch	
Session II.	**Carbon: Is Your Sink Full?**	
1:00 p.m.	Hannah Wiesner	Development of the carbon sink at the Harvard Forest
1:15 p.m.	Pat O'Hara	Getting to the core of the carbon question
1:30 p.m.	Christine Pardo	The legacy of land-use history in soil carbon stocks
1:45 p.m.	Sophie Bandurski	Understory on Prospect Hill in the Harvard Forest affects carbon sink development
2:00 p.m.	Break	
Session III.	**Carbon: Woody Debris, Isotopes, and Invasives**	
2:15 p.m.	Channing Press	Determining the accuracy of coarse woody debris measurements and its contribution to the carbon budget of a mixed-deciduous forest
2:30 p.m.	Monica M. Allende Quiros	Respiration and isotopic composition of soil cores and their components in relation to tree dominance
2:45 p.m.	Justin Vendettuoli	Hemlock woolly adelgid's impact on foliar and root microbial abundance in eastern hemlock stands
3:00 p.m.	Break	
Session IV.	**You Down with DDG?**	
3:15 p.m.	Shaylyn Adams	Capturing data provenance from R Script executions
3:30 p.m.	Vasco Carinhas	The data's story made accessible

21ST ANNUAL HARVARD FOREST
SUMMER RESEARCH PROGRAM SYMPOSIUM
FISHER MUSEUM
1 AUGUST 2013

	Speaker	**Title**
Session V.	**Where are the Wild Things?**	
10:00 a.m.	Angus Chen	The devil came down in the dirt: consequences of trophic interactions on carbon respiration and warming
10:15 a.m.	Justine Kaseman	Assessing how vertebrates affect soil ecosystems under warming
10:30 a.m.	Amy Balint	Effects of mast seeding on small mammal abundance and diversity in a declining eastern hemlock forest
10:45 a.m.	James Leitner	Effects of precipitation and temperature on a declining hemlock forest
11:00 a.m.	Break	
Session VI.	**The Human Factor**	
11:15 a.m.	Leah Nothnagel	The future of Massachusetts privately owned woodlands
11:30 a.m.	George Andrews	1984-2013 Timber harvesting along a rural to urban gradient
12—1 p.m.	Lunch	
Session VII.	**Phenology: Climate Change and the Rhythm of the Seasons**	
1:00 p.m.	Dmitri Ilushin	The effects of differing tracking methods for vegetative phenology
1:15 p.m.	Arturo Martinez	Deciduous tree phenology at Harvard Forest: A comparative study across species and habitat
1:30 p.m.	Guillermo Terrazas	Using remote sensing and the Urban Heat Island to understand the effects that global warming has on the phenology of vegetation
1:45 p.m.	David Miller	Assessing and modeling the urban heat island's impact on deciduous vegetation phenology with Landsat
2:00 p.m.	Katherine Bennett	K-12 Phenology Lessons for the *Phenocam* Project
2:15 p.m.	Break	
Session VIII	**Rooting for Growth**	
2:30 p.m.	Johanna Recalde Quishpe	The effects of soil warming and nitrogen fertilization on root phenology
2:45 p.m.	Arline Gould	Species-specific differences in fine root and mycorrhizal phenology
	Ticks Around Harvard Forest	
3:00 p.m.	Aaron Ellison	
5:30 p.m.	*** *EVERYONE* ***	**END OF SUMMER BARBEQUE!**

Lowell Chamberlain

State University of New York, College of Environmental Science and Forestry
Mentors: Chris William, Rich MacLean, and Myroslava Khomik

Are All Clearcuts Created Equal?
An Analysis of Species Variability

Forest disturbance is an essential part of ecosystem dynamics and function over time. Here, we investigate how species composition recovers from stand replacing disturbances at three clearcut sites in the Harvard Forest LTER. The three sites had a similar mix of plantation softwoods and hardwoods pre-cut, and were harvested within a year and a half time period. By observing the vegetation at three similar sites which experienced the same disturbance, this study attempts to quantify the natural variability present between similar, recovering forests. Species composition was quantified using four, 15 m, transects at each clearcut and recording the total transect length covered by each species. Additionally, we attempted to remotely detect vegetative differences by comparing NDVI at each site with Landsat derived NDVI. Due to the similarity of the three site's environmental state factors, we hypothesized that the three clearcuts would not have significantly different species compositions. The results of our analysis did not support this hypothesis. Using two-way-ANOVA with species and site, we found that percent cover, between species, was significantly different ($p < 0.05$). The interaction between species and site was significant ($p < 0.05$) and dominance was not held by one species throughout all three sites. Additionally there was no significant difference in total cover between sites. Our analysis shows that percent cover of a species is dependent on site. These results indicate that not all clearcuts are created equal and there is significant variability within similarly disturbed recovering forests.

Rebecca Walker

University of Virginia
Chris Williams, Rich MacLean, Howard Epstein, Myroslava Khomik, and Melanie Vanderhoof

Spatial analysis of early successional, temperate forest community structure

The global importance of sequestration of carbon by temperate forests makes characterizing the regrowth of these forests post-disturbance both ecologically and economically important. High intensity disturbances, such as logging, result in greater alteration of community composition post-disturbance, creating the potential for alterations to the cycling of carbon, water, and nutrients in the ecosystem. Because logging pressure in New England continues to increase, understanding how forest ecosystems in this region respond to disturbance is crucial. This study aims to characterize interspecies interactions within New England forests by identifying synchronous and asynchronous colocation of species following a disturbance. To accomplish this, line-intercept surveys of vegetation were conducted in a clearcut forest stand located within the Harvard Forest LTER site. Survey data collected two (2010) and five (2013) years post-clearcut were analyzed using a one-dimensional Ripley's K. Based on preliminary analysis of the 2013 data, species demonstrated definite patterns of synchronicity and asynchronicity based on both specific species interactions as well as functional group interactions. For example, *Maianthenum canadense* (Canadian Maylilly) is asynchronous with shrub species but synchronous with tree species, indicating sensitivity by *M. canadense* to stem density. Further results from 2010 and the comparison between 2010 and 2013 are pending. These analyses provide unique information about the interspecies interactions of New England forest communities during one of the most rich and dynamic phases of succession, allowing for more informed decisions to be made regarding the regrowth of forests following a high-intensity disturbance.

Devin Carroll

University of Massachusetts Amherst
Mentors: Paul Siqueira and Mark VanScoy

Designing and Assembling an Aerial Tram to Collect Data in Remote and Treacherous Terrain

The gathering and analysis of data is a driving force behind much of science. However, the data gathering process, especially if located in a treacherous or remote area, can take considerable time and can expose individuals to serious risks. One solution to this problem is an autonomously operating, self-sustaining aerial tram, deployed at the Harvard Forest for the purpose of making consistent and repeated measurements over a re-growing forest stand. Phase one of this solution is a two-fold process: first, a design must be engineered and a prototype built for testing. Using a three-dimensional modeling software, SolidWorks, the tram was designed in the lab. Next, a prototype was constructed and installed in a nearby location to test its functionality. Its movement, controlled using LabView, is currently being tested to identify different mechanical and coding problems and improve performance. The final step in the process is to make the tram self-sustaining. After preparing an energy budget, a computer aided design software (AutoCAD) was used to design a solar system to run the tram. Phase two of the project requires installing the tram above the re-growing forest stand. The plan is to install it this spring, collecting and uploading data to the Internet so that users can access the data in near real time for use in research on environmental reactions to a disturbance.

Faith C. Neff

Humboldt State University
Mentor: Paul Siqueira and Mark VanScoy

Expanding the Boundaries of Data Collection:
Construction and Application of an Aerial Tram at the Harvard Forest

Forests are the largest terrestrial carbon pool on earth. As such, they play a critical role in carbon dioxide sequestration as well as provide basic ecosystem services such as wildlife habitat, biodiversity and water quality. The behavior of forests in change, for example post clear-cut, is incompletely understood due to limitations in time, resources, and means of data collection. Our group sought to better study forest growth, CO_2 output, light emission and absorption, and vegetation stress in this situation, using an aerial tram with multiple sensors suspended over a previously clear-cut forest. In order to achieve this goal, we implemented the physical construction of the tram and supporting towers, the programming of its sensors and motor, and subsequent data collection. The tram was constructed, and its motor function and ecological sensors were programmed using LabVIEW, a programming language well suited for controlling the motor and sensors. For my project in particular, I sought to test the hypothesis that normalized difference vegetation index (NDVI) calculated using spectral reflectance sensors was within a reasonable margin of the NDVI obtained with a hyperspectral imager. This is an important component in the overall development and validation of the tram system as a whole. Results will be shown on the relationship between the spectral reflectance and hyperspectral data, as well as other aspects of the data collection system.

Lake Boddicker

Lake Forest Academy
Mentors: Mark VanScoy and Paul Siqueira

Estimating Net Energy Absorption of Vegetation Using an Aerial Tram

With the rise of the Internet and the decrease in cost of sensors, high-resolution measurements have become more prevalent. Such high-resolution measurements allow scientists and researchers to observe minuscule phenomenon that would otherwise go unobserved. Furthermore, high-resolution measurements can illuminate subtle trends over a long period of time. Our research team is developing an aerial tram that will take high-resolution measurements along a transect. A prototype of the tram and the two supporting towers were designed in SolidWorks and constructed at a pseudo site. The tram as well as the eight sensors mounted on it are controlled using a combination of LabView and CRBasic. A Campbell Scientific CR1000 data logger takes measurements from the sensors while a LabView code, running on the tram's onboard computer, controls movement and operation scheduling. The tram's eight sensors measure upwelling and downwelling long and short wave radiation, NDVI, PRI, and height of the canopy in addition to taking images of the foliage underneath. Using data from sensors such as the four channel net radiometer as well as from the hyper spectral camera will allow us to calculate the net radiation absorption of the vegetation across the transect. At present not enough data has been collected to determine how the net energy absorption varies across the transect, however we expect net energy absorption to vary throughout the length of the transect depending on vegetation type.

Hannah Wiesner

Macalester College
Mentor: Audrey Barker Plotkin and Liza Nicoll

Development of the Carbon Sink at the Harvard Forest

By acting as carbon sinks, forests play an important role in mitigating global climate change. As forests grow and change, so do their carbon dynamics. Studying permanent plots across time gives an understanding of how species composition and land use legacies influence carbon sequestration patterns. In this study, we measured aboveground vegetation biomass in order to compare the amount of carbon stored in trees within permanent plots between 1937, 1992 and 2013. We hypothesized that the amount of carbon stored between 1937 and 2013 would increase. We conducted vegetation surveys in 60 plots throughout the Prospect Hill tract of the Harvard Forest. Each .05 ha plot existed within one of four historical land use categories: cultivated, improved pasture, rough pasture or woodlot (primary forest). We measured the diameter at breast height (DBH) of each tree with a DBH >2.5cm, in addition to sampling coarse and fine woody debris. Aboveground biomass was calculated using species-specific allometric equations and the amount of carbon was estimated to compose 50% of the total biomass. There was an average of 33 Mg-C/ha in 1937, 89 Mg-C/ha in 1992 and 121 Mg-C/ha in 2013. In each year, plots in the woodlot category had the most C/ha. The difference in carbon stocks between land use types was greater in 1937 than in 1992 and 2013. These results suggest that studying forests over long time scales with attention to historical factors gives insight into carbon dynamics.

Patrick O’Hara

Harvard University
Mentor: Audrey Barker Plotkin

Getting to the Core of the Carbon Question

Understanding how a forest is taking in carbon from the atmosphere is critical in an age of global climate change. Determining which parts of the environment are acting as sinks or sources for carbon, and to what extent, can help shape climate policy. Eddy-flux and permanent plot studies indicate that the Harvard Forest in Petersham, MA is a significant carbon sink. This study seeks to determine how the Forest has changed in its role as an extractor of carbon over several decades. From a suite of permanent plots sampled in 1992 and 1937, I selected four 22.5m x 22.5m that best represent the diversity of the Harvard Forest’s core research area based on basal area, tree density, and species composition. In each of these plots, I extracted two increment cores from each tree greater than 10cm diameter at breast height, and the cores were analyzed for yearly growth based on ring width. Using a previously developed program in R, I used the raw measurement data gained from the tree core analysis along with data from live vegetation surveys to obtain a rough estimate of yearly carbon intake. It can be seen from this initial data that over the past century or so the amount of carbon being taken in by HF has been increasing. It is hypothesized that this general increase is due to both regrowth of the forest and to a fertilization effect of carbon dioxide in the atmosphere.

Christine Joelle Pardo

Florida International University
Mentor: Audrey Barker Plotkin and Jim Tang

The Legacy of Land-Use History in Soil Carbon Stocks

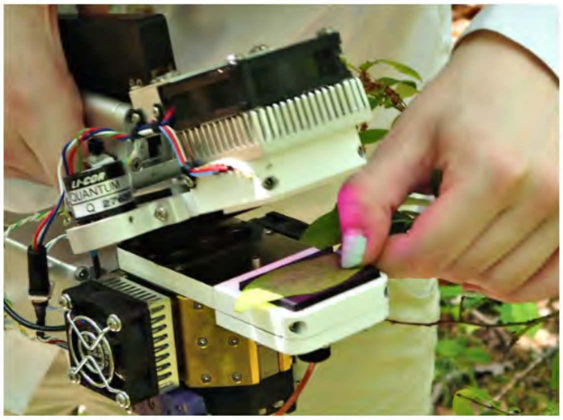
Soil is the largest terrestrial pool of carbon, with more than twice as much as the atmosphere or terrestrial vegetation. Long term studies show that the Harvard Forest ecosystem is a carbon sink. Improved knowledge of how forest soil carbon stocks vary over time and space will help inform land preservation targeted towards improving terrestrial carbon sinks to mitigate climate change. I sampled soils from a suite of permanent plots across the Prospect Hill Tract to examine changes in soil carbon over 20 years, and across historical variation on the Harvard Forest landscape. I predicted that carbon stock would increase over time. I also predicted lasting differences among land-use history categories. I sampled 34 of the original 137 plots from 1992. The full depth of the organic layer was collected, along with the top 15cm of the mineral soil. The samples were sieved, oven-dried at 70°C, and weighed. Subsamples were analyzed for carbon content using an elemental analyzer. Carbon stock was then calculated for each sample, from the bulk density (sample volume divided by oven-dry mass) and carbon content. Changes over time and among historical land-use categories were tested with ANOVA. Between 1992 and 2013, carbon stock in the soil increased significantly. Continuously forested land had higher carbon stocks in the organic layer of the soil. Combined with belowground, understory, and aboveground data collected this summer, we can piece together the carbon sequestration potential at Harvard Forest.

Sophie Bandurski

Smith College
Mentor: Danielle Ignace and Audrey Barker Plotkin

Understory on Prospect Hill in the Harvard Forest Affects Carbon Sink Development

The role of the understory vegetation in carbon sequestration in northern latitude forests currently lacks a complete understanding. Studies involving carbon fluxes and stocks tend to exclude the understory since it is often considered to have an insignificant contribution to carbon sink dynamics. I investigated differences in photosynthetic rate of the understory vegetation across Prospect Hill in the Harvard Forest. I sampled thirty-three permanent plots using the Li-Cor 6400XT to measure the photosynthetic rate of nine dominant non-woody understory species. The plots differed in land use history (cultivated, improved pasture, rough pasture, woodlot), soil drainage (well-drained, moderately well-drained, poorly drained, very poorly drained and somewhat excessively drained), and species composition. Leaf tissue samples were analyzed for percent carbon and percent nitrogen from a subset of twenty plots. I predict that photosynthetic values for all species will be highest on woodlot sites and well-drained soil with *Aralia nudicaulis* demonstrating the highest photosynthetic rates and *Coptis trifolia* showing the lowest photosynthetic rates. Additionally, in terms of soil drainage, I predict that the results will show the highest photosynthetic rates for *Dennstaedtia punctilobula* and the lowest photosynthetic rates for *Gaultheria procumbens*. The results from this preliminary study indicate that understory vegetation has potential to significantly contribute to the development of the carbon sink in the Harvard Forest and warrants future investigation. Understanding the physiology of the understory is key to knowing more about the forest ecosystem carbon dynamic, especially given future predictions of global climate change.



Channing Press

Villanova University
Mentors: Bill Munger and Evan Goldman

Determining the accuracy of coarse woody debris measurements and its contribution to the carbon budget of a mixed-deciduous forest

Forests are important ecosystems for sequestering Carbon, offsetting anthropogenic emissions. Up to 30% of this carbon sink could be ending up in Coarse Woody Debris (CWD) at Harvard Forest. I resurveyed CWD at Harvard Forest, previously measured in 2000, 2003, 2004, and 2009. I measured every piece of wood greater than 7.5 cm in diameter in the 33 10 m radius plots and noted additional characteristics and observations such as decay class and biological factors. This data shows that total carbon has been steadily increasing since 2000. Unfortunately, the protocol for measuring dead wood in the forest is sparse. It is unknown where our greatest source of error lies and how large that source of error is. Using data from Liu's previous study on CWD density, I analyzed that on average each individual piece of wood's density has a mean squared error of .40 in comparison to the average decay class density currently used. Furthermore, I took an additional 11 extra measurements at specific intervals on 64 randomly selected pieces of wood in order to make a closer estimate of true volume and to see if measurements would be more accurate if taken from a standard location. The current protocol for measurements revealed to be the most accurate way to estimate volume and has a relative error of 2%. From these tests I found that the biggest source of error arises from the density values and I propose that future studies use individual species densities when determining total carbon.

Mónica M. Allende Quirós

University of Puerto Rico, Rio Piedras
Mentor: Scott Saleska and Richard Wehr

Respiration and isotopic composition of soil cores and their components in relation to tree dominance

Soil respiration fluxes and belowground carbon pools represent a major component of ecosystem carbon cycling. Climate change impacts and is impacted by ecosystem carbon cycling, and understanding how belowground carbon processes work is necessary for predicting the future of the climate and the ecosystem. The two main objectives for this research project are 1) to determine how belowground respiration and its carbon isotopic composition vary according to tree dominance and 2) to determine the relative contribution of various belowground components to the total soil CO_2 efflux using their isotopic signatures. Soil cores were collected near the Environmental Measurement Site (EMS) from two plots with different dominant tree species: a mixed maple and oak plot and a hemlock plot. Using a quantum cascade laser spectrometer located at the EMS, CO_2 fluxes of the whole core and its components (litter, root free organic and mineral horizons, and roots) were measured, and Keeling plots were used to determine the isotopic compositions of these fluxes. While the magnitude of the CO_2 fluxes from the samples diminished over time after excavation, their isotopic signatures remained stable. The signature for root-free soil was close to -29‰, while the signature for root respiration was close to -27‰, both of these regardless of dominance. Although much is still unknown about belowground carbon pools, these isotopic signatures for roots and root-free soil may allow determining each component's contribution to the total soil CO_2 efflux.

Justin Vendettuoli

University of Rhode Island

Mentor: David Orwig

Hemlock woolly adelgid's impact on foliar and root microbial abundance in eastern hemlock stands

Eastern hemlock, *Tsuga canadensis*, is an integral species contributing to the ecosystem heterogeneity across many northeastern landscapes. An invasive insect, the hemlock woolly adelgid (HWA; *Adelges tsugae)*, has been devastating in hemlock stands by parasitizing the hemlock, eventually leading to needle loss and tree mortality. The adelgid creates a unique woolly by-product to protect its eggs that can cover branches resulting in a considerable influx of wool in heavily invested stands. There is a need to better understand how the system is altered as infestation progresses, especially with regards to changes in foliar and belowground or soil processes. To assess the impact of HWA, we measured bacterial abundance on foliage and fine roots from three trees each at 10 infested and 10 control sites across central MA. We also determined C:N ratio of woolly by-products and fine roots to examine how that may affect bacterial abundance. I predicted to find higher bacterial abundance on infested foliage and roots based on previous research on foliage. Woolly by-products were found to have high nitrogen (mean of 2.6% N), which may promote bacterial growth. Fine root percent N did not differ between treatments (0.98 – 1.02%), but percent C was modestly but statistically (P=0.0003974) higher in control (50.98%) vs. infested (50.19%) fine roots. Our results will contribute to an emerging conceptual model of how adelgid infestation affects above and belowground processes.

Shaylyn Adams

Mount Holyoke College
Mentor: Emery Boose and Barbara Lerner

Capturing Data Provenance From R Script Executions

To ensure the reproducibility and validity of scientific work, it is essential to keep a complete record of data analysis. Recording data's history can be tedious, especially without any explicit guidelines. Consequently, the records of data transformation are generally vague with insufficient details. Our research focused on using computer software to capture and display the data analysis history, or data provenance. We worked on increasing the usability of a formal metadata structure that captures data provenance, a Data Derivation Graph (DDG), to make it more accessible to scientists. The DDG describes a post computation data trace but its creation was previously limited to software unsuited for scientific data analysis. Our work this summer involved extending the DDG representations to work with the statistical language, R. A textual syntax describing DDGs was constructed and used with this software. We added more interactive features to the visualization tool allowing scientists to examine the visual DDG and view data values, input and output data files, plots, URLs and the R functions used in the analysis. The resulting DDG is stored in a database and available to be viewed at anytime. We tested the new features on data sets from meteorological and hydrological collections and from other summer student projects at the Harvard Forest. By supporting R, we hope to use these preliminary results to determine what features of the DDGs are most useful for scientists to understand the provenance of their work and how to further extend this technology.

Vasco A. Carinhas

University of Puerto Rico, Arecibo
Mentor: Emery Boose and Barbara Lerner

The Data's Story Made Accessible

The reproducibility of scientific results is a key element in any scientific experiment. In order to replicate the results, a storyline of the phases taken with the data should be delineated. With a Data Derivation Graph (DDG), a structured metadata that records the history of the data and its analysis, the scientist is able to establish the data's provenance, namely its derivation, by perusing the different steps the data took. The goal of this project is to make DDGs accessible to scientists from different computer backgrounds. To attain this objective, R was turned, with specific packages, into an interactive tool in which the user's understanding of R can be minimal to use R's features. *Quality Control Enforcer* is a Graphical User Interface tool that allows, using widgets, variables selection from a file and data input to perform modifications. The data can be subset by user input specifying a range. Also, quality control tests can be performed, with outliers and repeated values both depicted in different colors in the plot. Concurrently, the tool records the steps taken in a DDG. Such development in R allows an expansive experiment to test the DDG usefulness. The aims for the DDG development are to allow the scientists to explore the data analysis, and for the programmer to troubleshoot the R script and keep track of the program's process. A user-friendly platform is a crucial constituent to make the creation of DDGs easier in multiple scientific fields.

Angus R. Chen

Oberlin College
Mentor: Shannon Pelini

The devil came down in the dirt: consequences of trophic interactions on carbon respiration and warming

Soils occupy a pivotal position on the stage of terrestrial ecosystems, representing one of the largest fluxes of carbon after photosynthesis. As the threat of climate change rises, the question of carbon fluxes in the soil rise with it. Currently, most studies on soil respiration focus on total respiration of a soil ecosystem, but there has not yet been much inquiry on the isolated parts of soil ecosystems and their unique interactions. In order to do this, we independently examined two soil trophic groups, soil microbes and fungi, and invertebrates, by removing each one at a time through sterilization practices. When soil is sterilized and placed in an eastern deciduous forest, the soil experiences rapid recolonization by sugar fungi. We were then able to study the interaction of these fungi and certain soil invertebrates by observing the soil chambers' appearance and respiration. We imagined that the combination of fungi, microbes, and invertebrates would have the highest respiration, since this represents the greatest number and diversity of organisms. However, respiration by fungi and microbes appears higher in comparison to the respiration of recolonized soil with mealworms and earthworms, and both were higher than respiration in non-sterile soils. At the same time, there were considerable less visible fungi in soil chambers with invertebrates, while there were no visible fungi in non-sterile chambers. We observed invertebrate death after about two and a half weeks, resulting in the reversal of this trend. This suggests that fungal respiration is responsible for the majority of soil respiration in these chambers, and grazing of these organisms by invertebrates reduces total respiration. However, warming did not appear to have a strong impact on respiration, except in accelerating invertebrate death.

Justine Kaseman

Bowling Green State University
Mentor: Shannon Pelini

Assessing How Vertebrates Affect Soil Ecosystems Under Warming

Climate change is predicted to dramatically alter species interactions which will inevitably affect soil ecosystem processes such as carbon flux. Little study has been directed towards the influence of multiple trophic levels on soil respiration, an important ecosystem process that has direct consequences on climate change. In this study, we examined the influence of multiple trophic levels and their potential interactions with warming on soil respiration. Mesocosms were constructed to simulate the first (microbes only), second (microbes and invertebrates) and third (microbes, invertebrates, and a salamander) trophic levels. Each mesocosm was placed in a warming chamber ranging from 0-5.5 C for five weeks. The LICor 6400 soil respiration chamber was used to analyze efflux. We hypothesized that efflux will increase when (a) the entire food web is present because salamanders are large organisms which require higher respiration and (b) the mesocosms are placed in warmer chambers. When the atmosphere is warmer, we thought organisms will be put in higher stress, thus, higher respiration. However, we found there was no correlation showing higher respiration with neither the full food web nor warmer chambers. This could have resulted from the salamanders feeding on the invertebrates and decreasing respiration. Further studies should be conducted to clarify these results.

Amy Balint

Portland Community College
Mentor: Allyson Degrassi

Effects of mast seeding on small mammal abundance and diversity in a declining eastern hemlock forest

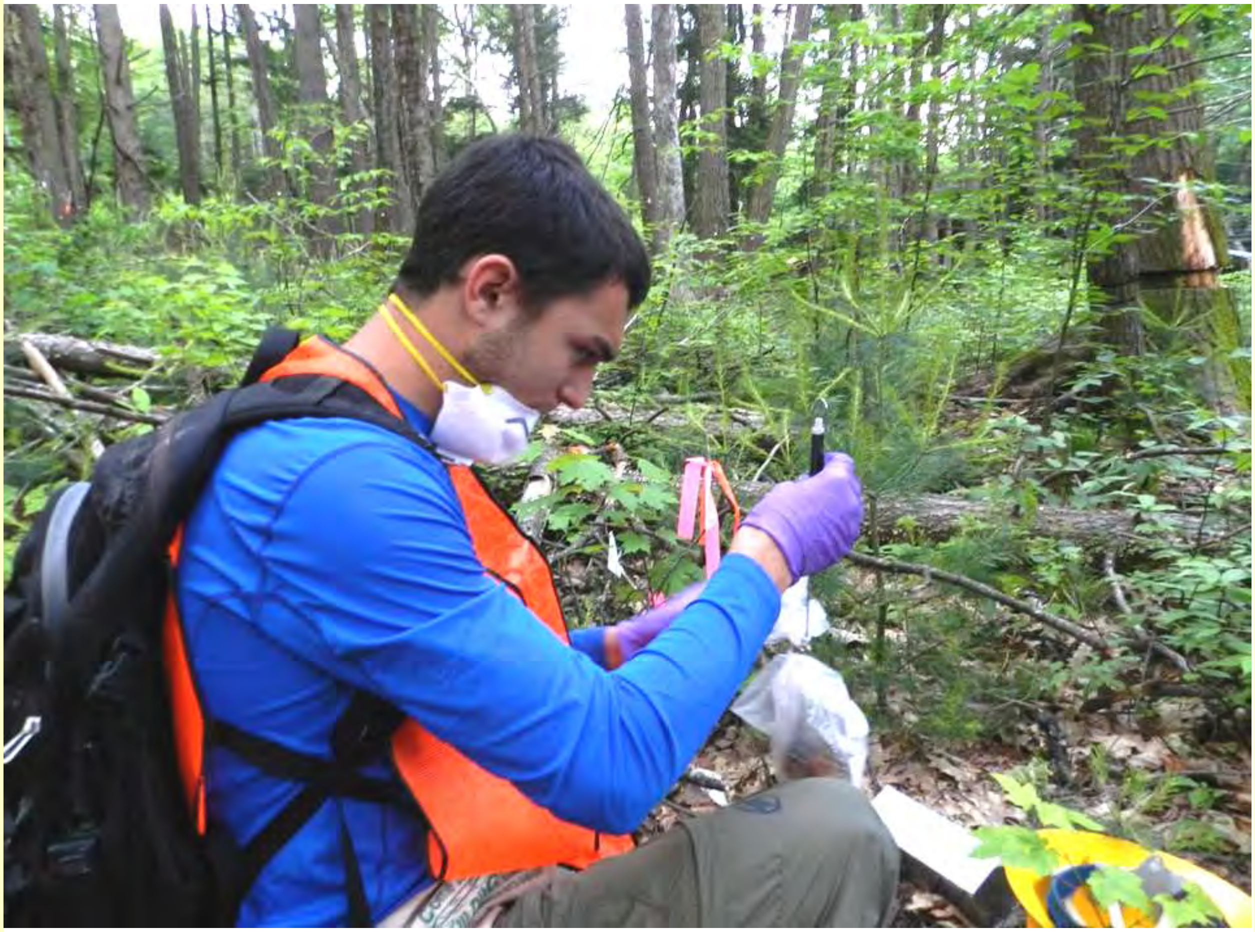
Eastern hemlock forests are declining throughout their range due to the hemlock woolly adelgid (*Adelges tsugae*), an invasive phloem-feeding insect. The effects of hemlock mortality and succession on small mammal community structure and interactions are not yet well understood. Mast seeding is an important driver of small mammal population and community dynamics in deciduous hardwood forests, but it is not clear how masting affects small mammals in adelgid-infested eastern hemlock forests undergoing successional change. From 2012 to 2013, small mammal populations in the Simes Tract declined sharply. I hypothesized that low mast production may be a factor, and that as hemlocks are killed by the adelgid and replaced by hardwoods, masting will become a stronger influence on small mammal communities. To assess small mammal abundance and diversity, we placed a grid of 49 Sherman live traps in each of four treatment plots in two replicated blocks. Captured animals were marked, PIT-tagged, and released. Population sizes were estimated using the Schnabel mark-recapture index and species diversity was determined using the probability of interspecific encounter. I predicted that small mammal abundance will be positively correlated with the previous year's seed rain mass. To date, our results show a decrease in all rodent populations from 2012 to 2013 except eastern chipmunks (*Tamias striatus*) and American red squirrels (*Tamiasciurus hudsonicus*). Red-backed vole (*Clethrionomys gapperi*) populations experienced the largest decline. Current data show a positive correlation between rodent capture yield and seed rain mass, indicating that masting may be a factor in this year's low rodent numbers.

James Leitner

University of Delaware
Mentor: Allyson Degrassi

Effects of Precipitation and Temperature on a Declining Hemlock Forest

The Eastern Hemlock tree, Tsuga Canadensis, is being declined by the invasive Hemlock Woolly Adelgid (HWA) insect. The removal of the eastern hemlock may have detrimental effects on small mammal populations as hemlocks provide food and shelter. Small mammals play an important role in vegetation establishment and growth because they disperse seed and fungi. Small mammals were sampled in 2012 and 2013 as part of an ongoing study on small mammal communities in eastern hemlock removal experiments at Harvard Forest in Petersham, MA. Four hemlock treatments (logged, girdled, hemlock control, and hardwood control) were manipulated to simulate the effects of HWA. In 2012, small mammal abundance was much greater than in 2013. I investigated abiotic factors in an attempt to explain the decrease in small mammal abundance in 2013 by using archived data from 2011-2013 and doing correlations between number of captures and temperature as well as precipitation. I hypothesized that the longer winter in 2013 than in 2012 and decrease in temperature may correlate to the decrease in the amount of captures. Temperature was being measured every day and was averaged in each of the treatments. Precipitation was being measured every 10 minutes by the environmental measurement system. After 3,379 trapping nights (traps X nights), I observed rodent captures increased when there is light precipitation, and when the weather is much warmer. I conclude that with warmer summers, capture rates will increase.



Leah Nothnagel

Minneapolis Community and Technical College
Mentor: David Kittredge

The Future Of Massachusetts Privately Owned Woodlands

Massachusetts is a heavily forested state, most of which is privately owned. For this reason knowing future projections of land use by its owners is important in order to understand what the landscape will look like in the coming years. My focus is on the attitudes of the residents along an urban to rural gradient regarding the future of their land, community, and their views on conservation. My thesis is that in suburban to urban communities the residents will own less land, but will be more pro-conservation.

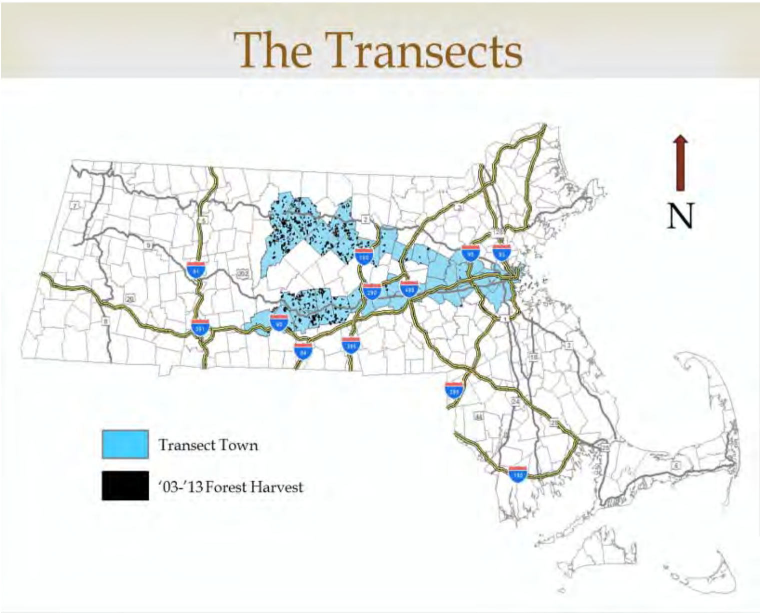
For the project we sent out surveys titled "Community and Conservation Survey of Massachusetts", which was sent out to residents along our transects, covering Boston all the way West to Athol and Palmer. From the surveys sent out, we received about a 30% response rate; which I then entered the participants responses into a spreadsheet and then analyzed the data looking for trends. From the responses we found that 50% of the participants felt they live in a rural community, and over half of all the respondents said they were unlikely to sell their land in the near future. Of all the respondents roughly 70% said that they found land conservation to be very important, and this is across both Urban and Rural communities. The differences in attitudes towards conservation not being too drastic. As this project is ongoing, I feel there will be much more to learn from the residents here in Massachusetts.

George Andrews

Worcester State University
Mentor: David Kittredge

1984-2013 Timber Harvesting Along a Rural to Urban Gradient

Massachusetts is one of many states dominated by non-industrial private forest (NIPF) ownership. Examining timber harvesting records from 1984-2013 along two rural to urban gradients across the state offers great insight into where timber harvesting occurs geospatially, reasons which may influence harvesting and human decision making, and changes or patterns over time as more recent harvests are analyzed. To collect and update the data we travelled to the DCR Office in Clinton, MA, and photographed the maps and sketches of all 588 forest cutting plans (FCPs) along the gradients which occurred between 2003 and 2013, and recovered archived attribute data for each harvest. We then georeferenced each FCP in ArcGIS, and created polygons with file numbers joinable to any of the harvest data. Previous statewide data from 1984-2003 were already collected and analyzed. The data indicate that factors such as decreasing parcel size, economic recession, and urbanization over the past decade have caused an overall decrease in timber harvesting along the gradients. Analysis of decadal harvesting data yielded that harvesting appears to recede west to rural areas along the gradients as recordable eastern harvesting becomes less viable and virtually nonexistent in the urban and suburban range of Boston. The addition of data from the years 2003-2013 show a decrease in timber harvesting, and a westward shift in cutting and harvest intensity. The map created from the FCPs offers a unique geospatial record of harvesting within an NIPF dominated landscape.



Dmitri Ilushin

Harvard University
Mentor: Andrew Richardson and Michael Toomey

The Effects of Differing Tracking Methods for Vegetative Phenology

Vegetation phenology, annual life cycles of plants, provides a key feedback with climate variability and change and is an important parameter in land surface models used to predict global climate. As such, there is a need to track the rhythm of the seasons with more detail. Common remote sensing methods used to track phenology are limited by their coarse temporal and/or spatial resolutions. Alternatively, I look to explore the usability of publicly available "webcams" in their use as an indicator of phenological trends. More specifically, I address the question of how this new measurement relates to that of satellite imagery, a standard technique for remote sensing of phenology. I have used a subset of images from publically available webcams from the Archive of Many Outdoor Scenes as my test data. From the 685 cameras used, I extracted the phenological transition dates calculated for both spring and fall using multiple differing methods and compared these values to corresponding dates extracted from satellite imagery. With this information, I will first determine the relationship of differing date extraction methods on the webcams to find out their utility as well as compare how the two techniques of phenological study compare with each other to find whether or not there is a bias in one measurement versus another. This information will help better our understanding of how growth patterns are affecting net uptake of carbon and how trees and forests respond to changing climate.

Arturo Martinez

Carnegie Mellon University
Mentor: Andrew Richardson and Steve Klosterman

Deciduous Tree Phenology at Harvard Forest: A Comparative Study Across Species and Habitat

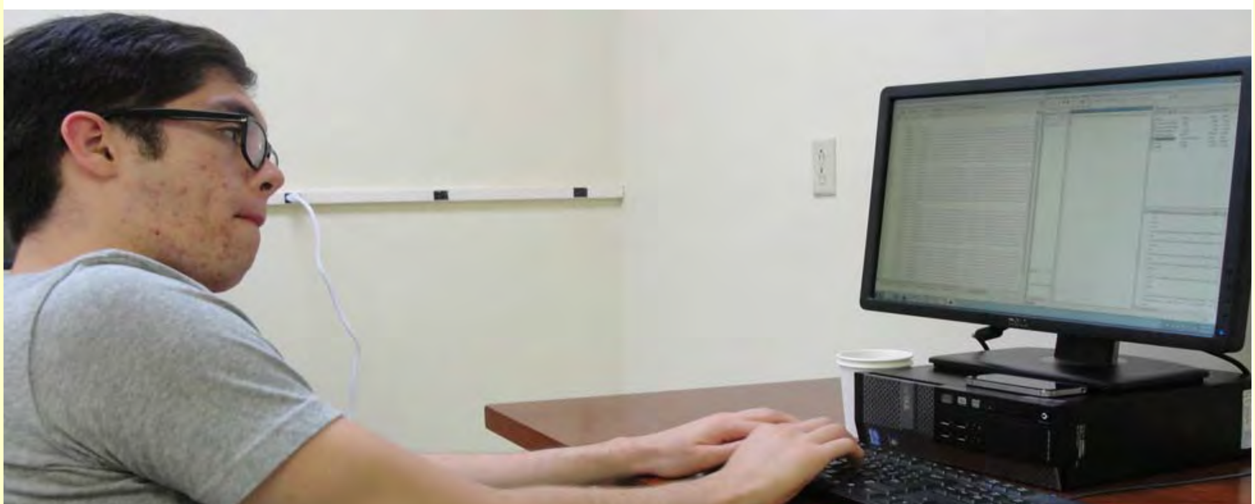
An understanding of plant phenology is crucial in order to predict how future climate scenarios will affect the timing of forest ecosystem processes, such as carbon sequestration. The aggregate phenology of a forest is made of divergent responses of individual trees, which may have different phenologies owing to species dependent response to climate, or microenvironmental variation. In order to observe leaf phenology of individual trees, this project uses a UAV (Unmanned Aerial Vehicle) to collect pictures of the forest canopy every five days over a defined area at Harvard Forest throughout spring. By analyzing greenness intensity over time for individual trees and applying model-based methods to extract phenology transition dates, leaf phenology is compared within and across deciduous tree species. This analysis yields insight into the degree of phenological plasticity within species, and how this compares to differences between species. After separating the area into subregions, the effects of local environment on the phenology of trees are examined. The results show that independent of the subregion, ring-porous trees have later leaf out than diffused porous trees. In addition, trees which were closer to wetland regions were more likely to leaf out later than those in dry regions. It is hypothesized that trees within a given species that have easier access to sunlight, such as open grown trees in wetlands, do not need to develop leaves as early as trees grown in a closed canopy, which have more competition for light from neighboring trees.

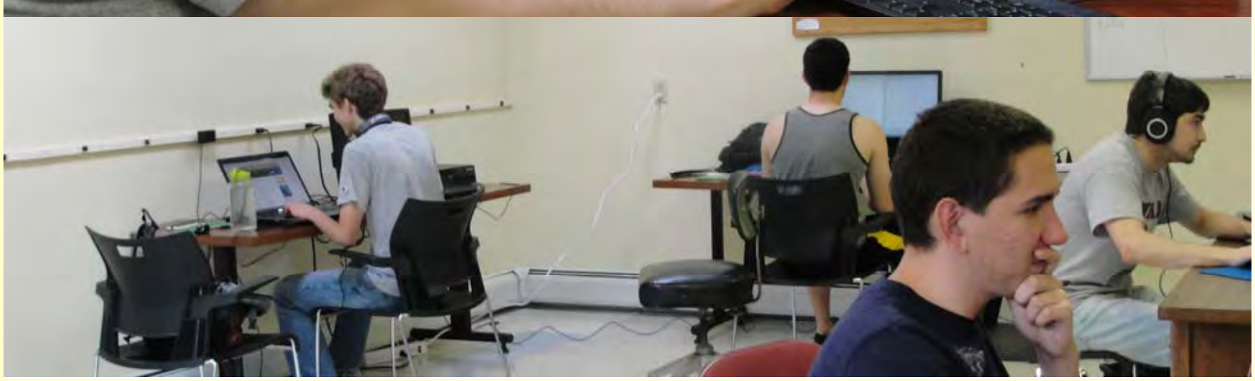
Guillermo Terrazas

The University of Texas at Austin
Mentors: Josh Gray, Eli Melaas, and Mark Friedl

Using remote sensing and the Urban Heat Island to understand the effects that global warming has on the phenology of vegetation

Climate change has altered the rhythm of the seasons. The study of these vegetative seasonal cycles is called phenology. For plants close to urban areas, the timing of both spring onset and autumn senescence is noticeably different than the surrounding rural region. This anomaly occurs because human development increases impervious surface areas, which reradiate infrared waves and increase the air temperature in what is known as the Urban Heat Island (UHI). The UHI presents the perfect proxy in order to investigate how the phenology of rural areas will behave in the future given the predicted rise in global temperatures. Understanding these effects is crucial, because even slight changes in the vegetative growing season has a significant impact in the atmosphere's carbon budget, water usage, and even the structure of entire ecosystems. In order to research the phenology of such large areas, we derive processed data transmitted by the Moderate-Resolution Imaging Spectroradiometer. This data contains information such as onset/senescence dates, land surface temperature, and land cover type. Although the data is provided for any place on Earth, we focus our research on the New England region. Computer algorithms are created in order to retrieve patterns between the phenology, temperature, and distance data. Results have confirmed the effect of the UHI on phenology, namely earlier start of season dates and later end of season dates, and therefore longer growing seasons. Although there is a correlation between distance from the urban center and phenology change, the main driving factor behind the change in phenology is temperature.



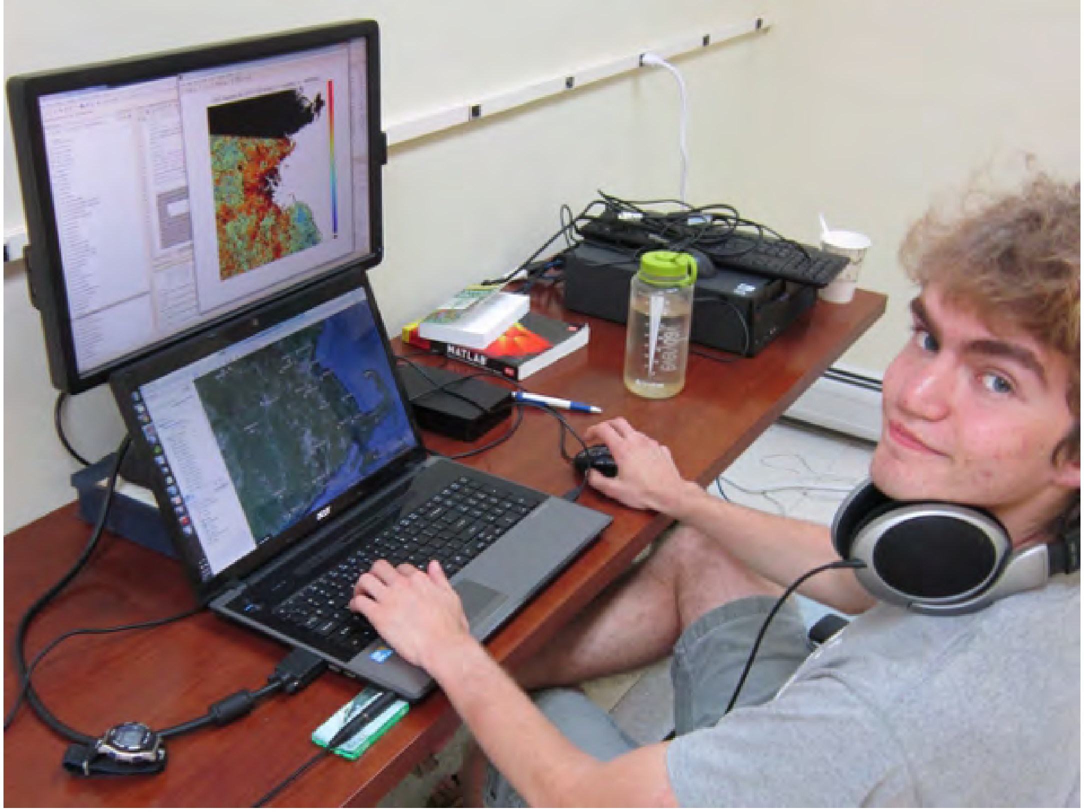


David Miller

Boston University
Mentor: Josh Gray, Eli Melaas, and Mark Friedl

Assessing and modeling the urban heat island's impact on deciduous vegetation phenology with Landsat

Deciduous vegetation phenology is directly affected by climate dynamics, and is a control on energy and carbon resources in forest ecosystems. It is responsive to temperature variations, such as those resulting from the urban heat island (UHI). Satellite remote sensing can evaluate interannual trends in the magnitude of the UHI's effect on phenology. Here, we used all available Landsat TM/ETM+ data from 1982-2011 to approximate yearly changes in spring and fall phenology of deciduous broadleaf forest, and quantified the intensity of the UHI with land surface temperature measurements for the Boston, MA metropolitan area. We have found that start of season (SOS) averages 8 days earlier and end of season 8 days later in high-temperature urban areas relative to nearby rural areas. In addition, we utilized daily air temperature data to predict SOS along the urban-to-rural gradient, and such models are capable of approximating interannual changes in SOS. We used Monte Carlo methods to seek parameters for a growing degree day model, the chosen model having a temperature threshold of 5° C, start day of year 90, and a GDD sum of approximately 225. When compared against Landsat-estimated SOS, the model had an RMSE = 7.4 days and R^2 = 0.25 for 1999 onward. These results enhance the spatial resolution of the UHI's impacts, and the UHI provides a unique glimpse at how forests may develop in the near future with increased temperatures.



Katherine Bennett

Ashburnham-Westminster Regional School District
Mentors: Andrew Richardson and Michael Toomey

K-12 Phenology Lessons for the *Phenocam* Project

In the fall of 2011, the Ashburnham- Westminster Regional School District became the first of five schools to join Dr. Andrew Richardson's *Phenocam* Network with the installation of a digital phenocam on the roof of Overlook Middle School in Ashburnham, Massachusetts. Our school district is now part of a network of near surface remote sensing digital cameras that send images of forest, shrub, and grassland vegetation cover at more than 130 diverse sites in North America to the digital archives at the University of New Hampshire. Our phenocam provides a digital image every half hour of the mixed deciduous/ coniferous forest canopy due north from the school. As a part of the *Phenocam* project, students at the K-12 level have expanded the scope of phenological monitoring that is part of the Harvard Forest Schoolyard Ecology Program protocol, *Buds, Leaves, and Global Warming*. In this protocol, students work with Dr. John O'Keefe to monitor buds and leaves on schoolyard trees to determine the length of the growing season, giving them the opportunity to be a part of real and important research concerning the critical environmental issue of climate change. Students involved in the *Buds, Leaves, and Global Warming* study have the opportunity to compare their ground data on the timing of budburst, color change, and leaf drop to the webcam images, from year to year and along longitudinal gradients. Lessons are being developed for comparing student data to GCC (Green Chromatic Coordinate- relative greenness) graphs extracted from the images, and satellite data. This project will greatly enhance the district STEM education initiative and further our goal of educating ecologically literate and concerned citizens.

Johanna Recalde

Pomona College
Mentor: Rose Ambramoff

The effects of soil warming and nitrogen fertilization on root phenology

Soils of northeastern forests serve as vital carbon (C) sinks, which are especially important in a time of rapid climate change. Driving the process of C accumulation and allocation in soils are roots, which are usually ignored in C estimates of forest soils. Due to climate change, soil warming and nitrogen fertilization may alter root processes such as growth, mortality, and mycorrhizal activity that drive C accumulation in soils. Changing root processes can result in changes in the timing and magnitude of C accumulation in the soil, such as earlier root growth in warmer soils that result in larger flux of C belowground. Thus, the purpose of this study is to gain better understanding of the effects of soil warming and nitrogen fertilization on root allocation and phenology by using a minirhizotron camera to take underground photos of roots in four different treatments: control, heated, nitrogen addition, and heated + nitrogen. In March through early July of 2013, there was no difference in root production between treatments (RM-ANOVA, $F=0.7365$, $p=0.6416$), suggesting that roots may have become acclimated to long-term soil treatments. While there was no significant effect of day of year on root production values, it is interesting to note that in the heated treatment, root growth began earlier, possibly due to earlier temperature cues. This suggests that as the climate warms carbon allocation to roots may increase, resulting in larger carbon storage in the absence of higher decomposition rates.

Arline Gould

University of Rhode Island
Mentor: Rose Abramoff

Species-specific differences in fine root and mycorrhizal phenology

In temperate forests, soil is potentially the largest and most long standing carbon sink. Fine root turnover is largely responsible for belowground C inputs, transferring much of the C allotted during seasonal growth into the soil via root mortality and exudation. An integral and even lesser understood portion of this cycle is the role of symbiotic fungi in delivering nutrients from the soil to plants as well as converting decaying plant material into soil. Utilizing the minirhizotron camera for *in situ* observation of roots and mycorrhizae, we will determine the varying seasonal patterns of root and mycorrhizal growth across stands dominated by *Fraxinus americana*, *Tsuga canadensis*, and *Quercus rubra*. The images captured with the minirhizotron will be analyzed using the open source software program, Rootfly. Preliminary analysis of 2012 minirhizotron data shows that there are differences in timing of root production between *Quercus rubra* and *Tsuga canadensis*. Full analysis will allow for a broader comparison of arbuscular *(F. americana)* versus ectomycorrhizal *(T. canadensis, Q. rubra)* dominated soils. Understanding the abundance, phenology, and functional roles of fine roots and symbiotic mycorrhizae is critical for understanding the controls on belowground C cycling. A more accurate description of seasonality in temperate forest soils will, in turn, provide a clearer picture of the impending effects of climate change.

Harvard Forest Personnel

» Staff

David Foster - Director

Research & Policy

Audrey Barker Plotkin - *Research Assistant*
Emery Boose - *Information Manager*
Betsy Colburn - *Aquatic Ecologist*
Elizabeth Crone - *Senior Ecologist*
Brian Donahue - *Environmental Historian*
Elaine Doughty - *Research Assistant*
Aaron Ellison - *Senior Ecologist*
Brian Hall - *Research Assistant*
David Kittredge - *Forest Policy Analyst*
Kathy Fallon Lambert - *Director of the Science & Policy Integration Project*
James Levitt - *Director of the Program on Conservation Innovation*
Liza Nicoll - *Research Assistant*
David Orwig - *Forest Ecologist*
Manisha Patel - *Lab Manager & Summer Program Coordinator*
Tristram Seidler - *Research Associate*
Kristina Stinson - *Community Ecologist*
Mark VanScoy - *Research Assistant*

Post-Doctoral Fellows

Benjamin Baiser
Greg Breed
Leone Brown
Joshua Rapp
Norah Warchola
Rui Zhang

Administration

Jeannette Bowlen - *Accounts Payable*
Laurie Chiasson - *Administrative Assistant*
Edythe Ellin - *Director of Administration*
Linda Hampson - *Administrative Assistant*
Julie Pallant - *System and Web Administrator*
Lisa Richardson - *Accounting Assistant*

Education

Clarisse Hart - *Outreach and Education Manager*
John O'Keefe - *Museum Coordinator (emeritus)*
Pamela Snow - *Schoolyard Program Coordinator*
Greta VanScoy - *Museum Assistant*

Woods Crew

Lucas Griffith
Oscar Lacwasan
Ronald May
Scot Wiinikka
John Wisnewski - *Woods Crew Supervisor*

» Affiliates

Harvard University

Stacey Combes - *Organismal & Evolutionary Biology*
Richard Forman - *Graduate School of Design*
Michele Holbrook - *Organismal & Evolutionary Biology*
Paul Moorcroft - *Organismal & Evolutionary Biology*
J. William Munger - *School of Engineering & Applied Sciences*
Anne Pringle - *Organismal & Evolutionary Biology*
Andrew Richardson - *Organismal & Evolutionary Biology*
Steven Wofsy - *School of Engineering & Applied Sciences*

Boston University

Adrien Finzi
Mark Friedl
Lucy Hutyra
Nathan Phillips
Anne Short
Pamela Templer

Marine Biological Lab

Jerry Melillo
Jim Tang

University of Massachusetts at Amherst

Jeffrey Blanchard
Elizabeth Chilton
David Kittredge
Lee Osterweil
Christine Rogers

University of New Hampshire

Serita Frey
Scott Ollinger
Eric Davidson - *Woods Hole Research Center*
Stephen DeStefano - *USGS Massachusetts Cooperative Fish and Wildlife Research Unit*
Brian Donahue - *Brandeis University*
Dianna Doucette - *Public Archaeology Laboratory*
Edward Faison - *Highstead*
David Fitzjarrald - *Atmospheric Sciences Research Center*
Danielle Ignace - *Smith College*
Bill Labich - *Highstead*
Barbara Lerner - *Mount Holyoke College*
Nsalambi Nkongolo - *Lincoln University of Missouri*
Wyatt Oswald - *Emerson College*
Shannon Pelini - *Bowling Green State University*
Evan Preisser - *University of Rhode Island*
Peter Raymond - *Yale University*
Sydne Record - *Smith College*
Cory Ritz - *NEON*
William Sobczak - *College of the Holy Cross*
Jonathan Thompson - *Smithsonian Conservation Biology Institute*
Christopher Williams - *Clark University*

Post-Doctoral Fellows and Graduate Students

Rose Abramoff - *Boston University*
Grace Barber - *UMass Amherst*
Elizabeth Burakowski - *U. of New Hampshire*
Allyson Lenora Degrassi - *U. of Vermont*
Israel del Toro - *UMass Amherst*
Josh Gray - *Boston University*
Danielle Haddad - *U. of New Hampshire*
Ahmed Hassabelkreem - *UMass Amherst*
Myroslava Khomik - *Clark University*
Steve Klosterman - *Harvard University*
Richard MacLean - *Clark University*
Eli Melaas - *Harvard University*
Laura Meredith - *MIT*
Eric Morrison - *U. of New Hampshire*
Grace Pold - *UMass Amherst*
Andrew Reinmann - *Boston University*
Jesse Sadowsky - *U. of New Hampshire*
Patrick Sorensen - *Boston University*
Michael Toomey - *Harvard University*
Melanie Vanderhoof - *Clark University*
James Wheeler - *Harvard University*

Summer 2013 Students


Mentor: Emery Boose
Shay Adams, Mt. Holyoke College


Mentor: David Kittredge
George Andrews, Worcester State University


Mentor: Allyson Degrassi
Amy Balint, Portland Community College


Mentor: Barker-Plotkin
Sophie Bandurski, Smith College


Mentor: Paul Siqueira

Lake Boddicker, Lake Forest Academy


Mentor: Emery Boose
Vasco Carinhas, University of Puerto Rico


Mentor: Paul Siqueira
Devin Carroll, UMASS Amherst

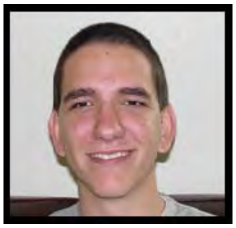

Mentor: Chris Williams
Lowell Chamberlain, SUNY ESF


Mentor: Shannon Pelini
Angus Chen, Oberlin College

Summer 2013 Students


Mentor: Rose Abramoff
Arline Gould, University of Rhode Island


Mentor: Andrew Richardson
Dmitri Ilushin, Harvard University


Mentor: Andrew Richardson
Arturo Martinez, Carnegie Mellon University


Mentor: Mark Friedl
David Miller, Boston University


Mentor: Paul Siqueira
Faith Neff, Humboldt State University


Mentor: Shannon Pelini
Justine Kaseman, Bowling Green State University

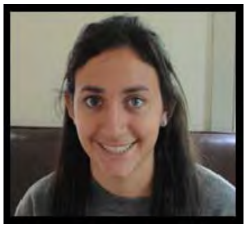

Mentor: Allyson Degrassi
James Leitner, University of Delaware


Mentor: David Kittredge
Leah Nothnagel, Minneapolis Comm. and Technical College


Mentor: Barker-Plotkin
Patrick O'Hara, Harvard University

Summer 2013 Students

Mentor: Barker-Plotkin
Christine Pardo, Florida International University



Mentor: J. William Munger
Channing Press, Villanova University

Mentor: Scott Saleska
Monica Allende Quiros, University of Puerto Rico

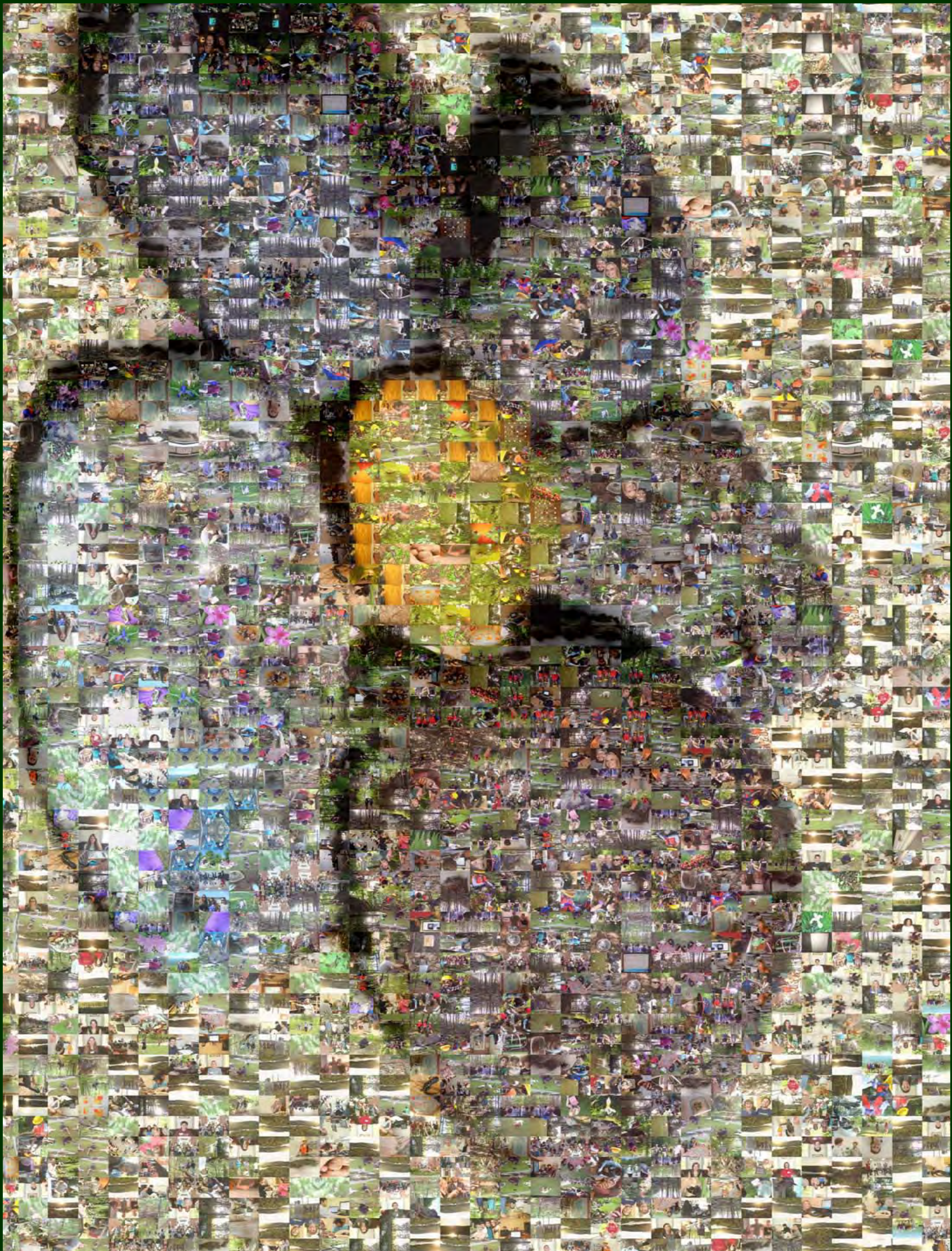
Mentor: Rose Abramoff
Johanna Recalde Quishpe, Pomona College

Mentor: Mark Friedl
Memo Terrazas, The Univ. of Texas at Austin

Mentor: David Orwig
Justin Vendettuoli, University of Rhode Island

Mentor: Chris Williams
Rebecca Walker, University of Virginia

Mentor: Barker-Plotkin
Hannah Weisner, Macalester College



RESEARCH—EDUCATION—INNOVATION

Recreation!