Harvard Forest Summer Research Program in Ecology

18th Annual Student Research Symposium Program

August 11-12, 2010

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Harvard Forest Fisher Museum
Petersham, Massachusetts

Photography by Maryette Haggerty Perrault, Aleta Wiley, Harvard Forest Staff, and 2010 Summer Researchers

Introduction to The 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 5000 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 5000-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 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.

About The Summer Student Research Program

In 2010, the Harvard Forest Summer Student Research Program, coordinated by Edythe Ellin and assisted by Maryette Haggerty Perrault and Aleta Wiley, attracted a diverse group of 34 students to receive training in scientific investigations and to gain 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 paths in science, and field exercises on soils, land-use history, nd plant identification. Students presented major results of their work at the Annual Summer Student Research Symposium in mid-August.

Summer Student Researchers 2010

Symposium Schedule

Wednesday, August 11, 1:00 p.m. – 5:00 p.m.

1:00 **Aaron Ellison** **Harvard Forest**
Welcome

Session I: Community Ecology

1:15	**Allison Gillette**	**Emerson College**	**Wyatt Oswald**
	Secrets of the mud: The hemlock mystery		
1:30	**Meredith Kueny**	**Cornell University**	**Audrey Barker Plotkin**
	The influence of legacy trees on forest regeneration after a severe wind disturbance		
1:45	**Lianna Lee**	**Mount Holyoke College**	**Audrey Barker Plotkin**
	Sprouting enables long-term persistence of trees damaged in a simulated hurricane		
2:00	**Carlyn Perovich**	**Tulane University**	**Ed Faison**
	Deer, moose, and oak regeneration in central New England forests		
2:15	**Milton Drott**	**Franklin & Marshall College**	**Ed Faison**
	Harvesting affects ungulate activity in surrounding intact forest		
2:30	**Roxanne Ardeshiri**	**University of California, Berkeley**	**Ben Baiser**
	Community assembly in relation to prey capture dynamics and the importance of biodiversity on ecosystem functioning of *Sarracenia purpurea*		
2:45	**Katherine Bennett**	**Ashburnham-Westminster Reg. School District**	**Aaron Ellison**
	The relationship of nectar production, anthocyanins and chlorophyll on *Sarracenia purpurea*		

~ BREAK ~

Session II: Cycling Carbon, Nitrogen and Water in the Forest Ecosystem

3:30	**Joanna Blaszczak**	**Cornell University**	**Jim Tang et al.**
	Soil carbon dynamics at Harvard Forest: An exploration of the abiotic and biotic drivers of soil respiration for future use in models		
3:45	**Claudia Reveles**	**Northern Arizona University**	**Jim Tang et al.**
	Soil carbon dynamics at Harvard Forest: Soil respiration variance in Prospect Hill Tract		
4:00	**Maya Thomas**	**University of Vermont**	**Jim Tang et al.**
	Soil carbon dynamics at Harvard Forest: Assessment of spatial relationships		
4:15	**Sarah Gray**	**Saint Norbert College**	**Sarah Butler et al.**
	Exploring the effect of soil warming on the level of nitrate reductase for different tree species		
4:30	**Sofiya Taskova**	**Mount Holyoke College**	**Emery Boose & Barbara Lerner**
	Software support for capturing digital data provenance		
4:45	**Morgan Vigil**	**Westmont College**	**Emery Boose & Barbara Lerner**
	Improving provenance capture using examples from hydrology		

<u>Symposium Schedule</u>

Thursday, August 12, 9:00 a.m. – 12:00 p.m.

Session III: Phenology & Physiology

9:00 **Corietta Teshera Sterne** **Mount Holyoke College** **Andrew Richardson**
A comparative study of digital image capture technology for phenological research

9:15 **Adam Young** **SUNY-ESF** **Andrew Richardson**
Processing digital webcam images to generate a clear phenological signal of forest canopies

9:30 **Andrea Garcia** **Humboldt State University** **Andrew Richardson**
Digital imagery reveals the effects of solar azimuth and altitude on the phenology of deciduous forests

9:45 **Lisa Chen** **Harvard University** **Jim Wheeler & Missy Holbrook**
Azimuthal variations in sap flux density suggest a trade-off between axial efficiency and tangential connectivity in tree vascular systems

10:00 **Sarah Choudhury** **Harvard University** **Jim Wheeler & Missy Holbrook**
Using Granier style thermal dissipation probes to analyze canopy-bole time lags and interspecies differences in daily sap flow patterns

~ BREAK ~

Session IV: Consequences of Climate Change

10.45 **Elisabete (Baker) Vail** **Simmons College** **Sydne Record**
Addressing uncertainties associated with computational models to improve the accuracy of forecasting species distribution response to climatic change

11:00 **Erik Oberg** **Texas A&M University** **Shannon Pelini & Israel del Toro**
Heat tolerances of northeastern United States ants explored to elucidate potential effects of climate change on forest ant populations and communities

11:15 **Margaurete Romero** **Saint Leo University** **Shannon Pelini & Israel del Toro**
How temperature will affect the ant, aphid, plant relationship

11:30 **Adam Clark** **Harvard University** **Shannon Pelini & Israel del Toro**
For ants on the Boston Harbor Islands, classical island biogeography explains island-scale species richness, but not where it came from or how it got there

11:45 **Sam Perez** **Harvard University** **Anne Pringle**
Decomposer fungi diversity decreases under nitrogen deposition but not warming

~ LUNCH ~

Symposium Schedule

Thursday, August 12, 1:00 p.m. – 4:30 p.m.

Session V: Humans in the Forest: From Wildlands to the City

1:00 **Madelon Case** **Princeton University** **Brian Hall & David Foster**
The influence of overstory characteristics on herb-layer diversity in New England forests

1:15 **Joseph Horn** **Unity College** **Brian Hall & David Foster**
An improved data management system for the Wildlands and Woodlands project at the Harvard Forest

1:30 **Autumn Amici** **University of Vermont** **Paige Warren**
Effects of an urbanization gradient on arthropod availability for nesting woodpeckers in Massachusetts

1:45 **Anthony Rivera** **Brown University** **Paige Warren**
Assessing noise pollution and sound propagation in three woodpecker species along urbanization gradient in central Massachusetts

2:00 **Leah Nagel** **Middlebury College** **Lucy Hutyra & Steve Raciti**
Urban-to-rural differences in tree growth rates: A comparison of native *Quercus rubra* and invasive *Ailanthus altissima*

2:15 **Israel Marquez** **San Diego State University** **Kristina Stinson**
Factors that help predict the distribution of ragweed in the New England Landscape

2:30 **Megan Jones** **Reed College**
Kristen Schipper **Calvin College** **Dave Kittredge**
What people do and who they talk to about it: Landowner decision-making and social networks in New Hampshire and Vermont

~ BREAK ~

Session VI: Carbon Dynamics of Temperate Forest Ecosystems

3:30 **Fiona Jevon** **Harvard University** **Leland Werden et al.**
Changes in understory vegetation composition and impacts on carbon sequestration in the Harvard Forest

3:45 **Crystal Garcia** **Baylor University** **Chris Williams**
Changes in vegetation composition of temperate forest following a clear cut at Harvard Forest

4:00 **Angela Marshall** **Clark University** **Chris Williams**
Harvest-induced elevation of coarse and fine woody debris imposes a legacy of carbon emissions: Comparison to pre-harvest and undisturbed forest

4:15 **Aaron Ellison** **Harvard Forest**
Tick Talk, and Closing

~ BARBEQUE ~

Effects of an urbanization gradient on arthropod availability for nesting woodpeckers in Massachusetts

Autumn A. Amici, *University of Vermont*
Mentor: Paige Warren

Urban sprawl and the resultant habitat loss have created a need for a new research focus. The encroachment of urbanization increases plant productivity and growth rate due to increased fertilizer use, changes the available habitat, and alters the species composition, such as through increasing exotic and decreasing native vegetation. Any of these events can greatly affect the prey availability for nesting woodpeckers. Woodpeckers and other cavity nesters are important components of ecosystems as they provide habitat for a suite of other species. The goal of this project was to assess the effect of various levels of urban development on arthropod food sources for three species of nesting woodpeckers: Downy Woodpecker (*Picoides pubescens*), Red-bellied Woodpecker (*Melanerpes carolinus*), and Yellow-bellied Sapsucker (*Sphyrapicus varius*) in central Massachusetts. I quantified food resources and nest provisioning along an urbanization gradient (wildland, small town, large town) using modified arboreal pitfall traps and nestling feeding observations, respectively. Preliminary results indicate that large town plots had the highest arthropod abundance, while small towns and wildland plots had the lowest arthropod abundance. A correlation between arthropod abundance and the number of visits shows a moderately negative trend. Understanding the impacts of urbanization on arthropod populations will provide crucial insight into the potential impacts of urbanization on woodpeckers and other wildlife, as well as future management goals, including city planning methods.

Community assembly in relation to prey capture dynamics and the importance of biodiversity on ecosystem functioning of *Sarracenia purpurea*

Roxanne Ardeshiri, *University of California, Berkeley*
Mentor: Ben Baiser

A pressing question that ecologists have mulled over is whether it is more important to invest conservation efforts on sustaining more taxonomically diverse communities, or ecologically diverse communities. This project aims to tackle that question through use of the Northern Pitcher Plant, *Sarracenia purpurea*, as a model ecosystem. We experimentally manipulated the Pitcher Plant inquiline community in the greenhouse to create treatments whose communities corresponded to varying levels of species richness and functional diversity. Decomposition of carpenter ant prey was then measured as an ecosystem response factor, and represents ecosystem functionality. Some unique aspects of this experimental design are that prey decomposition has never been measured as an ecosystem response factor in a Pitcher Plant community and that all species used in this experiment have a shared evolutionary history.

Aside from this project, we conducted a field experiment to observe how Pitcher Plant communities assemble themselves naturally and to see if increased prey capture leads to assembly of more diverse communities. Five field sites were set up at both Harvard Pond and Tom Swamp Bog. Each site contained a real Pitcher Plant, a fake Pitcher Plant, and a fake Pitcher Plant with pseudo nectar as an attractant for luring prey. After a 28-day period, a species and prey inventory was taken, and biodiversity was looked at between sites and treatments. The results show a significant difference in alpha diversity between the real and fake Pitcher Plant treatments, which are associated with high and low prey capture rates, respectively. Interestingly, there was a lower number of Diptera larvae present at Harvard Pond. The reason for this may be due to the presence of the Pitcher Plant moth, *Exyra fax*, which we found to have only colonized Pitcher Plants at Harvard Pond by the end of this experiment.

Addressing uncertainties associated with computational models to improve the accuracy of forecasting species distribution response to climatic change

Elisabete (Baker) Vail, *Simmons College*
Mentor: Sydne Record

Ecology has recently begun to depend heavily on the use of computational models to make predictions of how climate change will affect our planet. However, unaccounted "uncertainties" caused by inherent variation or often complete omission of projected data has led to disparity among current model forecasts, casting doubt on their presumed reliability. The greater project goal strives to improve the accuracy of these predictions, by evaluating relevant computer models and ultimately developing a new model that will address uncertainties currently overlooked by others. With a focus on the impact of how climate/species relationships will influence species distribution across both spatial and temporal scales, my role in this project was to create three test datasets, representing one present and two future climate scenarios of species-specific climatic variables for 27 local oak species. Each dataset contains the top five important variables for a given species, selected from 23 initial categories, using averaged results produced from 500 iterations of 1000 Classification and Regression Trees (CART). Species presence/absence data from over 50,000 Forest Inventory and Analysis (FIA) plots spanning the eastern United States were also included. Uncertainties sometimes caused by model type were compensated for by analyzing the datasets using an ensemble forecasting approach of nine models featured in the R based statistical software package – BIOMOD. I will present the process involved in creating the datasets along with the results for two oak species, *Quercus rubra* (red oak) and *Quercus virginiana* (water oak). Although these results were produced as reference data for the larger model development project, they yield interesting implications regarding the potential effect climate change may have on the distribution of important foundation species, such as oak, while further demonstrating the power models possess and the motivation behind investing effort into improving their accuracy.

The relationship of nectar production, anthocyanins and chlorophyll on *Sarracenia purpurea*

Katherine Bennett, *Ashburnham-Westminster Reg. School District*
Mentor: Aaron Ellison

The northern pitcher plant, *Sarracenia purpurea*, has adapted to its nutrient poor environment by developing pitcher shaped leaves that fill with rainwater. The plants possess extrafloral nectaries that secrete nectar to attract potential prey. Insects, especially ants, forage for this nectar and are trapped in the liquid contents of the pitcher. *Sarracenia purpurea* also displays a wide range of intricate red and green patterns that appear to correspond to available sunlight levels. Anthocyanin (red pigment) development is a response to light or heat stress, and acts as a "sunscreen," possibly resulting in a decrease in chlorophyll content, and less nectar production. We experimentally examined in the field during June and July 2010 the interactive effects of nectar availability, chlorophyll, and anthocyanin development and their resulting effect on prey capture. Fifteen green and fifteen red plants were selected for study and photographed. Five of each color were transplanted to the location of a plant of the opposite color to determine the plants' response to a significant change in light availability. Temperature and light level readings were taken at each plant. We sampled nectar at six locations on the front of one pitcher per plant before and after treatment. Nectar was analyzed colorimetrically for sugar concentration. Prey was extracted from pitchers weekly. Pitchers will be harvested at the end of the field season and photographed to determine percent of red coloration. Change in percent of red coloration on transplanted plants will be determined to measure the change in anthocyanin development in response to significant change in light levels. Percent of red coloration will be compared to light level readings, sugar concentration, and prey capture to determine possible correlations between anthocyanin production and light levels, anthocyanins and nectar production, as well as resulting prey capture.

Soil carbon dynamics at Harvard Forest: An exploration of the abiotic and biotic drivers of soil respiration for future use in models

Joanna Blaszczak, *Cornell University*
Mentor: Jim Tang et al.

The global terrestrial carbon flux is being influenced by many changing and interacting environmental factors including increased nitrogen deposition, temperature increases, and subsequent changes in terrestrial biomass production. Within global carbon pools, the soil carbon stock is the largest, containing more than twice the carbon as terrestrial vegetation or the atmosphere. In this project, we examined the effects of four different manipulation treatments on soil respiration through measurements of the rate of carbon dioxide efflux (μMol*$m^{-2}s^{-1}$) from the soil using a portable gas analyzer. The various experimental plots were sampled four times over the course of eight weeks on the Prospect Hill tract of Harvard Forest and the results were analyzed with ANOVA tests. We sampled a chronic nitrogen deposition experimental site that has been ongoing for 20 years and found no consistent statistical differences in soil respiration between the control and N addition plots (hardwoods: $p = 0.39$; pine: $p = 0.39$). We took measurements in the DIRT (Detritus Input and Removal Treatments) site to examine the effects of biomass changes on soil respiration and the results showed consistent significant increases in efflux rates with double litter fall as compared to a control plot ($p = 0.001$). We sampled in the soil warming chamber plots and found no significant differences between different temperatures or soil warming methods. Tree roots were excluded in trenched plots to separate out the heterotrophic (microbial) decomposition and autotrophic (root respiration) contributions to soil respiration rates. The efflux rates were only significantly higher in the control plots the fourth sampling round ($p = 0.012$). Soil respiration rates and their drivers are important to investigate before incorporating them into models making inferences about global carbon budgets. Future research should examine the interactive effects of the variables explored in this project.

The influence of overstory characteristics on herb-layer diversity in New England forests

Madelon Case, *Princeton University*
Mentors: David Foster and Brian Hall

The maintenance of biological diversity is a major focus of conservation projects because of potential effects on ecosystem health and stability. Much of the biodiversity in New England forests resides in the herb layer, so effective conservation management requires a clear understanding of the correlations between forest overstory composition and herbaceous diversity. Though general trends in the influence of overstory characteristics on understory diversity in temperate forests have been observed, few such studies have been done in New England. In this study, we established permanent 20x20 meter vegetation sampling plots at field sites in Petersham, MA; Strafford, NH; Dover-Foxcroft, ME; and Amherst, ME. We surveyed these plots for herbaceous species, tree and shrub species, and evidence of historical disturbance. I examined relationships between overstory characteristics and herb-layer diversity (measured in terms of richness and the Shannon diversity index) with correlation and regression statistics. Positive correlations were found between understory measures of diversity and balsam fir dominance, overstory species richness, overstory species evenness, and a weighted average of overstory shade tolerance. Hemlock dominance showed a negative correlation with understory richness and a positive correlation with understory evenness. The results of these analyses can provide forest managers with a useful tool for large-scale conservation management and biodiversity assessment.

Azimuthal variations in sap flux density suggest a trade-off between axial efficiency and tangential connectivity in tree vascular systems

Lisa Chen, *Harvard University*
Mentors: Missy Holbrook and Jim Wheeler

Different trees pull water at different rates as a function of xylem conduit size and associated vascular axial resistance. It is not known, however, whether axial resistance is correlated with hydraulic variation around the azimuth. In tree species with lower axial to tangential resistance, it is easier for water to move vertically instead of horizontally: this behavior predicts that greater variation in sap flow should be found in tree species with more hydraulically efficient vascular systems. Azimuthal variation of sap flux density measured using Granier's Thermal Dissipation Probe (TDP) system can serve as a proxy for how water is mixing at the trunk of a tree. Four or more probe pairs of Granier's TDP system were inserted into red oaks (*Quercus rubra*), white pines (*Pinus strobus*), and red maples (*Acer rubrum*). Measurements were taken from May through July 2010 in Petersham, MA. Mean, variance, and coefficient of variation (CV) were computed for and compared between the three species.

Results suggest the CVs of oaks are highly significantly different ($p < 0.01$) from that of pines or maples. The variances of all species were also found to be significantly different ($p < 0.05$) from each other. This is consistent with current knowledge about the vasculature of trees, and suggests that the highly efficient axial transport system supported by oaks comes at the price of reduced tangential communication. Such studies provide greater nuances in our understanding of different vascular evolutionary strategies of trees, as trade-offs are made between a tree's ability to pull large amounts of water for greater photosynthetic output and its ability to provide a more homogenous hydraulic environment that has enough flexibility to deal with the dynamics of cavitation.

Using Granier style thermal dissipation probes to analyze canopy-bole time lags and interspecies differences in daily sap flow patterns

Sarah Fouzia Choudhury, *Harvard University*
Mentors: Missy Holbrook and Jim Wheeler

Limitations in xylem transport capacity have a significant impact on rates of carbon uptake by forest trees. Although trees can offset such hydraulic limitations by drawing on water stored within the stem, a reliance on stored water is thought to be incompatible with high rates of xylem transport. We used Granier's style thermal dissipation probes to measure sap flow in oaks, maples and pines, with the goal of comparing temporal and spatial patterns of sap flow in species with markedly different xylem anatomies. By investigating time lags between the movement of water indicated by sap flow probes installed in the base of the tree and in the crown, we sought to determine if plants use water stored in their trunks to offset limitations in xylem transport capacity. The maples and pines show a crown - bole time lag that appears to be absent in the oaks. This suggests that the lags are biological in origin, and not an artifact of the probes themselves, as has been suggested. In the pines, the canopy sap flow varied between the East and West sectors, but the bole probe showed a more symmetrical pattern, indicating integration of flow and less sectoriality. Further study will help us understand daily patterns of water use and stomatal aperture by canopy species and thus will help elucidate how forest carbon and water exchange is affected by species composition.

For ants on the Boston Harbor Islands, classical island biogeography explains island-scale species richness, but not where it came from or how it got there

Adam Clark, *Harvard University*
Mentor: Shannon Pelini and Israel del Toro

The classical model of island biogeography proposed by MacArthur and Wilson in 1963 is among the most widely recognized theories in ecology. The concept of an equilibrium between immigration and extinction rates in island systems has provided the framework for many theories and models, particularly linking species richness to island isolation and area. While these variables have often been used to describe island-scale patterns of richness, less is known about how diversity varies within islands themselves. Using data collected as a part of the Boston Harbor Islands All Taxa Biodiversity Inventory, a five-year ongoing project surveying the arthropod diversity of the region, we have proposed two models describing ant species richness within the islands themselves: one based on classical island biogeography, and one on rarefraction. We found that models based on classical island biogeography consistently overestimate diversity within islands, suggesting that heterogeneous distribution of species across islands plays an important role even on very small scales.

Harvesting affects ungulate activity in surrounding intact forest

Mickey Drott, *Franklin & Marshall College*
Mentor: Ed Faison

In the last twenty years with the reappearance of moose and increase in deer populations in Massachusetts, the need for understanding the impacts of ungulate browsing on forest regeneration has become more pressing. This need is particularly important within and around timber harvests, which have increased greatly in recent decades across the state and often attract browsers. In addition there is some reason to think that parcelization may have reduced the average clearcut size. To assess the effect of harvesting on ungulate activity in surrounding intact forest, we examined browsing intensity and pellet pile densities of moose and deer at increasing distances from clearcuts (0m, 10m, 50m, 90m). In addition, we examined browsing and pellets at nearby interior forest plots that were more than 100 m away from a recent harvest or other clearing. Browsing intensity and pellet piles were compared among the five distance treatments and between "edge" forest sites less than 100 m from a clearcut and "interior" forest sites, more than 100m away from a clearing. Mean browsing intensity was significantly higher within clearcuts than at each of the distances in the surrounding forest, but ungulate activity did not differ by proximity to clearcuts among the forested sites. Browsing intensity and pellet pile density were higher overall in edge sites than in interior sites, although the differences were not quite significant. These results corroborate other studies that have previously documented higher ungulate densities within forest clearings, and our data indicate that the effects of timber harvesting on ungulate activity could be extending beyond cuts into the surrounding 100m of forest. Given these results, there is a need for further study on this question, which has potential implications for the implementation of new forest management practices to decrease the effects of ungulates on forests surrounding harvested areas.

Digital imagery reveals the effects of solar azimuth and altitude on the phenology of deciduous forests

Andrea Garcia, *Humboldt State University*
Mentor: Andrew Richardson

Phenological life cycles (such as bud-burst, flowering, and senescence) are known to be sensitive to various environmental factors including temperature and climate variability. Understanding other factors and the extent to which they can affect phenology is becoming increasingly important, especially in light of the current concerns of global climate change. We hypothesized that solar azimuth and solar altitude could be influential in the use of webcams as a tool for measuring forest phenology. We used digital images taken by webcams and processed them using R (2.11.1) in order to calculate the RGB values of a select region of interest for the images from two study sites: Harvard Forest (in Petersham, MA) and Morgan Monroe Sate Forest (near Bloomington, IN). We then used these RGB values to calculate an "excess green" index and a "percent green" index and tested the relationship between these values and solar altitude and solar azimuth. Initial linear regression analysis showed a strong correlation between the vegetation indices and solar altitude. However, a Shapiro-Wilk test demonstrated that the data were not normally distributed, disqualifying the initial linear regression results. A statistical test to determine the relationship between the vegetation indices and solar azimuth has yet to be determined. Further tests, including non-parametric regressions, should be conducted to fully determine the relationship between the vegetation indices and solar altitude and azimuth. By examining these variables, it may be possible to reasonably predict the extent to which phenological cycles can be influenced by environmental factors.

Changes in vegetation composition of temperate forest following a clear cut at Harvard Forest

Crystal Garcia, *Baylor University*
Mentor: Chris Williams

The classification of vegetative species present in the clear cut and the composition of the vegetation were examined in a fifteen acre site at Harvard Forest, Petersham Massachusetts. Formerly a Norway spruce (*Picea abies*) plantation, the site was cleared approximately two years ago. Post disturbance, vegetation follows recognized patterns of regrowth. The research site is in the early stage of forest succession, when we anticipate that shade intolerant pioneer species will be abundant and account for a large percentage of vegetative cover. We conducted a botanical inventory and assessed species-level vegetation density with a line-intercept transect method, as well as sapling/seedling plots to measure stem density. We also assessed the leaf area index of individual species. The data we collected was compared with Harvard Forest research scientist Audrey Barker Plotkin's pre-harvest data to evaluate changes in vegetation species and composition over the growing season. In addition we resampled the vegetation transects and seedling/sapling plots to capture changes in species and shifts in composition as the growing season ensued. We found that shrub species were most abundant and covered more than one third of the landscape. Woody debris also covered nearly a third of the clear cut. Pioneer species pin cherry (*Prunus pensylvanica*) and its associate species black cherry (*Prunus serotina*) had the highest stem densities. Comparison with pre-harvest data showed an increase in Allegheny blackberry (*Rubus allegheniensis*) and a decrease in herbaceous understory species. These results demonstrate high plant diversity by the second growing season following clearing. As the site enters later stages of succession our baseline data will serve as a basis for comparison as new plant species and shifts in percent composition emerge.

Secrets of the mud: The hemlock mystery

Allison J. Gillette, *Emerson College*
Mentor: Wyatt Oswald

Paleoecology - the study of past ecosystems - provides a valuable, long-term perspective, but its methods and key findings are not well understood by the general public. My work this summer at the Harvard Forest had two primary goals: First, I participated in the field and laboratory components of a paleoecological study of a site on Martha's Vineyard. We collected a sediment core from Black Pond and are analyzing pollen, charcoal, organic content, and chemistry to reconstruct past changes in vegetation, fire, and climate. Our preliminary findings indicate that this site, like others on Cape Cod and the adjacent islands, experienced an abrupt decline of oak and expansion of beech 5,500 years ago, synchronous with the decline of hemlock across much of eastern North America. The current mortality of oak across Martha's Vineyard due to the combined effects of drought and insect outbreaks may serve as an analogue for what took place along the New England coast 5,500 years ago. Second, I created a documentary film to share the methods and findings of this project with a general audience. My film shows how lake-sediment cores are collected, explains the laboratory procedures, and presents data and interpretations. The documentary features interviews with several paleoecologists and highlights hypothesized causes of the hemlock and oak declines. The film was created to inspire a general audience to learn more about paleoecology and science in general.

Exploring the effect of soil warming on the level of nitrate reductase for different tree species

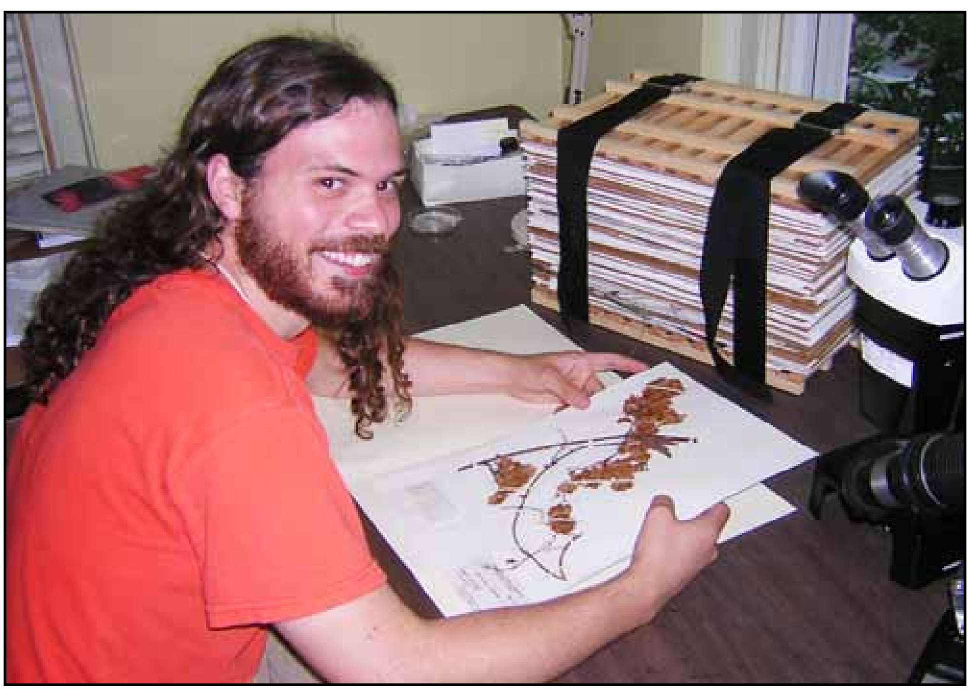
Sarah Gray, *Saint Norbert College*
Mentors: Sarah Butler, Rose Smith, Chelsea Vario, and Jerry Melillo

Nitrogen is the limiting nutrient in a New England forest; however, with increased soil temperatures and microbial activity, there is more nitrogen available to synthesize amino acids. An eight-year soil warming experiment at Barre Woods in the Harvard Forest has shown that, with increases in soil temperature, the rate of nitrogen mineralization, the conversion of organic nitrogen to ammonium, has also increased. The rate of nitrification, the conversion of ammonium to nitrate, increased as well. I wanted to determine the effect warming could have, for different species, on the rate of nitrate reduction into ammonium by nitrate reductase. I measured the activity of nitrate reductase, an enzyme that reduces nitrate to ammonium, in the overstory and understory by sampling leaves from oak (*Quercus rubra*), maple (*Acer rubrum*, *A. saccharum*), ash (*Fraxinus americana*), and birch (*Betula lenta*) tree species located in a plot heated 5 degrees above ambient soil temperature and a control plot. A greenhouse experiment was also carried out to measure the influence of added inorganic nitrogen, in varying amounts and ratios of ammonium and nitrate, on leaf and root nitrate reductase activities. Nitrate reductase activity was measured using an in vivo assay. Samples were incubated for 2 hrs in 5 mL of 40 mM KNO3 buffer. Color reagent was added after incubation and samples were read on a spectrophotometer at 540 nm. I found that *Q. rubra* had higher nitrate reductase activity in the overstory for both May and July than *A. rubrum*, and *F. americana*. In the understory *B. lenta* had higher nitrate reductase activity in June than *A. saccharum*, *A. rubrum*, and *Q. rubra*. *Q. rubra* in the control plot had higher nitrate reductase activity than the heated plot. Although these trends were shown none of the results were significantly different. The greenhouse results were inconclusive due to the lack of samples and amount of variance.

An improved data management system for the Wildlands and Woodlands project at the Harvard Forest

Joseph Horn, *Unity College*
Mentors: David Foster and Brian Hall

Correct and consistent plant identification is an important part of any plant ecology study. This is even more crucial when a given plot is to be sampled repeatedly over time as in a long-term monitoring program. Data compatibility through time and space can be challenging due to varying crew experience levels, official changes in plant nomenclature, and unclear or incorrect herbarium specimens and field guides. These problems can be minimized through well-organized data and species lists with site specific plant frequencies. To overcome these issues with the long-term ecological monitoring in the Wildlands and Woodlands program at Harvard Forest, a dynamic data entry and species list generator was created using Microsoft Access. The data entry system will improve data entry and consistency between years by automatically generating a standard six letter species code so that any mistake one sampling crew may make will automatically be resolved for future crews. The species list includes the frequency of occurrence in the study sites around New England as well as the Latin names, common names, the six-letter code for each species, as well as hotlinks to pictures and supporting information. The self-correcting database and the automatically generated species list will help future Wildlands and Woodlands sampling crews in gathering data that is correct and consistent with that of past years, and greatly reduce analysis preparation time.



Changes in understory vegetation composition and impacts on carbon sequestration in the Harvard Forest

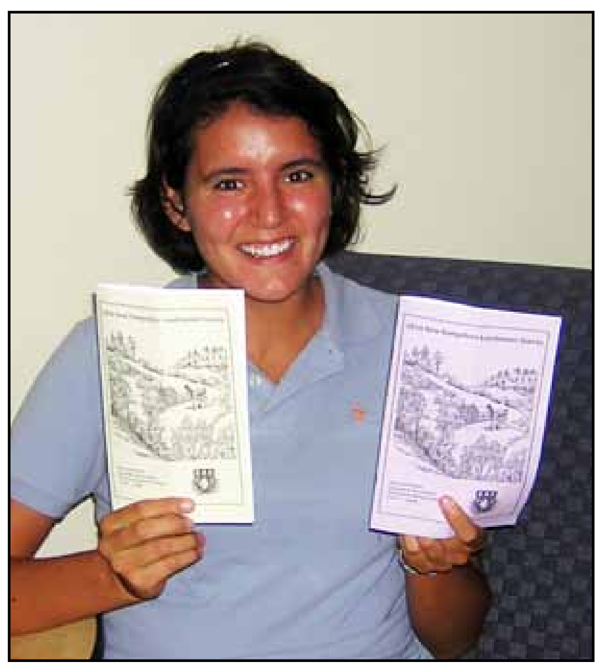
Fiona Jevon, *Harvard University*
Mentor: Leland Werden et al.

Over the last 21 years CO^2 exchange has been measured at the Harvard Forest EMS tower. There has been a systematic increase in the magnitude of C-uptake, which has also been observed in biometry plots that provide ground-based measurements of C pools. Meteorological data and changes in growing season length have not significantly contributed to the observed increase in C-uptake. We examined how the understory might contribute to this trend. We quantified the biomass of all understory species (1 cm ≤ DBH < 10 cm) in the 33 biometry plots and measured *in situ* photosynthetic rates of the dominant species using a LI-COR LI-6400. While the overall biomass of the understory has not changed significantly (2.38 ± .51 kgC/ha in 2006 and 2.27 ± .50 kgC/ha in 2010), the species composition has. Over the last four years the understory biomass of red maple (*Acer rubrum*) has decreased 0.18 kgC/ha while the biomass of red oak (*Quercus rubra*) has increased 0.15 kgC/ha. We found that some tree species, such as black birch (*Betula lenta*), have relatively high photosynthetic rates at lower light levels but others may be light-limited in the understory. The understory only accounts for 1.82% of the total aboveground C storage in the forest and may be light-limited during the peak of the growing season. Future measurements of photosynthetic rates at the beginning and end of the growing season, when understory species are not shaded out, will help determine the influence of these trees and shrubs on overall CO^2 exchange at Harvard Forest.

What people do and who they talk to about it: Landowner decision-making and social networks in New Hampshire and Vermont

Megan Jones, *Reed College,* and Kristen Schipper*, Calvin College*
Mentor: David Kittredge

Private landowners own nearly 70% of New England woodlands, and will therefore play a huge role in the future of this landscape. In order to better understand how private landowners manage their land, we used a survey to explore New Hampshire and Vermont landowner social networks and decision-making processes. Over a month-long period we sent two waves of surveys to 500 Vermont landowners and 500 New Hampshire landowners, and achieved a response rate of 50%. Half the landowners in each state received a longer survey and the other half received a shorter version to elicit information about different aspects of social networks. We estimate that woodland owners' social networks are composed of seven individuals on average. The majority of social networks were principally made up of family members, friends and neighbors. Loggers, foresters and conservation group members were less likely to feature in a social network, but when they did they were the most involved and most helpful people. In the past two years the most commonly made decisions were cutting of trees for personal use and enrolling in the current use property tax program. Those who cut trees for personal use, enrolled in current use, or did a conservation easement were more likely to be satisfied with that decision than those who sold land or sold timber commercially. Landowners in New Hampshire and Vermont were more likely to talk to family, friends and neighbors than to talk with experts. However, when landowners did talk to experts, these experts had a greater impact than non-experts. Landowners are actively managing and discussing their land; future research might explore landowner decisions that were not made recently or that are anticipated for the future, and interplay between different vectors of communication in landowner social networks.



The influence of legacy trees on forest regeneration after a severe wind disturbance

Meredith Kueny, *Cornell University*
Mentor: Audrey Barker Plotkin

Approximately every 50-100 years, a major hurricane makes it far enough up the east coast to create large paths of wind-disturbed forests and landscapes in New England. Hurricane disturbance consistently shapes affected areas, leaving most, but not all, of the canopy level trees blown over. This retrospective study, on 20 years of data collected from the Simulated Hurricane Experiment (1990), looks specifically at how legacy trees influence forest regeneration via their effects on sapling growth and distribution. The study site is 1.4 hectares (0.8ha experimental plot and a 0.6ha control plot) and dominant tree species are red oak and red maple. On the experimental plot 80% of trees were damaged to recreate the effects of a severe hurricane. To understand the influence of legacy trees, we examined how sapling basal area and density varied with proximity to red oaks, which are the main legacy trees in the site and still contribute more than 40% of the total stand basal area. We focused at the neighborhood level for this study. Sapling basal area and density were calculated on a $100m^2$ focal cell, and compared to oak influence (basal area) which was calculated in the surrounding $900m^2$ "neighborhood"; this was done with data from 2000, 2003, 2006, and 2009. Our analysis revealed that the residual, large oak trees were not exerting a strong influence on sapling growth and distribution. Although oaks are considered foundation species in their environment, playing a large role in perpetuating certain forest structures, oaks do not appear to structure forest regeneration at the neighborhood spatial scale examined. Understanding how legacy trees shape forest regeneration, and at what spatial scales, will be very important for predicting the future of New England forests as climate change increases the frequency of extreme weather events.

Sprouting enables long-term persistence of trees damaged in a simulated hurricane

Lianna Lee, *Mount Holyoke College*
Mentor: Audrey Barker Plotkin

This study evaluates the long-term survival and growth capacities of *Acer rubrum* and other tree species by sprouting in response to a simulated hurricane blowdown. Severe wind disturbance plays an important role in shaping New England forest structure and species composition. The Harvard Forest carried out an experimental blowdown treatment within a *Qurcus rubra – Acer rubrum* forest to replicate severe wind damage from the hurricane of 1938, and has evaluated ecosystem responses over 20 years. Selected trees were pulled over with a winch in the 0.8 ha experimental site that was paired with a 0.6 ha control site. Sprouting of hardwood trees was critical in the initial stabilization of ecosystem processes. Using the extensive datasets available in the twentieth year of this LTER study, I selected trees that had been damaged in 1990, had either basal, trunk or both types of sprouts in the following year, and continued to sprout in 2010. The total sample of 67 trees included 46 *A. rubrum* and 21 other hardwood trees. I recorded diameter at breast height (DBH) for each individual sprout. Basal area was calculated for each tree's sprouts, from the DBH measurements. Summed basal area in 2010 was used to calculate the mean change in basal area between 1990 and 2010. A mean change basal area change of >25% from 1990 to 2010 was considered meaningful. Sixteen of the 67 trees experienced basal area gain of 50% or greater, and eleven of these trees were *A. rubrum*. Overall, mean basal area declined significantly between 1990 and 2010 for non-*A. rubrum* species. In contrast, mean basal area for *A. rubrum* did not change significantly between 1990 and 2010. Sprouting has been a moderately successful form of persistence among the original damaged *A. rubrum* trees within the blowdown site, whereas other species have persisted but no recovered pre-manipulation basal area. Studies with an emphasis on the ecological significance of sprouting are still relatively new and further research about sprouting across varying damage regimes and geographical areas will provide new insights.

Factors that help predict the distribution of ragweed in the New England Landscape

Israel Marquez, *San Diego State University*
Mentor: Kristina Stinson

Ambrosia artemisiifolia, better known as common ragweed, is a plant that causes allergies such as hay fever. Mapping its distribution and understanding the environmental and human factors that can predict its presence is of vital importance in order to understand how allergy patterns might be affected with changes in land use and climate. The questions we are asking are how land use and temperature affect the distribution of ragweed and how this data can be used by public health authorities to analyze spatial distribution of ragweed on a changing landscape and climate. Because ragweed is an early successional plant that prefers disturbed soils, we hypothesized that there would be more presence in developed areas and farm fields. We also hypothesized that ragweed presence would be higher at warmer and drier climate temperatures. Using GIS, we created nine land cover per average minimum temperature (from 1970-2000) categories and collected presence/absence data from a number of random points across Massachusetts and New York. We are still in the process of collecting data from Vermont. We included census data to calculate population density per square kilometer in order to estimate development levels, household median income, and percentage of people living on farms. We used a classification and regression tree (CART) analysis to see what factors were more likely to predict presence of ragweed. So far, we have found that when using only GIS categories such as temperature, land cover and census data, the main factors predicting presence of ragweed are latitude, temperature and then longitude. In places where averaged minimum temperature is greater than 2.75 ˚F, longitude would be the next predicting factor. In places where averaged minimum temperature is lower than 2.75 ˚F, latitude would be the next predicting factor. We also found that when we combined GIS categories with field observations, agricultural fields, bare soils and longitude are the dominant predictors. We concluded GIS categories alone are sufficient for predicting temperature based variation in ragweed distribution, but easily collected field data are sensible predictors at smaller spatial scales, where farm fields and bare soils are highly identified as habitats for ragweed. Data can be use to create land use generalizations if spatial analysis is needed for public health or other issues of human and environmental concern.

Harvest-induced elevation of coarse and fine woody debris imposes a legacy of carbon emissions: Comparison to pre-harvest and undisturbed forest

Angela Marshall, *Clark University*
Mentor: Chris Williams

The fate of carbon stored on land is a key determinant in the rate and magnitude of climate change. Forests serve as large carbon stores, but are vulnerable to deforestation and associated emission. My research seeks to assess the role of on-site carbon storage in the form of woody debris as a component of the disturbance legacy in harvested forests. This study quantitatively assessed the woody debris composition at a post-harvest site in Harvard Forest, Petersham, MA. The results were compared to pre-harvest data as well as data from a nearby mature forest in order to evaluate the different amounts of woody debris between the sites/times. Woody debris at the clear-cut was measured using a plot method for coarse woody debris and a transect method for fine woody debris. The density of the fine and coarse woody debris was then calculated using volume equations, and compared to pre-harvest woody debris densities as well as densities in nearby mature forest sites. We found there to be 5 times the amount of coarse woody debris and 4.7 times the amount of fine woody debris at the disturbed site compared to the mature forest. Furthermore, there was 2.5 times more coarse woody debris post-harvest than pre-harvest. Harvest-induced elevation of woody debris imposes a long-term legacy of carbon gradually emitted over time. Thus, the harvested site can be expected to release elevated levels of carbon over time as the woody debris decays compared to the nearby mature forest. Deforestation disturbances can disrupt a landscape's carbon storage capacity by transforming sites from carbon sinks to sources. This can in turn increase atmospheric carbon and exacerbate global climate change.

Urban-to-rural differences in tree growth rates: A comparison of native *Quercus rubra* and invasive *Ailanthus altissima*

Leah Nagel, *Middlebury College*
Mentor: Lucy Hutyra and Steve Raciti

Urban ecosystems represent a complex mix of competing positive and negative influences on plant growth rates. In this study, we examined the growth rates of two deciduous tree species at the end points of an urban-to-rural gradient between Boston and the Harvard Forest. Red oak (*Quercus rubra*) is a mid-successional tree with a moderate growth rate found throughout the Northeast, while Ailanthus (*Ailanthus altissima*) is a very fast-growing, highly pollution-tolerant invasive that is found throughout North America and is often targeted for eradication. We cored and measured tree rings from both species in urban and rural locations to compare the ring widths, total and annual carbon sequestration, and growth rates as a function of tree size within species at opposite ends of the gradient and between species grown in the same location. The maximum ring width for Ailanthus was substantially higher than that of oak with widths of 1.31 and 0.93cm, respectively. However, the mean ring widths for Ailanthus were smaller than oak (0.16±0.06 as opposed to 0.19±0.01 cm), likely due to the differences in the mean size of the individuals sampled. Normalized by the mass of the individual tree, Ailanthus showed higher mean growth rates than oak, 14.90±3.25 and 5.79±2.33% yr^{-1}, respectively, and rural Ailanthus sequestered more carbon annually than oaks growing in a rural setting, (9.98±16.31 and 8.41±26.07 kgC). Sequestration rates as a percentage of overall size declined with tree size and age across the gradient, with Ailanthus individuals attaining large sizes much faster than oaks. Ailanthus is an invasive species, but it can account for ~25% of urban biomass (Nowak 2002); if extrapolated to the Boston area, this would represent 7 Mg C ha^{-1}. Efforts to remove all Ailanthus individuals due to its invasive status would result in the removal of a significant amount of sequestered carbon from the city that would not be replaced for decades.

Heat tolerances of northeastern United States ants explored to elucidate potential effects of climate change on forest ant populations and communities

Erik Oberg, *Texas A&M University*
Mentor: Shannon Pelini and Israel del Toro

In this study we determined the heat tolerances of northeastern United States ants and described related traits. Our overarching objective was to determine the highest temperature at which activity of New England ants becomes unfeasible. We hypothesized that heat tolerances of the ants tested from our study site, the Harvard Forest, would differ by species and be related to body size and ability to resist desiccation. Heat tolerance, changes in weight due to desiccation, and Weber's length were determined with in vitro experiments for each species tested. The heat tolerance experiment consisted of brief heat exposure to escalating temperatures using a digital dry bath. Heat tolerances ranged from 36 to 44 degrees Celsius and differed by species. Generally, higher tolerance was related to larger body size and ability to resist desiccation. Our study indicates sensitivity of certain important New England ant species to rising temperatures. We recommend, as climate change continues, ant populations and forest communities should be closely monitored for loss of key forest services, such as seed dispersal and wood debris breakdown, if ant heat tolerances are reached.

Decomposer fungi diversity decreases under nitrogen deposition but not warming

Sam Perez, *Harvard University*
Mentor: Anne Pringle

The soil microbial community, which consists of bacteria, protists and fungi are responsible for mediating the decomposition of dead organic matter. The process of decomposition releases nutrients into the soil for other organisms to use in development, physiological processes and reproduction. There is growing evidence that global change resulting from human disturbance may increase, reduce or compromise certain natural processes. However, the effects of global change on soil decomposers as warming and nitrogen deposition increase have not been documented. To document a potential change in the species diversity of decomposer fungi, plots were exposed to high levels of nitrogen deposition and soil warming at the Harvard Forest in Petersham, Massachusetts. We collected fruiting bodies to make species counts for the nitrogen deposition plots (control, low N deposition and high N deposition) and the soil warming plots (control, +5°C above ambient temperature). We took cultures of the fungi and slime molds found in the plots. There were lower numbers of species in the plots exposed to higher levels of nitrogen deposition than the control plots with no deposition. However, the number of species for the warming plots was unchanged in comparison to the control plot. This suggests that the effects of global change on the microbial community may affect the species composition significantly or not at all depending on the types of future global change.

Deer, moose, and oak regeneration in central New England forests

Carlyn Perovich, *Tulane University*
Mentor: Ed Faison

In the past several decades New England forests have seen both an increase in ungulate populations and a general decline in oak regeneration. Although studies have linked high deer densities to poor oak regeneration at a landscape scale, it remains unclear whether ungulate browsing is an important factor controlling oaks at a regional scale. Our objectives in this study were to (1) investigate the hypothesis that an increase in ungulate browsing is reducing oak regeneration in central New England forests and (2) examine other environmental variables that may influence oak regeneration.

We sampled 71 randomly located plots in central New England for oak seedling abundance and height, ungulate activity (browsing intensity and pellet counts), and other habitat characteristics including slope, aspect, overstory tree composition and basal area , shrub cover, and soils. We also examined broader land use characteristics such as forest fragmentation and calculated estimates of mean annual temperature for each plot. We analyzed oak seedling density in relation to several candidate models of predictor variables.

Our results indicate that oak seedling density increases with both mean annual temperature and ungulate relative density. While a positive correlation between ungulate browsing and oak seedling density is unexpected, it could be explained by a number of factors. Ungulate browsing pressure is generally moderate in our study region, and at that level it may offer oak seedlings a competitive advantage by reducing competition from other tree seedlings and shrubs that are less able to resprout than oaks after being damaged. It is also possible that ungulates are attracted to areas with higher densities of oak seedlings because of the abundance of available browse. Further study focusing on the effects of different densities of ungulates on the recruitment of oak seedlings could offer greater illumination on relationships between ungulate browsing and oak regeneration.

Soil carbon dynamics at Harvard Forest: Soil respiration variance in Prospect Hill Tract

Claudia Reveles, *Northern Arizona University*
Mentor: Jim Tang et al.

Soil respiration is comprises two components, root and microbial respiration. It is the second largest terrestrial carbon flux and has twice as much carbon than the atmosphere. The purpose of this project was to measure soil respiration over the Prospect Hill tract at Harvard Forest and its relationship to soil stand type and drainage type. There were a total of 56 sampling locations created from a map using GIS. Each of the 56 plots had a specific combination of tree species diversity and soil drainage type. Locations were sampled for soil respiration, soil moisture, and soil temperature every two weeks with a LiCor 6400 portable photosynthesis machine. Birch stands had the highest soil respiration when both soil temperature and soil moisture values were high, whereas pine stands had the lowest respiration rate when soil temperature and soil moisture was low. With respect to drainage type, well drained areas with high soil temperatures gave the highest rate of soil respiration. However, statistical analyses (ANOVA) showed no significant difference. This is a research project that will contribute to the ultimate goal of determining soil carbon loss for the Prospect Hill area.

Assessing noise pollution and sound propagation in three woodpecker species along urbanization gradient in central Massachusetts

Anthony Rivera, *Brown University*
Mentor: Paige Warren

Recent studies on the effects of urban noise on calling behavior have shown the adaptability of songbirds (suborder Passere). However, birds belonging to the order of Piciformes do not possess the same neurological adaptations that allow vocal flexibility. Rapid urbanization becomes problematic for these species, as communication is essential for survival and reproduction. This study examined sound environments around woodpecker nests for their impact on short-distance communication. I measured noise pollution along a suburban-rural gradient at nest sites of Red-bellied Woodpeckers (*Melanerpes carolinus*), Downy Woodpeckers (*Picoides pubescens*), and Yellow-bellied Sapsuckers (*Sphyrapicus varius*). Additional tests to examine sound propagation measured the amplitude of Downy Woodpecker calls between more urban versus more rural forests. Nests higher on the urbanization gradient experienced more anthropogenic noise disturbance, and vocalizations were able to propagate further. Trends suggest a difference in nest sites among species based on noise levels. Ultimately, we can begin devising a more intelligible approach to city planning for urban forests once further research is conducted on whether noise pollution or sound propagation has a greater effect on woodpecker communication.

How temperature will affect the ant, aphid, plant relationship

Margaurete Romero, *Saint Leo University*
Mentor: Shannon Pelini and Israel del Toro

Ants and aphids are mutualistic; aphids secrete a honeydew substance that the ants collect for carbohydrate in their diet, and in return the ants provide protection to the aphids. With rising temperatures occurring throughout the world, plants may be under more stress than they have been; this could change the relationship to the aphid pest by limiting certain nutrients, and in turn changing the relationship with ants that normally tend the aphid for their carbohydrate source. We proposed to see how rising temperatures would affect this ant, aphid, plant relationship and examine whether the ants would tend more to the aphid for more sugar or instead prey on them for protein source. In order to see whether temperature would change this mutualistic relationship, we placed four quaking aspen into each of the ten different chambers, which ranged from control (ambient air), +2°C, +4°C, and +8°C. The trees were either treated to allow for only ants, only aphids, for both, or for none to be on the plants. The plants were then observed for tending, which yielded only a *Tapinoma sp.* consistently tending aphids. Testing for stress of the plants with a fluorometer showed little range among plants within each of the chambers. Further research is needed to demonstrate the changing relationships between ants, aphids, and plants with global warming. Results will be crucial in understanding how natural pests will affect plants in the future.

Software support for capturing digital data provenance

Sophia Taskova, *Mount Holyoke College*
Mentor: Emery Boose and Barbara Lerner

Scientists perform complex analyses on massive data sets to address research questions. Insufficient documentation of the manipulations used for obtaining desired quantities from raw data may compromise confidence in the results. Scientists can increase the reliability and acceptance of their results by providing metadata that describes how the data was collected and processed, such as information on the equipment used, the time and location of the collection and manipulation of the data, computations applied to the data, and identification of when modeled values were substituted for measured values. To be consistent and complete, data provenance must be captured during the processing of the data of interest.

We worked with hydrologists in the Harvard Forest who are measuring precipitation, evapotranspiration and stream discharge to study the role of streams and wetlands in the ecosystem. Their data provenance concern is motivated in part by the need to recalibrate the sensors that output raw data. The automated collection of provenance information is imperative for identifying data items affected by the recalibration and is hence decisive for the reliability of the hydrological data. The solution that we propose to the problem of documenting data provenance uses a mathematical graph structure. We introduce two different graphs to represent the provenance of digital data. The Process Definition Graph (PDG) defines the possible ways in which data can be processed. The Dataset Derivation Graph (DDG) describes how a concrete piece of data was processed. We are working toward making the data collected by the software accessible to scientists via queries and visualization. Putting the software into practice will inform our future efforts for an optimal provenance capturing architecture.

A comparative study of digital image capture technology for phenological research

Cory Teshera-Sterne, *Mount Holyoke College*
Mentor: Andrew Richardson

Phenological researchers investigate how changing environmental factors will affect the duration and intensity of recurring organismal life-cycle events, such as the seasonal photosynthetic activity of a deciduous New England forest. Like many scientific disciplines, phenology has in recent years experienced significant changes in measurement techniques, from individual observations of small areas to large-scale and data-intensive satellite spectroradiometry measurements. A third approach, intermediate in cost and scale, is to observe study sites with networked digital cameras. Phenocam (*http://klima.sr.unh.edu*) is a national phenology observation network creating a database of digital images from cameras installed at research forests and National Parks. Image analysis, however, is affected by cameras designed to perform pre-processing to produce "higher quality" images, consequently retaining less of the raw color data needed for tracking photosynthetic activity. Post-processing can reduce these effects, but conflicts remain between researchers' needs and the capabilities of instruments generally optimized for surveillance applications. To determine the best equipment for this application, we installed fourteen cameras on the Harvard Forest EMS walk-up tower in a comparative experiment. The data captured by these cameras range from high-quality video from internet-enabled surveillance models to low-frequency time-lapse images from modified point-and-shoot consumer models. Several models were configured to compare photographic settings such as exposure and infrared capabilities. Future work will include evaluation of the cameras' performance and data quality after operation over a full field season, and will ultimately provide recommendations for future installations. In addition, camera- and satellite-derived data are being compared to validate digital image data and processing methods, with the goal of presenting this information in a form intended to expand the Phenocam website's usefulness to phenological researchers and the general public.

Soil carbon dynamics at Harvard Forest: Assessment of spatial relationships

Maya Thomas, *University of Vermont*
Mentor: Jim Tang et al.

While many studies utilize random sampling as a way to have an unbiased representative view of their study area, this study bases its sampling locations on unique combinations of forest attributes. To create these unique combinations, the first step was to use geographic information systems (GIS) to identify the different stand types and soil drainage classes in Prospect Hill. These two layers were joined and the largest polygons of each combination (well drained red maple stand, very poorly drained mixed red oak stand, etc.) were selected for the preliminary sampling site map. The center points of the selected polygons were used as a guide to finding an appropriate sampling plot and a global positioning unit (GPS) was used to obtain the new site coordinates. Soil respiration, moisture, and temperature were measured every other week for four weeks at each site location. A weighted average soil respiration for all of Prospect Hill, as well as for each of the soil drainage classes, was then calculated. The first, third, and fourth weeks had average soil respiration rates around 5.0 $\mu Mol*m^{-2}s^{-1}$, while the second week had a lower average of 3.7 $\mu Mol*m^{-2}s^{-1}$. Well drained areas had higher soil respiration values than very poorly drained areas. Well drained areas also had the most contribution to the overall average because they took up more than fifty percent of Prospect Hill in area and had the highest soil respiration values. Understanding the spatial distribution of soil respiration within the predominate combinations of forest attributes is important to more accurately estimate soil carbon losses from forested systems.

Improving provenance capture using examples from hydrology

Morgan Vigil, *Westmont College*
Mentor: Emery Boose and Barbara Lerner

Advanced sensor technology has drastically increased the amount of data researchers can collect in a short time span. Scientific results ensuing from these sensor data must be reproducible and reliable. However, tools or protocols that competently manage these data with the intent of facilitating data reproduction and reliability are lacking. A solution to this problem is data provenance, a record of the processes and tools used to refine raw data into information. A detailed record of the manipulations and systems used to process data into information allows a user to retrospectively trace information through the process, giving credence to the result of the process. By providing transparency to the data refinement process, software designed to collect provenance metadata can help data consumers trust results derived from sensor data.

Little-JIL, a visual programming language developed at the University of Massachusetts, Amherst, facilitates the collection of such provenance metadata by decomposing the process into individual steps. This discretization facilitates provenance metadata collection by making obvious where data is manipulated, thus assisting capture of the manipulations. From the characteristic steps of data read-in, verification, and manipulation this process was applied to the ecological example of collecting hydrology data from various sensors (and other sources) around Harvard Forest to understand the water budget of a forest watershed. Continuing research begun last summer, research performed this summer has improved the Little-JIL process as a provenance-collecting tool by adding several data collection steps, designing a GUI for users, and abstracting the process to allow for multiple types of gauges. Future research seeks to continue this development as well as address questions that may arise about the provenance of the data – such as the types of equations used, intermediate measures made for individual gauges, and how sensor drift was handled for a particular data set.

Processing digital webcam images to generate a clear phenological signal of forest canopies

Adam Young, *State University of New York, ESF*
Mentor: Andrew Richardson

Phenology is the study of recurring life cycle events which have previously been studied with individual observations and satellite remote sensing. Digital webcams have the potential to become an effective tool for measuring the phenology of forest canopies. We used the Phenocam website (*http://klima.sr.unh.edu/*) to download pictures taken throughout the year from several coniferous and deciduous sites. Annual and diurnal time series were evaluated at each site. We determined an appropriate Region of Interest for each site from which Red, Blue, and Green color channels were extracted. Specified vegetation indices, excess green and percent green, were calculated using these extracted color channels. Bad weather and early morning pictures had lower and much more scattered vegetation index values, providing a less clear signal. These images were filtered out using a moving window that calculated the 90th percentile and a running mean. We developed an effective processing algorithm that uses the vegetation indices and filters out the bad weather days. This algorithm provides a clear phenological model. Understanding the structure and function of forests can be greatly increased by examining forest canopy dynamics. The ability and versatility in processing images of forest canopies supports the use of webcams in studying the phenology of forests.

2010 Student Seminars and Programs

May 27	Reading the New England Landscape: A Walk in the Woods	**David Foster**
June 10	Data/Model Fusion	**Aaron Ellison**
June 11	Harvard Museum of Natural History Behind-the-Scenes Tour	
June 15	Woodland Owner Behavior and Change in the Forest	**Dave Kittredge**
June 16	Ethics Lunch: "The Statute of Limitations" - *on collaboration and authorship*	
June 22	Ethics Day	
June 24	Carbon Metabolism Across Urban-to-Rural Gradients	**Lucy Hutyra**
June 25	Ethics Lunch: "Planning an Invasion" - *on experimental design*	
July 8	How Disturbances in the Amazon Relate to Harvard Forest	**Chris Neill**
July 9	Ethics Lunch: "Endangered Species and Landowner Rights" - *on woodpeckers, habitat and management*	
July 13	Why Should I Trust Your Data?	**Barbara Lerner**
July 15	Service & Career Day	
July 16	Ethics Lunch: "The Big Story" - *on science and the media*	
July 20	Sustaining a Wood-Wide Web in a Changing World	**Alix Contosta**
July 27	Scientific Presentation Workshop	**Dave Orwig**
July 28	Graduate Student Panel	
August 3	Scientific Abstract Writing Workshop	**Clarisse Hart**
August 6	Ethics Lunch: *on data archiving, management, and the public domain*	

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National Science Foundation

1. LTER IV: Integrated Studies of the Drivers, Dynamics, and Consequences of Landscape Change in New England (DEB-0620443)

2. Ecosystem Responses to Progressive and Rapid Climate Change During the Holocene in New England (DEB-0815036)

3. REU Site III: Harvard Forest Program in Forest Ecology: Multi-Scale Investigations of a Forested Ecosystem in a Changing World (DBI-0452254)

4. 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)

5. Collaborative Research: Moths, Ants, and Carnivorous Plants: the Spatial Dimension of Species Interactions (DEB-0541680)

US Department of Energy

1. National Institute for Climatic Change Research and Pennsylvania State University – Improving forecasts of species' responses to climatic change: Hierarchical Bayesian analysis of tree distributions and abundance across space and time (3892-HU-DOE-4157)

2. Terrestrial Carbon Program: Detection of Long-Term trends in Carbon Accumulation by Forest in Northeastern U.S. and Determination of Causal Factors (DE-FG02-07ER64358)

3. Department of Energy and Univ. 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)

Other Funders

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Blue Hills Foundation

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Personnel at the Harvard Forest - 2010

Audrey Barker Plotkin	Site and Research Coordinator
Michael Babineau	Summer Field Technician
Mackenzie Bennett	High School Research Intern
Emery Boose	Information & Computer System Manager
Jeannette Bowlen	Accountant
Gerald Breault	Summer Field Technician
Chelsea Carr	High School Research Intern
Laurie Chiasson	Financial Assistant/ Receptionist
Elizabeth Colburn	Aquatic Ecologist
Samuel Cohen	Bullard Fellow
Sheila Connor	Archivist
Elizabeth Crone	Senior Ecologist
Quentin Cronk	Bullard Fellow
Elaine Doughty	Research Assistant
Israel Del Toro	Graduate Student
Xioajun Du	Bullard Fellow
Edythe Ellin	Director of Administration
Aaron Ellison	Senior Ecologist
Kathy Fallon Lambert	Science & Policy Integr-tion Project Director
Christian Foster	Summer Field Technician
Ava Foster	High School Research Intern
David Foster	Director
Kyle Gay	Summer Field Technician
Lucas Griffith	Maintenance Technician
Maryette Haggerty Perrault	Summer Resident Advisor
Brian Hall	Research Assistant
Linda Hampson	Staff Assistant
Clarisse Hart	Outreach and Development Manager
Jeffrey Hutchins Jr.	Summer Field Technician
David Kittredge	Forest Policy Analyst
Sarah Klein	Summer Assistant Cook
Oscar Lacwasan	Maintenance Technician
James Levitt	Director, Program on Conservation Innovation
Heidi Lux	Research Assistant
Tamara Martz	Summer Field Technician
Ron May	Maintenance Technician
Chris Neill	Bullard Fellow
Liza Nicoll	Research Assistant
Nathan Nkongolo	High School Research Intern
Nsalambi Nkongolo	Bullard Fellow
John O'Keefe	Museum Coordinator
David Orwig	Forest Ecologist
Wyatt Oswald	Paeloecology Lab Coordinator
Julie Pallant	System and Web Administrator
Michael Pelini	Research Assistant
Shannon Pelini	Post Doctoral Fellow
Jennifer Popham	Summer Maintenance Crew
Sydne Record	Postdoctoral Researcher
Lisa Richardson	Accounting Assistant
Michael Scott	Maintenance Technician
Sabrina Smith	Maintenance Crew
Pamela Snow	Environmental Educator
Kristina Stinson	Staff Scientist/ Population Ecologist
Jonathan Thompson	Post Doctoral Fellow
P. Barry Tomlinson	E.C. Jeffrey Professor of Biology, Emeritus
Mark VanScoy	Research Assistant
Judith Warnement	Librarian
Scot Wiinikka	Maintenance Technician
Aleta Wiley	Summer Resident Advisor
John Wisnewski	Maintenance Technician
Tim Zima	Summer Cook

Harvard University Affiliates

Peter del Tredici	Arnold Arboretum
Richard T.T. Forman	Graduate School of Design
Charles H.W. Foster	Harvard Kennedy School
N. Michelle Holbrook	Organismic & Evolutionary Biology
Paul Moorcroft	Organismic & Evolutionary Biology
William Munger	Div. Engineering & Applied Sciences
Steven Wofsy	Div. Engineering & Applied Sciences

2010 Summer Research Program Students

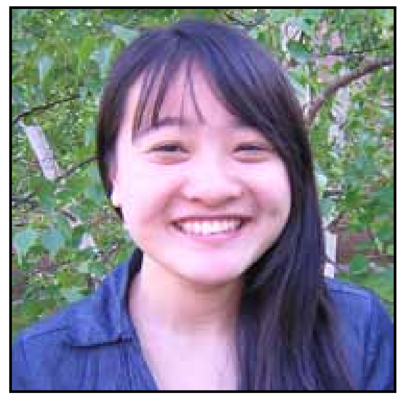
Autumn Amici
U. of Vermont

Roxanne Ardeshiri
U. of California, Berkeley

Elisabete (Baker) Vail
Simmons College

Joanna Blaszczak
Cornell University

Maddy Case
Princeton University



Lisa Chen
Harvard University

Sarah Choudhury
Harvard University

Adam Clark
Harvard University

Mickey Drott
Franklin & Marshall

2010 Summer Research Program Students

Andrea Garcia
Humboldt State University

Crystal Garcia
Baylor University

Allison Gillette
Emerson College

Sarah Gray
Saint Norbert College

Joseph Horn
Unity College

Fiona Jevon
Harvard University

Megan Jones
Reed College

Meredith Kueny
Cornell University

Lianna Lee
Mount Holyoke College

2010 Summer Research Program Students

Israel Marquez
San Diego State University

Angie Marshall
Clark University

Leah Nagel
Middlebury College

Erik Oberg
Texas A&M University

Sam Perez
Harvard University

Carlyn Perovich
Tulane University

Claudia Reveles
Northern Arizona University

Anthony Rivera
Brown University

Margaurete Romero
Saint Leo University

2010 Summer Research Program Students


Kristen Schipper
Calvin College


Sofiya Taskova
Mount Holyoke College


Cory Teshera-Sterne
Mount Holyoke College


Maya Thomas
University of Vermont


Morgan Vigil
Westmont College


Adam Young
State University of New York - ESF


Julianne Henry
UMass, Dartmouth

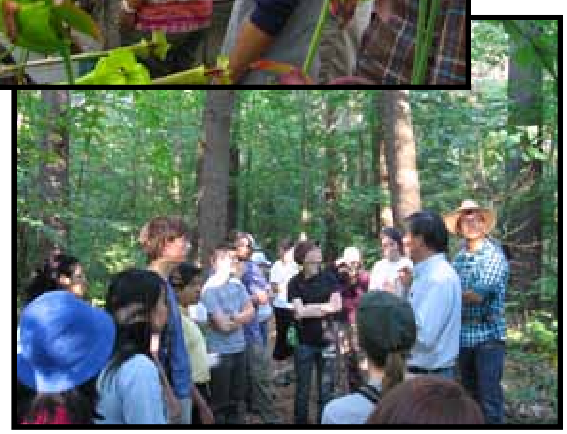

Maryette Haggerty Perrault
Raup House Proctor


Aleta Wiley
Fisher House Proctor

Pizza Party in Raup House just after move in!

Oh how we'll miss Tim's desserts

Orientation



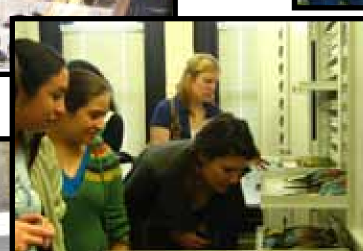
Starting to explore the forest!

Clockwise: atop the Walk-Up Tower; in the Greenhouse; wandering the trails with Brian Hall; learning about past land use from Director David Foster

Harvard Forest Events

Ethics & Career Days

NSF Site Visit



Exploring the Harvard Museum of Natural History

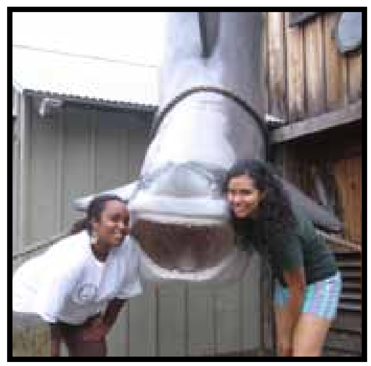
Service Day at The Trustees of Reservations

Around the Forest

Cookouts, beefalo, black-berries, mealtime on the weekends, campfires & game night

Adventures Outside the Forest

Peace Pagoda & Montague Bookmill



Six Flags New England

Mt. Monadnock, NH

Canobie Lake Park, NH

Salem, MA: At the Bewitched statue & stuck in the stockades

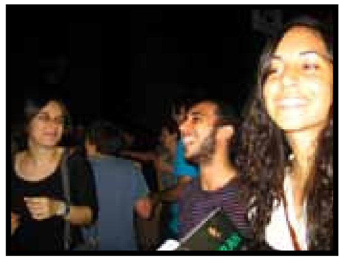
Taking a swing at the batting cages

Bluegrass concert at the Iron Horse in Northampton, MA

Dr. Seuss National Memorial Sculpture Garden in Springfield, MA

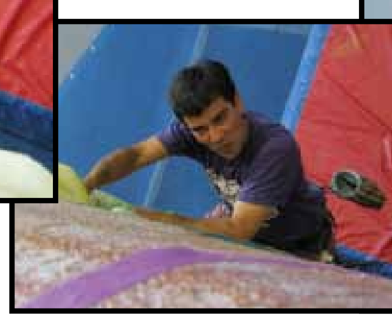
"I am the Lorax. I speak for the trees!"

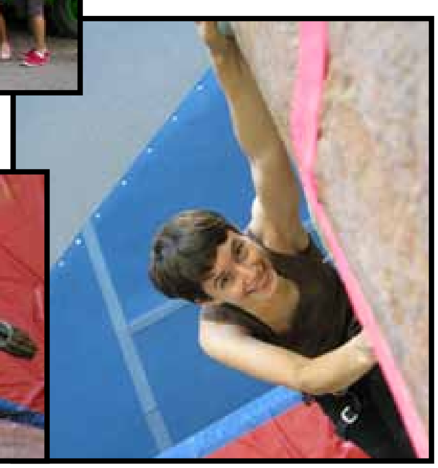
City of Cambridge Outdoor Dance Party



Camping trip to Burlington, VT area--not complete without a trip to Ben & Jerry's!

Playing on the shores of Lake Champlain

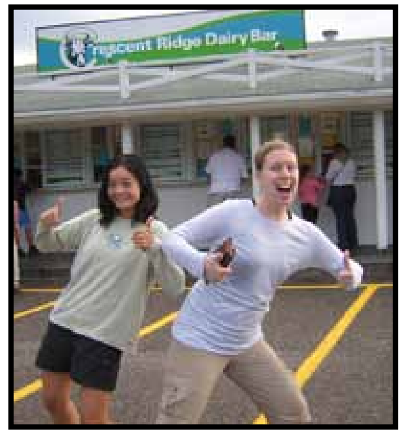




Indoor Rock Climbing in Worcester, MA

Hiking in the Blue Hills Reservation Milton, MA

Excited for ice cream after a hike



Whale watching in Stellwagen Bank, from Gloucester, MA

Contra Dancing in Greenfield, MA