Harvard Forest
Harvard University

2011 Summer Research Program in Ecology

Symposium Abstracts

August 3-4, 2011

The Harvard Forest Summer Research Program in Ecology is an opportunity for a diverse group of students to participate in 11 weeks of mentored research.

19^{TH} ANNUAL HARVARD FOREST SUMMER RESEARCH PROGRAM SYMPOSIUM

3-4 August 2011

HARVARD FOREST
FISHER MUSEUM

Photography by Moshe Roberts & Relena Ribbons, Harvard Forest Staff and 2011 Summer Program Participants

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, along with current literature in the Fisher Museum and Harvard Forest library.

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. 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 2011 Summer Student Research Program

This year, the Harvard Forest Summer Student Research program, coordinated by Edythe Ellin and assisted by Relena Ribbons and Moshe Roberts, attracted a diverse group of thirty one students to receive training in scientific investigations, and experience in long-term ecological research. All students worked closely with researchers while conducting their own independent projects. The program included weekly seminars from resident and visiting scientists, discussions on current ethics issues in science, and field exercises on navigation, land-use history, and plant identification. Students presented their projects, progress, and major results of their work at the Annual Summer Student Research Symposium in August.

The Summer 2011 Students

FUNDING FOR THE 2011 SUMMER RESEARCH PROGRAM IN ECOLOGY

The Harvard Forest Summer Research Program in Ecology in 2011 was supported by the following organizations:

<u>National Science Foundation</u>
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. RAPID: Regional and Landscape Initiatives at Harvard Forest LTER (DEB-0952792)
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)
6. FSML: Infrastructure for molecular and microbial ecology at the Harvard Forest (DBI-0930516)

<u>US Department of Energy</u>
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)

<u>Other Funders</u>
US Environmental Protection Agency, Predicting Regional Allergy Hotspots in Future Climate Scenarios (RD-83435901-0)

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

Mount Holyoke College – 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.

19TH ANNUAL HARVARD FOREST SUMMER RESEARCH PROGRAM SYMPOSIUM

3 - 4 AUGUST 2011 FISHER MUSEUM

Wednesday, 3 August. 9:00 a.m. – 5:00 p.m.

9:00	Aaron Ellison			Welcome

Session I: Disturbance and Forest Dynamics (Moderator: Melanie Vanderhoof)

9:15	Katharine Chute	Harvard College	Williams & Vanderhoof	A survey of vegetation growth, density, and species composition in an early-successional temperate forest
9:30	Marcus Pasay	Clark University	Williams & Vanderhoof	Post-Disturbance Dynamics of Carbon, Water and Energy Fluxes Between Land and Atmosphere
9:45	Jakob Lindaas	Harvard College	Munger & Werden	Fine Woody Debris Dynamics after an Ice Storm Disturbance Event in Harvard Forest

BREAK

Session II: Microbial composition and ecosystem function (Moderator: Lindsay Scott)

10:15	Rachel Brooks	University of Vermont	Ellison, Gotelli & Ballif	Proteomic signatures of experimentally manipulated pitcher plant communities and their corresponding state changes
10:30	Alanna Yazzie	San Juan College	Melillo, Scott, Baldino & Werden	Addressing forest soil microbial composition and function in a warmer world
10:45	Tara Mahendrarajah	University of Massachusetts	Blanchard	Using genomic methods to address microbial community function in experimentally warmed soils
11:00	Kelden Pehr	Massachusetts Institute of Technology	Blanchard	Acidiobacteria and Proteobacteria Found to Dominate Harvard Forest Soil Samples
11:15	Deepa Rao	Massachusetts Institute of Technology	Meredith	Studying the Hydrogen Soil Sink at the Harvard Forest through Isolation of Streptomyces and Flux Chamber Work
11:30	Julianna Brunini	Harvard College	Tang, Yu & Savas	Assessing the Importance of Various Biotic and Abiotic Factors in Soil Respiration Modeling
11:45	Moussa Bakari	Lincoln University	Tang, Yu & Savas	Soil carbon dynamics and its controls across gradient floor of Harvard Forest
12:00	Leticia Delgado	Northern Arizona University	Tang, Yu & Savas	Soil Respiration and Its Response to Manipulation Treatments

LUNCH

Session III: Biotic interactions with climate change (Moderator: Koen Hufkens)

1:30	Samuel Safran	Middlebury College	Stinson & Record	A regional ragweed distribution survey: Identifying factors that predict ragweed presence
1:45	Linn Jennings	Mount Holyoke College	Stinson & Record	A Demographic Study of A. artemisiifolia Across a Rural to Urban Gradient in Massachusetts
2:00	Laura Hancock	Christopher Newport University	Stinson & Record	Predicting Ragweed Allergy Hotspots: How Elevated CO2 Effects Different Ecotypes of *Ambrosia artemisiifolia*
2:15	Natashia Manyak	University of Massachusetts	Pelini & DelToro	Warming Effects on Ants Soil Movement and Mortality Rates
2:30	Michael Marquis	Arizona State University	Pelini & DelToro	Warming does not affect colony growth or mutualistic association with ants in the aphid *Chaitophorus populicola*
2:45	Kevin Towle	University of Notre Dame	Pelini & DelToro	The Role of Competition in Shaping Local Ant biodiversity and Community Dynamics

BREAK

Session IV: Climate change impacts on phenology and ecosystem processes of Northeastern forests (Moderator: Oliver Sonnentog)

3:30	Lakeitha Mitchell	Lincoln University	Richardson, Friedl, Keenan & Sonnentag	Observing Phenological Events in Vegetation through Technological Methods
3:45	Rachel Norman	University of North Carolina	Richardson, Friedl, Keenan & Sonnentag	Observing Phenological Events in Vegetation through Technological Methods
4:00	Isaac Lavine	Lafayette College	Richardson, Friedl, Keenan & Sonnentag	Observing Phenological Events in Vegetation through Technological Methods
4:15	Katherine Bennett	Ashburnham-Westminster Reg. School District	Richardson, Friedl, Keenan & Sonnentag	Student Scientists : Monitoring phenology with the Phenocam Network in K-12 schools
4:30	Elizabeth Felts	Harvard College	Richardson, Friedl, Keenan & Sonnentag	Is Digital Cover Photography a Viable Method for Calculating Leaf Area Index For Phenological Research in Closed Forest Canopies?
4:45	Bridget Darby	Boston University	Richardson, Friedl, Keenan & Sonnentag	Do physiological changes at leaf level explain the increase in canopy greenness over the growing season?

Thursday, 4 August 9:00 a.m. – 12:15 p.m.

Session V: Long-term Forest and Land Dynamics (Moderator: Audrey Barker Plotkin)

9:00	Ashley Golphin	Kent State University	Phillips, Ryan & Warren	To Green or Not to Green: Urban Greening and Human Behavior
9:15	Stephan Bradley	Lincoln University	Phillips, Ryan & Warren	Urbanization & Land Use Change Dynamics
9:30	Lauren Lynch	University of Massachusetts	Phillips, Strohbach & Warren	Arthropod abundance, population dynamics and predator-prey interactions in urban and rural model ecosystems
9:45	Collette Yee	Skyline College/ San Mateo College	Barker Plotkin	Red Maple Growth Rate Responds to Environment, Not Competition
10:00	Katherine Eisen	Amherst College	Barker Plotkin	Red oak dominance and understory development in a temperate northeastern forest support the continuation of the regional carbon sink
10:15	Lindsay Day	Emerson College	Oswald	History of New England Vegetation: Pollen Morphology of Eastern Hemlock in New England Lake-Sediment Records

BREAK

Session VI: Hydrology: from trees to watersheds (Moderator: Emery Boose)

11:00	Alena Tofte	Harvard College	Holbrook & Wheeler	Diurnal Dynamics of Stem Conductance
11:15	Andrew Kaldunski	Ripon College	Boose & Lerner	Using Little-JIL to Model Complex Scientific Processes
11:30	Sofiya Taskova	Mount Holyoke College	Boose & Lerner	Capturing, persisting, and querying the provenance of scientific data
11:45	Garrett Rosenblatt	University of Rochester	Boose, Lerner & Osterweil	A Study of Scientific Workflow Systems and Their Interoperability
12:00	Aaron Ellison	Harvard Forest		Closing

2011 Seminars and Programs
Harvard Forest Summer Research Program in Ecology

Wed., May 25	Using data and models in ecology – David Moore, NEON
Tues., May 31	Taste of Orange – Kirby Lecy, Program Coordinator, North Quabbin Woods
Wed., June 1	Navigation primer – Sydne Record and Audrey Barker Plotkin, Harvard Forest
Mon., June 6	*** Longer one starting right after dinner -** Reading the New England landscape: a walk in the woods – David Foster, Harvard Forest Director
Wed., June 8	Why should I trust your data? – Barbara Lerner, Mount Holyoke College
Mon., June 13	Using Science to Guide Conservation Decision-Making – Elizabeth Crone, Harvard Forest Senior Ecologist
Wed., June 15	Graduate School Panel
Wed., June 22	Using forest soil microbes to fuel your car- Jeff Blanchard, University Of Massachusetts
Tues., June 28	Mid-summer presentations by students, Part I.
Wed., June 29 ALL DAY	Harvard Museum of Natural History Behind-the-Scenes Tour, and Harvard School Fair/Barbeque
Thurs., June 30	Mid-summer presentations by students, Part II.
Wed., July 6	Scientific Presentation Workshop- Dave Orwig, Harvard Forest
Mon., July 11	Global Change and Human Health: Predicting Ragweed Hotspots in New England – Kristina Stinson, Population Ecologist, Harvard Forest
Wed., July 13	Career Panel- starting at 3:00 pm
Mon., July 25	Scientific Abstract Writing Workshop – Clarisse Hart, Harvard Forest Outreach & Development Manager
Tues., July 26	Pitcher Plants & Carbon Economy – Aaron Ellison, Harvard Forest Senior Scientist & REU Director

Moussa Bakari

Lincoln University

Mentors: Jim Tang, Qian Yu & Tim Savas

Soil carbon dynamics and its controls across Gradients at Harvard Forest

Environmental conditions and the components of an ecosystem respiration play a significant role in the understanding of climate change. Soil respiration has a potential role in amplifying global warming due to its sensitivity to environmental conditions. Carbon cycles rapidly change between the atmosphere and soil as CO_2. Soils, depending on how they are managed, represent an important source or sink of CO_2 to the atmosphere. At Harvard Forest we explored the dynamics of soil carbon fluxes across the gradient of plant composition and soil properties. We measured soil flux using the licor 6400 across the gradient in 174 points as well as litter mass, root biomass, soil carbon and nitrogen ration. We also looked at diameter at breast height (DBH) of tree trunks across the gradient of the forest, tree species, soil drainage and slope gradient. Over the period of 9 weeks we accomplished 5 biweekly cycles of measurements for carbon flux in relation to moisture and temperature among the variables considered. The weekly efflux rates varied from 14 to 22 µMol*m-$_2$s-$_1$ in response to temperature and time of day. We also established significant links between soil respiration and root mass and soil type and moisture. Each of the 49 plots had a specific combination of tree species diversity and soil drainage type leading to a conclusion that red maple stands had the highest correlation between soil moisture and the carbon flux across five measurement cycles.

Stephan Bradley
Lincoln University
Mentors: Nathan Phillips & Robert Ryan

Urbanization & Land Use Change Dynamics

Around the world, the mass migration by humans from rural to urban areas (Urbanization) has contributed to social and environmental changes visible throughout many cities. This phenomenon has brought about serious concern, leading scientist across the globe on a quest for knowledge of social and environmental responses to the land use changes rapidly occurring. This study investigates temporal fluctuations, vegetative growth responses, and human behaviors resulting from land use change, through the analysis of environmental indicators. Environmental indicators including temperature, weather, geospatial data, and vegetation were compared across a rural to urban gradient. In addition, human observations were conducted to develop an understanding of the inner mechanics of urban ecosystems under different land management practices. From this research, we believed we would find significant differences in weather, vegetative trends, and human use of "greened" vs. "non greened" urban space. Preliminary results show significant differences in vegetative abundance and growth trends as well as human use of the urban sites studied. Some findings include a 50% greater abundance in vegetation in the urban roof-top plots compared to the rural roof-top plots. Additionally, there was 60% Oak survival at the urban site while there was 100% Oak mortality at the rural site in our urban to rural roof-top Oak study. Thermal readings indicated that the six non green urban sites produced lower temperatures in our six paired urban green to non green study. However, our ground readings contradicted these findings, showing all non green urban sites higher in temperature. This study raises questions for further investigation while providing a strong foundation of knowledge into the ever expanding urban environment.

Rachel Brooks
University of Vermont
Mentors: Aaron Ellison & Nick Gotelli

Proteomic signatures of experimentally manipulated pitcher plant communities and their corresponding state changes

Since a fully functioning ecosystem produces numerous biomolecules, protein biomarkers have the potential to serve as early warning indicators before tipping points are reached and ecosystems undergo irreversible change. To test this potential, we used the fully functioning micro-ecosystem found within the rain-filled pitcher-shaped leaves of *Sarracenia purpurea* (the Northern Pitcher Plant). In a controlled press experiment, we imposed treatments that mimicked the effects of eutrophication from nutrient enrichment, the loss of top predators from hunting and over-harvesting, and the isolation of the ecosystem from nutrient and material exchanges across ecotones. Respectively, these treatments included the daily additions of ground-up prey, the manual removal of the food-web's top predators, and the cutting of the plant stem to reduce its inputs and outputs. Microbial community samples were collected both before and after two weeks of treatment application. Samples were analyzed using SDS-PAGE and mass spectrometry techniques to identify and quantify protein change between treatments and over time. Initial results show promising differences in signature protein bands that could serve as important biomarkers. Final results will allow for detailed temporal studies on specific ecosystem management and conservation techniques.

Julianna Brunini
Harvard University
Mentors: Jim Tang, Qian Yu & Tim Savas

Assessing the Importance of Various Biotic and Abiotic Factors in Soil Respiration Modeling

In order to understand global carbon cycling, we must understand soil respiration—the process by which plant roots and soil microbes exchange carbon dioxide (CO_2) with the atmosphere. Though temporal patterns in soil respiration are relatively well-understood, spatial variation in soil respiration has proven more difficult to explain. This study investigated numerous variables—soil temperature, soil moisture, stand density, root density, and litter mass—as possible predictors of the spatial variation seen in soil respiration. We measured the CO_2 efflux five times over the course of ten weeks at forty-nine sites throughout the Prospect Hill tract at the Harvard Forest. Using stepwise, multivariate regression to analyze the data, we found that soil temperature is the most consistent predictor of CO_2 efflux, though it cannot explain CO_2 efflux alone. Our best overall model incorporates a combination of biotic and abiotic variables, relating carbon flux to soil temperature, stand density, root density, and litter mass (AIC=570.54, $0.10 < r^2 < 0.52$ for the five cycles of measurement). However, models incorporating soil moisture content fit early measurements well, suggesting that moisture plays an important role in CO_2 flux towards the beginning of the summer, but not towards the end. Thus, carbon cycling models must incorporate both biotic and abiotic factors, though further study is necessary to determine if the appropriate choice of biotic factors varies with the seasons.

Katharine Chute
Harvard College
Mentors: Chris Williams & Melanie Vanderhoof

A survey of vegetation growth, density, and species composition in an early-successional temperate forest in New England

The cycling of carbon, water, and energy between forests and the atmosphere drives global climatic patterns. Yet these large-scale processes have many contributing factors that are not fully understood. This study analyzes the effects of clear-cut logging on forest-atmosphere dynamics. These disturbances are common within managed forests and play an important role in regional-scale forest cycles. Our study site, located in Harvard Forest, in Petersham, Massachusetts, is a former Norway spruce (*Picea abies*) plantation that was clearcut in fall 2008 as part of a management plan to restore the forest to its native state. An eddy covariance flux tower was installed in spring 2009 to monitor the carbon, water, and energy dynamics at the site as it recovers towards a mature forest. The work completed in summer 2011 provides necessary supporting data to assist in the verification of the flux tower's gross primary productivity (GPP) measurements. Onsite species composition, sapling/seedling density and growth were measured using sample plots and line-intercept transects, and the data was compared to measurements from summer 2010. Of 38 total species, Allegheny blackberry (*Rubus allegheniensis*), red maple (*Acer rubrum*), and pin cherry (*Prunus pensylvanica*) were most dominant by percent cover in both June and July of 2011. Though growth varied by species, total percent vegetation coverage increased. Between summer 2010 and summer 2011 there were minimal significant differences in the average stem density and species composition. These results are important in two ways. First, our data add to the body of research describing typical patterns of New England forest succession. Second, this work provides key site-specific data to support flux tower measurements in a recently disturbed temperate forest. Such sites have not been extensively monitored with flux tower equipment, and this study is thus an important contribution to the overall understanding of forest-atmosphere exchange dynamics.

Bridget Darby

Boston University

Mentors: Andrew Richardson & Trevor Keenan

Do physiological changes at leaf level explain seasonal changes in remotely sensed canopy greenness?

The Phenocam network is a network of digital cameras used to analyze phenological events and track canopy greenness levels throughout the growing season. As a near surface remote sensing platform it acts as an intermediary between leaf level measurements and satellite based remote sensing products. The cameras typically document a rapid increase in canopy greenness after leaf out, which peaks in early summer and gradually declines thereafter. Open questions remain, however, as to whether the observed changes in canopy greenness are directly related to changes in leaf physiology, or changes in canopy structure. The goal of this study was to determine if a correlation exists between the physiological changes occurring at leaf-level and the seasonal greenness as measured by the cameras. Such relationships may also allow for leaf level changes to be estimated indirectly using images from the Phenocam network, and better inform our interpretation of remotely sensed satellite products. We sampled the leaves of three species: red oak (*Quercus rubra)*, red maple (*Acer rubrum)* and yellow birch (*Betula alleghaniensis*) at Harvard Forest (*MA, USA*) directly surrounding a Phenocam. Leaf mass per area and fluorescence were measured for each leaf, along with spectral indices of reflectance and transmission. Preliminary results show that changes in leaf mass per area and photosynthetic capability at leaf-level appear to reflect trends in the GCC data. Further study through the end of the growing season is expected to confirm these results.

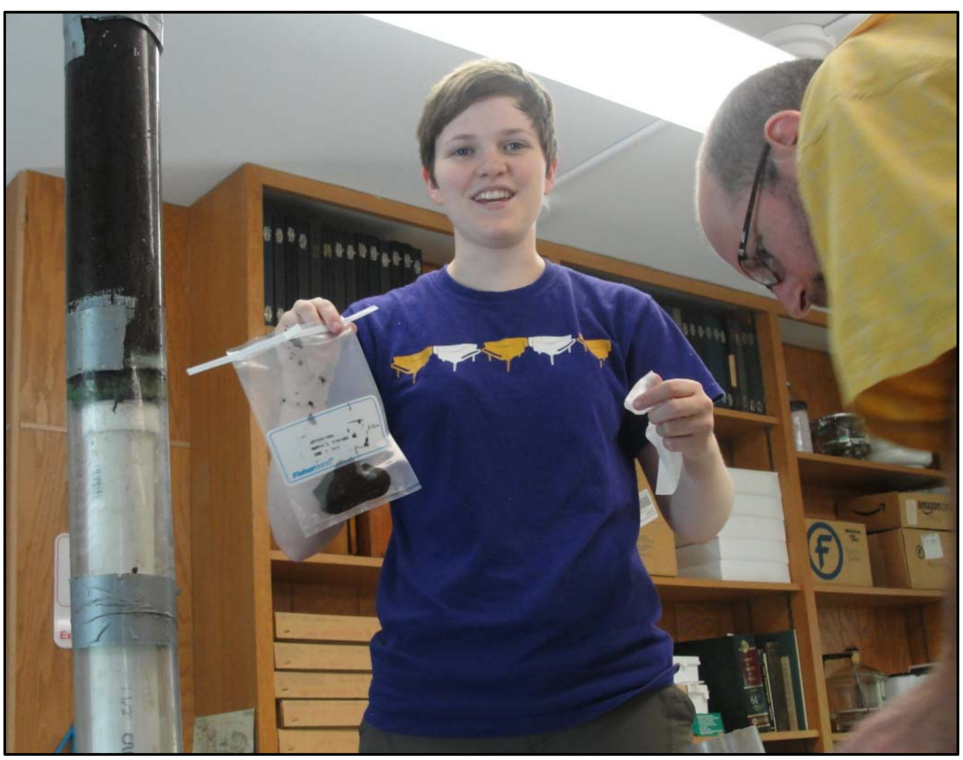
Lindsay Day

Emerson College

Mentor: Wyatt Oswald

History of New England Vegetation: Pollen Morphology of Eastern Hemlock in New England Lake-Sediment Records

The mid-Holocene decline of eastern hemlock (*Tsuga canadensis*) is one of the most studied yet least understood events in the vegetation history of Eastern North America. The widespread collapse of hemlock 5500 years ago originally was interpreted as disease-caused mortality followed by the evolution of resistance and the recovery of hemlock around 3000 years ago. Subsequent research on the event suggests that major droughts initiated and sustained the decline, but questions remain about evolutionary changes during the mid-Holocene. We explored the question of evolutionary change by analyzing the morphology of fossil hemlock pollen. We measured the diameters of hemlock pollen grains from lake cores in two sites in New England, Little Pond in Royalston, MA and Knob Hill Pond in Marshfield,VT. We found that pollen grains from within the hemlock decline were significantly smaller than those from before and after. The trends in pollen size parallel the dramatic decline and recovery of pollen percentages and water levels in sites across the Northeast. These data are not consistent with unidirectional evolutionary change but instead suggest that the changes in pollen morphology are linked to climate. The fluctuation in pollen size could illustrate population dynamics in which the subpopulation of hemlock trees with smaller grains was favored during the interval of dry conditions. Alternatively, the pattern may represent the effect of drought on individual hemlock trees. Under stressful conditions, trees may devote fewer resources to reproduction, including the growth of pollen grains. Taken with other evidence from the region, our data lend further support to climate as the driver of the mid-Holocene decline.



Leticia Delgado

Northern Arizona University

Mentor: Jim Tang

Soil Respiration and Its Response to Manipulation Treatments

Forest ecosystems contain more than two-thirds of their carbon in the soil. Soil respiration is the release of carbon from belowground (roots and microbes) into the atmosphere. Respiration rates are affected by various environmental and anthropogenic factors including: temperature, moisture, nitrogen addition, root removal and increased litter levels. This project explores the CO_2 flux at five different manipulated treatment sites located in the Prospect Hill and Tom Swamp tract in Harvard Forest. Throughout the summer, five cycles of CO_2 flux, temperature and moisture measurements were collected at each of the following manipulation sites: Warming, Trenching, Nitrogen Amendment, Detritus Input and Removal Treatments (DIRT), and Ants. Soil flux measurements were taken using the LICOR-6400 infrared gas analyzer. The warming site is a model of how future global warming will influence soil respiration rates. Results from this site can also be used to predict how the carbon flux will change in the natural gradient sites. At the trenching site, roots have been isolated to allow only for microbial respiration; flux rates for the trenched plots were on average 3.231383 µMol*m-2s-1 lower than the control plots. Data collected at the nitrogen addition site showed lower flux values as nitrogen levels increased in the hardwood stand but was inconsistent in the pine stand. Litter manipulation, DIRT, showed the highest flux values in plots with double litter and the lowest flux values in plots with no above or below ground inputs. The ant site consists of buckets containing three different soil types and ants placed under three different temperature treatments. CO_2 flux at the ant site was higher in the heated plots containing ants than the controls. Understanding data from a manipulated site allows us to make predictions on the response of CO_2 flux to that variable across a gradient.

Kate Eisen

Amherst College

Mentor: Audrey Barker Plotkin

Red oak dominance and understory development in a temperate northeastern forest support the continuation of the regional carbon sink

Using atmospheric and forest inventory measurements, previous studies have demonstrated that northeastern forests act as a carbon sink, but few have examined relationships between forest stand dynamics and carbon uptake. Using 42 years of forest census data from a 2.88 hectare permanent plot at the Harvard Forest, we examined changes in species composition and total forest aboveground biomass to determine if stand dynamics impact the forest's carbon uptake. The diameter at breast height, canopy class, and condition were recorded for all living and dead individuals in 1969, 1975, 1991, 2001, and 2011, with additional measurements taken on dead individuals, creating record of over 6000 living and dead individuals. From 1969 to 2011, red oak (*Quercus rubra*) increased its dominance of the stand's total basal area from 52% to 60%; however, red maple (*Acer rubrum*) has become relatively less abundant, decreasing from 30% to 23%. While red oak and red maple continue to account for the majority of the basal area in the stand, the secondary species experienced a dramatic increase in relative abundance of individuals in the stand; yellow birch (*Betula alleghaniensis*), black birch (*Betula lenta*), American chestnut (*Castanea dentata*), American beech (Fagus grandifolia), witch hazel (*Hamamelis virginiana*), eastern white pine (*Pinus strobus*), and eastern hemlock (*Tsuga canadensis*) have increased from comprising 25% of the individuals in the stand in 1969 to comprising 52% in 2011. The total biomass of living individuals is increasing linearly ($R2=0.99$, $p=0.0002$), which implies that the stand has not yet experienced an age-induced decrease in biomass accumulation. These results suggest that New England forests may be increasing the region's carbon sink at a constant rate, largely due to the continued persistence of dominant individuals. However, while red oak comprises the largest percentage of the total forest biomass and basal area, it is not prominent in the understory, suggesting the forest composition may change significantly in the future.

Elizabeth Felts

Harvard University

Mentors: Andrew Richardson & Oliver Sonnentag

Is Digital Cover Photography a Viable Method for Calculating Leaf Area Index For Phenological Research in Closed Forest Canopies?

The use of digital hemispherical (fisheye) photography (DHP) as a method for calculating Leaf Area Index (LAI) based on gap-fraction has been established through past studies; however this method has relied on very specific light conditions and the 180° viewing angle degrades image resolution. A promising alternative is digital cover photography (DCP). The method has been developed and tested in various open ecosystems such as Eucalyptus forests and oak savannas where enough light can penetrate the canopy. This research seeks to explore the viability of DCP as a method of obtaining LAI and thus tracking phenological changes in closed forest canopies where light limitation might pose a methodological constraint. To test DCP, weekly imaging of 33 long-term incremental biomass plots located at the Harvard Forest in Petersham, Massachusetts, a deciduous-dominated temperate forest, using a digital single-lens reflex camera (Pentax K100D), was undertaken. To examine the role of scene illumination, the images were acquired in RAW format to allow maximum control over image exposure in the post-processing. LAI values were calculated after image binarization using the recently introduced two-corner method. These estimates were then compared to LAI estimates obtained from gap-fraction measurements made with the LAI-2000 instrument at the same plots, recomputed using only the first 7° ring, to better align this method with the field-of-view given by DCP. The data was further compared against canopy greenness obtained from a fixed webcam at Harvard Forest. Our results demonstrate that DCP is a viable method to track spring phenological changes at Harvard Forest, especially in comparison to canopy greenness. Furthermore, our results demonstrate the need to account for the changing contributions of woody canopy elements to light interception. We show that a normalized color index might be useful for separating green image elements (i.e., foliage) from non-green image elements (i.e., wood, sky).

Ashley Golphin
Kent State University
Mentors: Nathan Phillips & Robert Ryan

To Green or Not to Green: An Investigation of Urban Greening, Biodiversity, and Human Behavior

Urban ecosystems create one of the greatest challenges to global sustainability, biodiversity retention, and public health. Attaining sustainable urban socio-ecological systems requires understanding how urban landscapes can be designed and managed to support wildlife diversity and human health. Urban greening, the expansion and conservation of vegetated areas in cities through local stewardship practices, is one such land management tool that can be utilized to study the effects of urban green space on humans and wildlife. Cityroots, an urban greening program in the City of Boston, provides technical and financial support to community groups who want to improve their neighborhoods through greening. The support offered is based on environmental justice and allows community members to transform abandoned lots (non-green space) into community gardens and parks (green space). Throughout the City of Boston, seven Cityroots community-developed green spaces were chosen for this study and paired with seven nearby abandoned lots to explore how human use patterns, along with related measures of urban biodiversity (i.e., macroinvertebrate and avian populations) differ between urban green and non-green sites. Human use patterns involved behavior observations at the study sites during different times of the day. Statistical analysis showed that human behaviors are significantly different between green and non-green sites and suggests that humans are more engaged in green sites, particularly with regard to active and passive recreation. Sample collection and data analysis for macroinvertebrate and avian diversity are ongoing. Preliminary analysis suggest that naturally regenerating sites that occur as part of urban disinvestment may have biodiversity benefits while intentionally planned green spaces provide more benefits for local residents. The results of this study provide new insights into the relative importance of landscape perception in influencing human behavior and yield practical implications for urban planners to develop greenscapes that support human health and well-being.

Laura Hancock

Christopher Newport University

Mentor: Kristina Stinson & Sydne Record

Predicting Ragweed Allergy Hotspots: How Elevated CO_2 Affects Different Ecotypes of *Ambrosia artemisiifolia*

Ambrosia artemisiifolia, better known as common ragweed, is a leading cause of hay fever in humans. Increased atmospheric CO_2 has been shown to increase the pollen production of ragweed. Thus, with predicted climate change and increased atmospheric CO_2 levels, pollen production of common ragweed is likely to increase, causing adverse health and economic issues. Hoop houses were used to create three treatments of CO_2 – 400ppm, 600ppm, and 800ppm – and untreated control environments. Growth, morphology, and reproduction characteristics of 1248 individuals consisting of 24 total populations from New York, Massachusetts, and Vermont were analyzed using Analysis of Variance (ANOVA) to show how, and if, these characteristics differed between treatments and between ecotypes from the different states. We found that there were distinct qualities to these three different ecotypes and that they reacted to the CO_2 treatments differently. Specifically the Vermont populations, which are from cooler, less urbanized environments, had distinct characteristics when compared to the more similar New York and Massachusetts populations. Combining these results with a presence/absence and a demographic study of common ragweed across New England, an allergy hotspot map can be created that will show how ragweed populations in different regions of New England might change with climate change.

Jamia Linn Jennings

Mount Holyoke College

Mentors: Kristina Stinson & Sydne Record

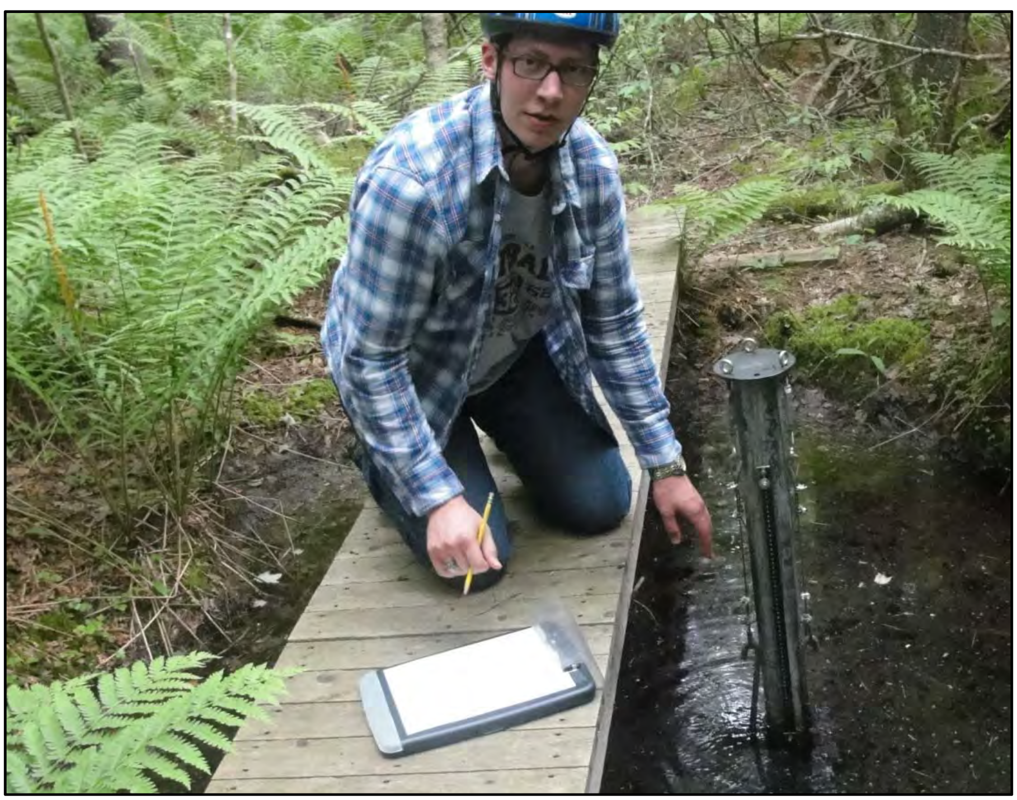
A Demographic Study of *Ambrosia artemisiifolia* across a Rural to Urban Gradient in Massachusetts

The pollen produced by *Ambrosia artemisiifolia* (common ragweed) is one of the primary causes of allergy symptoms in the United States. Previous research indicates that an increase in the concentration of CO_2 in the atmosphere will increase plant size and pollen production of A. artemisiifolia. Our research focuses on the current phenology and life cycle of *A. artemisiifolia* in 24 populations located along rural to urban and warm to cool gradients from Boston to the Berkshires in Massachusetts. We collected data on growth rates and flowering for each population. Other data, such as percent cover in each plot (3 to 5 plots per population) and land cover, were collected to evaluate the impact of surrounding vegetation and fine scale land cover on plant phenology. The data demonstrate a trend of taller plants in the cooler, less urbanized sites, which might indicate selection for shorter plants in regions that are mown more frequently. Further, the most important predictor variables found in the presence-absence survey were not significant predictors of plant size and flowering. When modeling future allergy hotspots, different predictor variables will be needed when modeling the presence and absence of ragweed and when modeling the plant size and flowering time of ragweed. The information collected will be used in tandem with a presence-absence survey of *A. artemisiifolia* in New England and a greenhouse project predicting the growth of *A. artemisiifolia* in an elevated CO_2 environment to model current and future *A. artemisiifolia* pollen hotspots in New England.

Andrew Kaldunski
Ripon College
Mentors: Emery Boose & Barbara Lerner

Using Little-JIL to Model Complex Scientific Processes

A scientific data analysis (or process) must be clearly definable by a list of steps or activities performed. A scientific process should also be reproducible, i.e. it should return the same results if the same input data are used. Scientific processes encapsulate every step used from the creation of data to the analysis of data. At Harvard Forest, we are tracking the water flux through the forest to better understand the interactions involving water and gases between the atmosphere and the forest. Measuring stream discharge is part of tracking the water flow. We used Little-JIL, a graphical language that defines a process with agents, to define the process of measuring stream discharge. Using Little-JIL, we were able to model the stream discharge process precisely. This may lead to a reproducible automation of stream discharge data processing throughout the forest. Little-JIL uses visual representations of steps to direct the agents that perform the scientific process. In this case the agents range from the collection of data, whether done by a human or by an electronic device, to the calculations needed to calculate the discharge of streams. The steps direct the execution of agents and the agents perform the desired tasks in the process. The current stream discharge model created in Little-JIL has steps that are optional, steps that are performed an unpredictable number of times, steps that can be executed during or after the process, and steps that depend on other steps. Modeling stream discharge in Harvard Forest with Little-JIL displays Little-JIL's ability to represent a complex scientific process.



Isaac Lavine

Lafayette College

Mentors: Andrew Richardson & Koen Hufkens

Observing Phenological Events in Vegetation through Technological Methods

Phenology is the study of changes in organisms due to the seasonal cycle. Phenological shifts in forests and other ecosystems, due to climate change, could have important impacts on carbon and nutrient cycling. Therefore it is important to find easy and accurate ways of tracking phenology in numerous ecosystems over an extended period of time. We compared the effectiveness of a nationwide network of webcams, the Phenocam network, and MODIS satellite data in tracking phenological events such as bud burst and maximum canopy in the spring, and the beginning and end of senescence in the autumn. Phenological events were gathered through visual inspection and automated processing of the Phenocam images. As a measure of vegetation in the Phenocam images we extracted the green chromatic coordinate (GCC) based upon the RGB digital numbers. The dates of the four major phenological events were estimated from the spring rise and autumn decline of the GCC. MODIS satellite based phenology data (MCD12Q2) was downloaded and compared to visual and GCC based phenological estimates. Overall, we found that individual human observations covary strongly with each other through the years. The GCC based estimates correlate strongly with human observations for temperate forest sites. However, in other ecosystems the GCC data shows diverging phenological patterns. The MODIS data is mostly accurate over large time scales, but not a precise enough tool to detect inter-annual variation of only a few days. In addition, the MODIS satellite consistently predicts the beginning of senescence ~50 days earlier than both human observation and GCC based dates. The Phenocam network tracks temperate forest phenological dynamics most accurately, and has the potential to characterize phenology across a wider range of ecosystems.

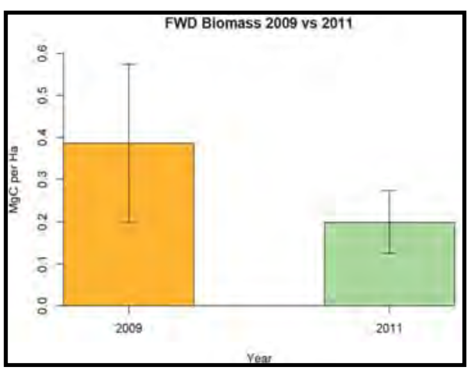
Jakob Lindaas

Harvard College

Mentors: Leland Werden & Bill Munger

Fine Woody Debris Dynamics after an Ice Storm Disturbance Event in Harvard Forest

The forest C cycle has major impacts on Global Greenhouse Gas levels and climate change. The exchange of C between the atmosphere and the forest has been measured at the Harvard Forest EMS for the past 22 years. Biometry measurements made in 33 plots surrounding the EMS tower help to partition the forest C cycle into three main components: live biomass, soil, and detritus. Fine Woody Debris (FWD; 2 cm≤ diameter <7.5 cm), coarse woody debris (CWD; 7.5 cm < diameter) and litterfall make up the detritus C pool. A major ice storm in December of 2008 sent a pulse of FWD to the forest floor. This FWD biomass was quantified in the 33 plots during the summer of 2009. We resurveyed the FWD biomass in a subset of the plots during the summer of 2011. Samples of different decay classes and species were taken and average densities were calculated for each species and decay class. The decomposition rate of the resurveyed FWD was calculated to be 0.09 Mg C ha^{-1} yr^{-1}. The FWD biomass in 2009 was 0.39 Mg C h^{-1} (±0.19) and the biomass in 2011 was 0.20 Mg C ha^{-1} (±0.07) [see Figure]. Because the 95% confidence intervals overlap (due to high spatial variability in FWD), we cannot claim the decrease in the FWD biomass to be statistically significant. However, the decay measured was due almost entirely to density change, making these results ecologically significant. Our density measurements show a negative C flux from the downed FWD over this time period, with a decrease of 24% yr^{-1} of Mg C ha^{-1}. This can be compared to a decrease of 4.54% yr^{-1} of Mg C in the CWD pool during the most recent CWD measurement period. This indicates that FWD has a higher turnover rate than CWD in temperate forests. Since FWD is an important C reservoir in temperate forests, these results suggest that disturbance events such as an ice storm may lead to rapidly increased C flux out of the FWD C pool in forested ecosystems.



Lauren Lynch

UMass-Amherst

Mentors: Nathan Phillips, Michael Strohbach, Paige Warren

Arthropod abundance, population dynamics and predator-prey interactions in urban and rural model ecosystems

With continuing growth of cities, it is vital to gain an understanding of the effects of urbanization on ecosystem functions. In this study we examine the differences in arthropod diversity and abundance between an urban and rural model ecosystem. Fifty pots in which weeds were allowed to grow freely were placed on rooftops at Boston University and the Harvard Forest research station (located in Petersham, MA). At each location, exclosures were placed over half of the pots to prevent predation by birds. The arthropods on the pots were surveyed each week between June 1 and July 14, and the arthropod abundance, population dynamics and food webs were compared between the urban and rural locations. Aphids dominated the arthropod communities both in Boston and Petersham. It was found that the peak of arthropod abundance was greater at Boston University, and that when the family aphididae was excluded the overall abundance was greater at Boston University. In addition, there were differences in the food webs between the urban and rural sites and increases in food web complexity over time. The presence of bird exclosures had little effect on the arthropod abundance although the results may suggest that bird predation had some effect on the abundance of insects of the order Lepidoptera (butterflies and moths) at BU. For future research we suggest monitoring the seasonal and long-term changes in arthropod abundance and diversity in rural and urban areas and extending the study to designed green roofs.

Tara Mahendrarajah

UMass-Amherst

Mentor: Jeff Blanchard

Using computational genomic methods to address microbial community function within experimentally warmed soils

Long-term soil manipulations at the Harvard Forest are being used to investigate the role of microorganisms on community structure within an experimentally warmer world. Microbial communities are a major component of soils and are therefore intrinsically linked to the global carbon cycle. Evidence suggests that global climate change has the potential to alter microbial community composition and subsequently lead to communities that are able to use a wider range of carbon sources within the soil – ultimately altering the global carbon cycle. Therefore, it is imperative to understand the association between microbial species diversity and function within soil ecosystems. The primary objective of this research project focused on evaluating microbial community composition using laboratory and computational techniques. Soil samples collected at four time points from a long-term experimentally warmed plot in Barre Woods were processed and had the DNA extracted using molecular laboratory procedures. Following the final soil sampling period in August, 100 samples will be pooled and sent for sequencing in order to obtain metagenomic data that will be analyzed for microbial species taxonomy counts and classification, and gene prevalence and function. In addition, a secondary goal of this study was to develop strategies to effectively integrate analyses of species diversity and microbial function, in order to understand how community dynamics may differ in warmed soil. The National Ecological Observatory Network (NEON) collected a soil sample from Prospect Hill, and provided us with metagenomic data in the form of amino acid and nucleotide sequence files. Ribosomal 16S rRNA sequences were processed through the Ribosomal Database Project Classifier and revealed that the soil sample was dominated by members belonging to the phyla Acidobacteria (28%) and Proteobacteria (22%). This suggests that soil on Prospect Hill is composed of a plethora of bacteria involved in several ecologically significant processes including chemical decomposition, nitrogen fixation, and carbon cycling. The amino acid metagenomic data was processed through the Basic Local Alignment Search Tool, which compared the query sequences to an extensive database of protein domains of known function. We found that 16% of the proteins present within the NEON soil sample are involved in carbohydrate metabolism and energy production, suggesting that a majority of genetic material within microbial communities is allotted to biomass degradation. Methods used to evaluate microbial diversity and community function, as performed in this study, will be used in parallel with enzyme activity assays, in future analyses of data collected from the Barre Woods warming plot, in order to understand changing community dynamics in response to a warming climate.

Natashia Manyak

UMass-Amherst

Mentors: Israel Del Toro & Shannon Pelini

Warming Effects on Ants Soil Movement and Mortality Rates

Ants are important components of most terrestrial ecosystems since they are often associated with key processes like soil movement. Specifically, ants that build subterranean nests have an effect on soil nutrient dynamics due to the large amount of soil that are displaced during nest excavation. Our study focuses on the effects of warming on a common ant of the forests of the Northeastern U.S, *Formica subsericea*. My objective was to determine if the rate of soil movement and total mortality varies under different warming treatments .We hypothesized that under warmer treatments, ant soil movement may peak at a temperature under which ants can work most efficiently and still survive, but beyond which their activity may be detrimentally affected. We also hypothesized that under warmer treatments ant mortality rate will increase as a consequence of metabolic exhaustion. We tested these hypotheses in a microcosm warming experiment using two warming treatments (+3°C and +5°C) and a controlled, non-manipulated treatment. One hundred individual ants were kept in 90, 19 liter containers and left to build nests for a period of four weeks. Rate of soil displaced was determined through time series photographs taken at 12 hour intervals for a duration of 120 hours. We analyzed the resulting images using ImageJ freeware. Mortality rate was measured weekly by counting number of dead ants per colony at all 90 microcosms. We found that ant mortality rate was not significantly different across the temperature treatments and was directly linked to rate of soil excavation. Further analysis is required to evaluate the variation in excavation rates between warming treatments. This study provides an analysis of how predicted regional warming may affect ant soil movement dynamics.

Michael Marquis
Arizona State University
Mentor: Shannon Pelini

Warming does not affect colony growth or mutualistic association with ants in the aphid *Chaitophorus populicola*

Mutualisms between ants and aphids can have a large impact on the arthropod communities around them, so it is important to understand how they might be affected by climate change. Most research on the subject to date focuses on the effects of increased greenhouse gas concentrations, rather than warming, on aphid colony growth. We examined the effects of warming on colonies of the aphid *Chaitophorus populicola* and the ants tending them in potted aspen (*Populus tremuloides*) trees over a four week period using open-top warming chambers at Harvard Forest. We monitored aphid colony growth and plant stress in the presence and absence of ants in five different warming scenarios. Three species of ants (but only one per plant) were observed tending the aphids: *Camponotus pennsylvanicus, Formica subsericea,* and *Lasius alienus*. There was no relationship between temperature and the species of the tending ant. Species of ant had no effect on production of non reproductives (apterous adults), but it did influence the number of winged reproductives (alates) produced. We found no significant relationship between temperature and aphid colony growth in either the ant tended or exclusion colonies. Similarly, temperature did not affect number of alates produced or colony lifespan in either treatment. On average, ant tended colonies survived for a greater length of time than the ant exclusion colonies and exhibited a nonsignificant trend towards producing a greater number of alates. During the course of the study, colonization of trees by another aphid, *Myzus persicae*, was noted and recorded. *M. persicae* colony size increased linearly with temperature when tended by ants. The lack of a relationship between either ant species or aphid colony growth and temperature suggests that warming does not affect *C. populicola* and its mutualistic association with ants, but the linear increase of *M. persicae* colony size with temperature indicates that this may not be true for other aphids. These findings highlight the fact that findings regarding the affects of warming should not be generalized across species or genera.

Lakeitha Mitchell

Lincoln University

Mentors: Andrew Richardson & Koen Hufkens

Observing Phenological Events in Vegetation through Technological Methods

Phenology is the study of periodic plant and animal life cycle events. Phenology has been shown to be a robust indicator of climate change, as plant phenology is driven by temperature and photoperiod. Consequently, life cycles are responsive to diverse environmental factors such as temperature and overall climate. In the past, many phenological studies have been *in situ* field observations. In general, these observations are time consuming, proven to be inconsistent amongst observers, and often limited in their spatial extent. Using near-surface remote sensing with webcams, most of these issues can be addressed as measurements that have a high temporal frequency, covering a large spatial extent, and are unbiased. Furthermore, the webcams provide a bridge between the spatial scales of ground observations and the scale of satellite remote sensing observations. The Phenocam Network is a national phenology observation network which gathers digital images from cameras installed at research forests and National Parks. The network consists of 24 core sites and 63 affiliated sites from around the country and a few outside the country. We used the digital images taken by the phenocams and visually determined when budburst, full canopy of deciduous vegetation, beginning of senescence, maximum coloration and dormancy occurred. In addition, similar dates were retrieved from the MODIS phenology product (MCD12Q2), and algorithmically determined based upon the image time series. Preliminary results comparing all these data suggest that each of these methods have consistent biases. The results improved the understanding of the mechanisms that determine observational differences at regional to continental scales using two data sources and three methods. These results will be used to develop models to predict ecosystem response to climate change in the future.

Rachel Norman

UNC Chapel Hill

Mentors: Andrew Richardson & Koen Hufkens

Observing Phenological Events in Vegetation through Technological Methods

Phenology is commonly referred to as the rhythm of the seasons, or the study of life cycle events. These cycles are responsive to various environmental factors, such as climate change. Studying phenology and the changes resulting from response to environmental factors are important because they affect a range of ecosystem functions- including global carbon cycles, plant and animal survival, air and soil temperatures, and soil moisture. Up until recently the most commonly used method has been field site observations. Although effective, field observations have proven to be time consuming and discrepancy amongst observers. This has prompted urgency for more timely and efficient methods through the use of technology. This project looks into the potential of these technological methods by extracting phonological dates (bud burst, peak canopy, start of senescence, max coloration, and end of senescence) from visual inspection of a digital image archive created by the Phenocam Network. The Phenocam Network consists of 24 core sites and 63 affiliated sites based primarily in the United States, with a few international sites. The network creates an archive of digital images from cameras that take multiple images daily. These different sites boast various altitudes, continental locations, climates, and resulting vegetation types. The goal of this project was to compare our human eye observations and the green chromatic coordinate (GCC) of the digital images to the MODIS (Moderate Resolution Imaging Spectroradiometer) on the Tera and Aqua satellites. Both MODIS and GCC track canopy changes and provides phenocam time series. Through the comparisons of the data sets generated from each method, we seek to develop computer models that will further our understanding of phenological transitions and their responses to climate change at regional and continental scale. We have found a variance within each set of results, indicating the bias of patterns in each program. For example, MODIS usually extracts earlier dates for phenological events. These findings confirm previous studies indicating consistent biases.

Marcus Pasay

Clark University

Mentors: Chris Williams & Melanie Vanderhoof

Post-Disturbance Dynamics of Carbon, Water and Energy Fluxes Between Land and Atmosphere

Forest structure and composition affects climate and the flux of carbon on a variety of scales. Woody detritus, specifically coarse woody debris (CWD) is a significant component of stored carbon in forest ecosystems and affects the ecological patterns and processes found within these systems. CWD is an integral part of a forest ecosystem because it releases many organic nutrients, including compounds such as carbon dioxide, through decomposition. To determine the effect forest structure has on the rate of respiration, or the rate at which carbon dioxide is released to the atmosphere, we repeatedly measured the respiration rate for sixty-four pieces of CWD in two study areas, including a three-year-old early successional forest and a mature spruce stand. Carbon dioxide respiration was measured using a LI-6250 Infrared Gas Analyzer over the course of nine weeks in a variety of environmental conditions. Analysis indicated that CWD with a decay class of three has a higher rate of respiration than decay class two CWD. It has also been found that CWD with larger diameters (15-30cm) and thus larger surface area and volume have greater rates of respiration than CWD of smaller diameters (8-13cm). This type of respiration rate quantification allows us to better understand the carbon fluxes between the land and atmosphere across a landscape.

Kelden Pehr
MIT
Mentor: Jeff Blanchard

Acidiobacteria and Proteobacteria Found to Dominate Harvard Forest Soil Samples

Despite the preeminent importance of the carbon cycle, much remains unclear on the influence of particular feedback systems upon the changing cycle. One such feedback, the fluctuation of carbon stored in the soil, may be caused by the alteration of microbial communities in response to warmer climates. Past studies have shown that soil carbon respiration increases for a short period of time in warmer plots before leveling off and then increasing again. One theory suggests that microbial communities quickly use up the available labile soil organic carbon pool, and must then shift toward optimizing the use of other available carbon sources. To test this, we will be looking at microbial community diversity and function in warming and control plots at Harvard Forest. We will evaluate microbial community composition and function by analyzing soil samples collected at four time points from warming and control plots at Barre Woods, in Harvard Forest, to determine the response of microbial communities to a warming soil ecosystem. To date we have collected two points and are waiting to sequence them. As a parallel study, we analyzed unpublished metagenomic sequence data of 60 soil samples from Prospect Hill in Harvard Forest, generously made available by Bill Landesman. Using a pipeline of python scripts, collectively known as QIIME (Quantitative Insights Into Microbial Ecology), we looked at microbial taxonomy along with diversity among and between the collected soil samples. Our analysis revealed the dominant phyla present in the soil samples to be (in decreasing order) Acidobacteria, Proteobacteria, Actinobacteria, Verrumicrobia, Bacteroidetes, and Planctomycetes, all common soil phyla. The representative phyla in each sample were relatively consistent, although slight correlations were found with regards to soil pH and tree species near at the site of individual samples. This study provides the first insights into the bacteria that are present in Harvard Forest soils. This analysis will provide a foundation for the interpretation of our Barre Woods study.

Deepa Rao

MIT
Mentor: Laura Meredith

Studying the Hydrogen Soil Sink at the Harvard Forest through Isolation of Streptomyces and Flux Chamber Work

Atmospheric H_2 is a secondary greenhouse gas (GHG) and is vital to the removal of methane (CH_4) from the atmosphere. Natural and anthropogenic outputs are nearly equally responsible as sources of H_2 and human output is expected to increase in the future. Soil microorganisms are responsible for about 80% of the Earth's atmospheric H_2 sink and are the least understood term in the overall H_2 budget. It is speculated that *Streptomyces*, a ubiquitous genus of soil microbe, is a large contributor to H_2 deposition through its enzyme: hydrogenase. Specifically, *Streptomyces* has a unique high-affinity, low-threshold hydrogenase. How *Streptomyces* and other hydrogenase-containing microbes respond to changes in the climate can help us predict if and how the H_2 cycle can potentially change. We will examine soil uptake of H_2 by isolating and varying the environment of *Streptomyces* from the Harvard Forest (HF) and by measuring soil's H_2 flux in a set of plots that cover a wide range of environmental conditions (soil moisture, temperature, increased and decreased levels of H_2, etc.). So far, we have optimized a protocol for *Streptomyces* isolation from forest soil, extraction of DNA, and amplification of the hydrogenase DNA sequence through polymerase chain reaction (PCR). We plan on testing our isolated strains to see if their H_2 uptake drastically alters under different environmental conditions. The second part of our project deals with measuring H_2 uptake by using flux chambers in various long-term plots around the HF (e.g., nitrogen amendment, heated, litter removal plots) With these two methods combined, we will gain a better understanding about the variability of the Earth's largest H_2 sink and how it may respond to climate change.

Garett Rosenblatt

University of Rochester

Mentors: Emery Boose, Leon Osterweil & Barbara Lerner

A Study of Scientific Workflow Systems and Their Interoperability

A key principle of the scientific method is to make scientific data analysis reproducible. For an analysis to be reproducible, scientists must record every detail of the analysis applied to their data. However, In many studies, the complexity of the data analysis makes this endeavor extremely difficult and time consuming. In real time sensor networks data is being produced too rapidly for the data processing to be done by hand, so the processing, and its documentation, must be automated. In response to this difficulty, a number of tools for diagramming and executing scientific data analysis are being developed to aid scientists. These executable diagrams are called workflows, and the tools used to create and execute them are called scientific workflow systems (SWS). SWS monitor the execution of a workflow, and record the provenance of the data they produce. Data provenance – information about the origin and derivation of data – can be used to reproduce the analysis, and verify results. Several existing systems, including Kepler, Little-Jil, and Taverna, where investigated to assess their capabilities, including their ability to collect data provenance. Each of these systems were found to have their own strengths and weaknesses. It would be desirable to be able to combine them together into a single SWS so as to take advantage of all their strengths. In order to support interoperability, it is necessary that these SWS to have the ability to exchange information with each other, and that their data provenance records to be combined. A prototype workflow that integrated both Little-Jil and Kepler was created and tested.

Sam Safran

Middlebury College

Mentors : Kristina Stinson & Sydne Record

A regional ragweed distribution survey: Identifying factors that predict ragweed presence

Common ragweed (*Ambrosia artemisiifolia*) is a widely distributed annual weed and produces pollen that is the leading cause of hay fever in North America. While understanding its current distribution is important for public health, most efforts to map allergy "hot spots" today are done at a large scale that is not useful on smaller, more relevant regional levels. Additionally, since ragweed's growth and pollen output increase at warmer temperatures, with higher atmospheric CO_2 concentrations, and in disturbed habitats, there is also interest in understanding its distribution under predicted future environmental scenarios. In this study, we conducted a presence-absence survey across New York, Massachusetts, and Vermont aimed at identifying climate and land use variables influencing ragweed distribution. We used the PRISM climate layer and state-level land cover layers in GIS to identify nine climate-land cover categories in each state. By randomly selecting ten points within each category, we generated a stratified random sample of 90 sites per state. At each site, we constructed a 20 m^2 plot and recorded the plant's abundance and local land cover data. A preliminary analysis of 200 of the 270 sites using bagged Classification and Regression Tree (CART) analysis indicates strong positive correlations between observed edge habitat and ragweed presence as well as between observed forest habitat and its absence. The strongest predictor of ragweed presence was found to be distance to nearest road, a variable derived remotely with GIS. Some clear climate effects—including average precipitation and temperature during the growing season—were also shown to be highly relevant predictors of ragweed presence. This dataset will be used to test the accuracy of free and simple methods for identifying ragweed habitat, to model its distribution under current climate conditions, and to map regional allergy hotspots under future climate scenarios at a scale relevant to an individual's exposure to pollen.

Sofiya Taskova

Mount Holyoke College

Mentors: Emery Boose & Barbara Lerner

Capturing, persisting, and querying the provenance of scientific data

Scientists use technology ubiquitously to collect and process data. They often use software to handle massive datasets and produce scientific results, and post those results on the web, making them readily available to the public. Flaws and differences in the way data is collected and processed can make the results less useful for interpretation. The ability to trace the provenance, or history, of any given result is essential for ensuring the authenticity and reproducibility of that result, as well as for improving the result by incorporating corrections in its processing. Data provenance is defined as the information describing all entities - procedures and data - that were involved in producing a result. We aim to create a software tool that provides provenance for scientific data analyses. It is essential that the user is able to derive meaningful answers to interesting provenance questions with our software. We used a process definition written in the graphical programming language Little-JIL to generate a graph (Data Derivation Graph or DDG) documenting the provenance of the data for each process execution. We stored the DDG into an RDF (Resource Description Framework) database and made it available for querying. We are exploring whether our software collects and stores an adequate amount of provenance to verify results and serve a foundation for reenacting processes. We are also looking to find whether our software supports useful queries and can display the results so that they are easily navigated.

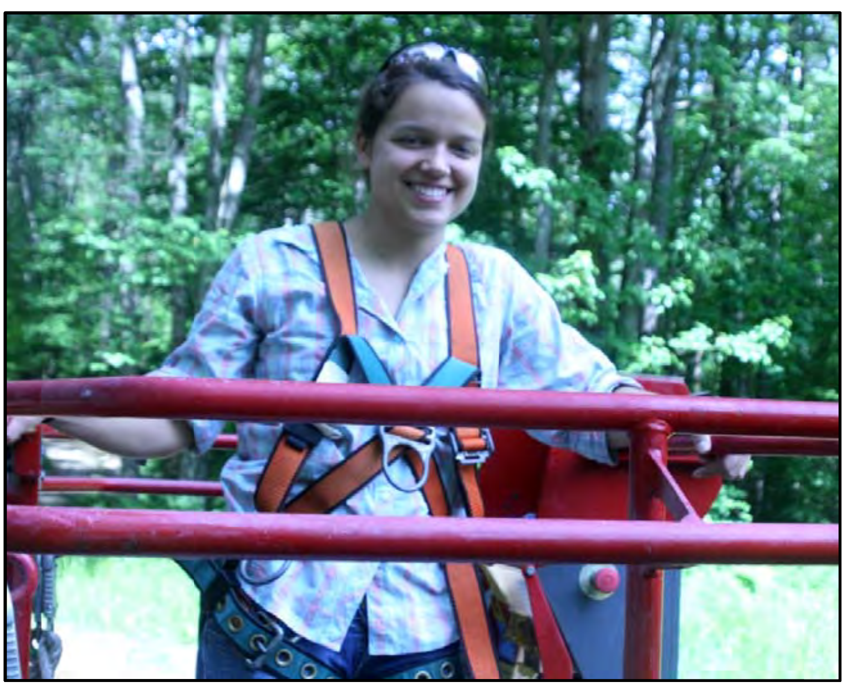
Alena Tofte

Harvard University

Mentor: Jim Wheeler

Diurnal Dynamics of Stem Conductance

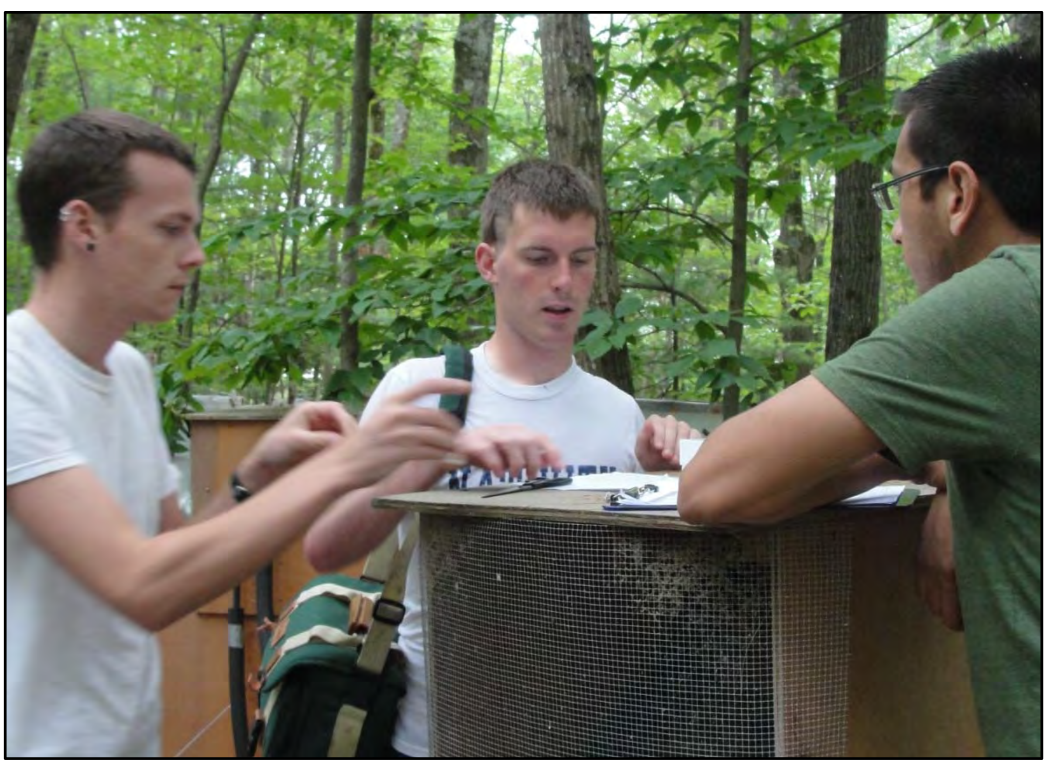
A plant's ability to support growth, photosynthesize and sequester carbon effectively in variable environmental conditions is strongly dependant upon the dynamic capacity of water transport. Woody plants provide adequate whole-plant water supply through upward water movement from soil to crown within the plant's vascular system. This system experiences negative pressure from stomatal transpiration, which thereby drives the upward movement of a continuous water stream. Diurnal variation in this tension gradient due to atmospheric conditions can induce cavitation, or the formation of gaseous embolisms within xylem conduits. These bubbles decrease the overall efficiency of water transport. Previous thought cites permanent elimination of the functionality of these affected vessels. However, some evidence has implied that cavitated conduits refill on a diurnal cycle. To address the ongoing debate surrounding refilling, we replicated an experiment from an earlier paper, published at Harvard Forest within the Holbrook Laboratory (Zwieniecki M.A. & N. M. Holbrook 1998, Plant, Cell & Environment. 21:1173-1180). We measured xylem hydraulic conductivity, percent loss of conductance and water potential on one ring-porous species (*Fraxinus americana L.,* white ash) and two diffuse porous species (*Acer rubrum L*. red maple, *Betula papyrifera Marsh*., paper birch). Measurements were conducted in the afternoon between 1300 and 1400 hours, and were made again the following morning between 0600 and 0700 hours, June through July 2011 at Harvard Forest, Petersham, MA. Our results for ash corroborate previous results with preliminary evidence of refilling, while our results for maple and birch contrast results outlined in the 1998 paper. Possible explanations for this discrepancy include induction of embolism as an artifact of collection methodology, small sample size in the previous study, or natural variation in behavior due to differing climatic conditions between sampling years. Species-specific physiological capacities like diurnal embolism and refilling may determine rates of photosynthesis and carbon sequestration, tolerance of water stress, and associated geographic distribution with respect to water availability.



Kevin Towle
Notre Dame University
Mentor: Shannon Pelini

The Role of Competition in Shaping Local Ant Biodiversity and Community Dynamics

Patterns of global biodiversity follow a latitudinal gradient, with higher species richness being correlated with lower, tropical latitudes. A recent ant biodiversity study determined that forested sites follow this latitudinal trend, while open habitats do not. The goal of this study is to examine competition as a potential driver of local biodiversity, as interspecific competitive interactions have been shown to influence the community composition and species distribution within different habitats. We hand sampled ant species richness and nest abundance at 10 forest and 10 open habitat 5x5 m plots at the Harvard Forest LTER (Petersham, MA) and Myles Standish State Forest (Plymouth, MA). To evaluate competition strength, we conducted a behavioral assay of naturally occurring interactions using tuna baiting, and recorded the number of aggressive and neutral interspecific interactions. We found that open sites have a significantly higher species richness than forest sites, as estimated by the CHAO I Index. We also found that open sites have a significantly higher amount of aggressive competition than forest sites, despite there being no significant difference in relative ant nest abundance between sites. These results suggest that a higher degree of competition in local habitat types facilitates species coexistence and can increase species richness. Additionally, we suggest that community assembly is likely influenced by the level of competition between aggressive and neutral species.



Alanna Yazzie
San Juan College
Mentor: Lindsay Scott

Mechanisms underlining the response to soil warming: the Microbial Component

Harvard Forest is home to two long term soil warming experiments. Prospect Hill is currently in its 20th year of warming and Barre Woods is in the 9th year of warming. The first decade of warming at Prospect Hill showed an increase in soil CO_2 respiration. The initial increase in soil¬ CO2 respiration with warming was also observed at Barre Woods, indicating that an increase in temperature will increase labile carbon respired from heated plots. Labile carbon differences between the heated and control plots at the 20 and 9 year warming plots were measured using short term carbon mineralization incubations and an infrared gas analyzer. Microbial function potential in heated and controlled plots at Prospect Hill and Barre Woods were estimated through the quantification of extracellular enzyme activity potentials for labile carbon and recalcitrant carbon using hydrolytic and oxidative enzyme assays. Hydrolytic assays performed were for enzymes β -1, 4-glucosidase (BGu) and β -D-1, 4-cellobiosidase (CBH). Oxidative assays performed for enzymes phenol oxidase and peroxidase. With nine years of warming labile carbon pools in the control and heated plots were observed to be similar. With similar reserves of labile carbon, hydrolytic enzymes are responding to temperature by breaking down more carbon in the heated than in the control plots, especially for BGlu. The data suggest that the hydrolytic enzymes, under increased soil temperature, are breaking down certain labile carbon compounds faster in heated soils. The data for Prospect Hill suggests no difference in microbial activity in relation to labile carbon turnover. Although, within the organic horizon there was a higher labile carbon pool in the control plots than in the heated plots. Comparing the two sites, further studies need to be done asses microbial function in relation to carbon turnover over time.

Collette Yee

Skyline College/ San Mateo College

Mentor: Audrey Barker Plotkin

Red Maple Growth Rate Responds to Environment, Not Competition

The understory dominant red maple (*Acer rubrum*) is one of the most common trees in eastern North America and grows well across a wide range of site conditions. While some studies suggest an increase in its canopy importance over time, other conflicting evidence displays unchanging canopy dominance. Using a permanent forest plot that spans environmental gradients, we studied the influence of site, disturbance and biotic factors on the growth rates of *A. rubrum* over time. Growth patterns of 2492 red maples were analyzed from the Lyford Grid, a 3 hectare permanent plot censused in 1969, 1975, 1991, 2001 and 2011. For every tree ≥5cm diameter at breast height, its size, condition and location within the canopy were recorded at each census. Mapped data displaying the types of soil moisture and levels of damage from the 1938 hurricane was used to assign environmental conditions for each individual tree. At each census interval, we tested how growth rates of *A. rubrum* varied with differing soil moisture (ranging from dry to wet), 1938 hurricane damage (low, moderate, severe), neighborhood competition and initial diameter. The average annual growth for all *A. rubrum* continuously declined until the last census period between 2001 and 2011. Trees in the most saturated soils grew more than twice as much as individuals located on the driest areas of the plot. Areas that were severely damaged by the hurricane supported faster growth during the first three decades of the survey. Competition did not strongly affect annual growth rates. Initial diameter also had a modest but positive influence on the growth rate. Over the last 42 years, *A. rubrum* was the most numerous species in this forest, although it has steeply declined in percent composition after 1991. Overall, *A. rubrum* showed its characteristic flexibility by growing moderately across a wide range of environmental and competitive conditions.

Katherine Bennett

Ashburnham-Westminster Regional School District

Student Scientists : Monitoring phenology with the Phenocam Network in K-12 schools

Student and citizen science has the potential to be a valuable part of the collection of data surrounding phenological events such as budburst, senescence, and leaf abscission. Becoming a part of the Phenocam Network will enable students at the K-12 level to expand the scope of the phenological monitoring that is presently 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 school grounds to determine the length of the growing season. Students collect and record data which is posted on the Harvard Forest website, involving the students in real and important research concerning the critical environmental issue of climate change. A phenocam that provides a digital image every half hour of the mixed deciduous/ coniferous forest canopy will be installed at Overlook Middle School in the Ashburnham-Westminster School District. As part of the Phenocam Network, our school district will join 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 worldwide to the digital archives at the University of New Hampshire. Teachers and students have access to these canopy photographs to incorporate into their curriculum for use in a wide range of subjects such as phenology and forest ecology, plant processes, and statistics. Students participating in the Buds, Leaves, and Global Warming protocol will have the opportunity to compare their ground data to the webcam images, compare and contrast their schoolyard site to diverse sites with a variety of vegetation cover, to GCC (Green Chromatic Coordinates) data extracted from the images, and MODIS satellite data. This project will greatly enhance the district science and mathematics curriculum and further our goal of educating ecologically literate and concerned citizens.

PERSONNEL AT THE HARVARD FOREST - 2011

Audrey Barker Plotkin	Site and Research Coordinator
Ben Baiser	Post Doctoral Fellow
Jeffrey Blanchard	Bullard Fellow
Emery Boose	Information & Computer System Manager
Jeannette Bowlen	Staff Accountant
Greg Breed	Post Doctoral Fellow
Laurie Chiasson	Financial Assistant/Receptionist
Elizabeth Colburn	Aquatic Ecologist
Sheila Connor	Archivist
Elizabeth Crone	Senior Ecologist
Keala Cummings	Field Assistant
Elaine Doughty	Research Assistant
Israel Del Toro	Graduate Student
Edythe Ellin	Director of Administration
Aaron Ellison	Senior Ecologist
Kathy Fallon Lambert	Science & Policy Integration Project Director
David Foster	Director
Lucas Griffith	Maintenance Technician
Brian Hall	Research Assistant
Linda Hampson	Staff Assistant
Clarisse Hart	Outreach and Development Manager
Stephen Johnson	Bullard Fellow
Debby Kaspari	Bullard Fellow
David Kittredge	Forest Policy Analyst
William Labich	Fellow in Conservation Policy
Oscar Lacwasan	Maintenance Technician
James Levitt	Director, Program on Conservation Innovation
Heidi Lux	Research Assistant
Ron May	Maintenance Technician
Liza Nicoll	Research Assistant
David Orwig	Forest Ecologist
Julie Pallant	System and Web Administrator
Michael Pelini	Research Assistant
Shannon Pelini	Post Doctoral Fellow
Joshua Rapp	Post Doctoral Fellow
Sydne Record	Post Doctoral Fellow
Lisa Richardson	Accounting Assistant
Relena Ribbons	Summer Program Assistant
Moshe Roberts	Summer Program Assistant
Simon Smart	Bullard Fellow
Pamela Snow	Environmental Educator
Kristina Stinson	Population Ecologist
Margaret Toscanini	Summer Kitchen Assistant
P. Barry Tomlinson	E.C. Jeffrey Professor of Biology, *Emeritus*
Judith Warnement	Librarian
John Wisnewski	Maintenance Technician
Mark VanScoy	Research Assistant
Norah Warchola	Post Doctoral Fellow
Scot Wiinikka	Maintenance Technician
John Williams	Bullard Fellow
Tim Zima	Summer Chef

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
Andrew Richardson	Organismic &Evolutionary Biology
Steven Wofsy	Div. Engineering & Applied Sciences

HF Summer Program 2011 Students

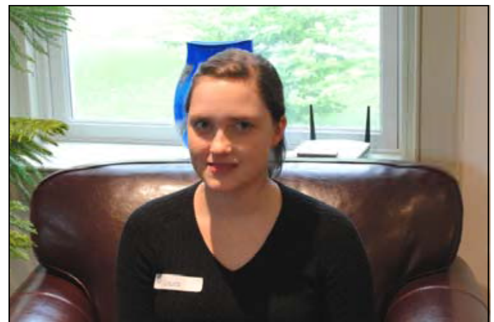
Collette Yee
Skyline College
Mentor: Audrey Barker Plotkin

Lindsay Day
Emerson College
Mentor: Wyatt Oswald

Lakeitha Mitchell
Lincoln University
Mentor: Andrew Richardson

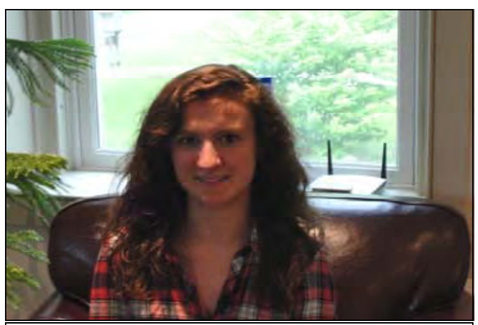
Kate Eisen
Amherst College
Mentor: Audrey Barker Plotkin

Garett Rosenblatt
University of Rochester
Mentor: Emery Boose

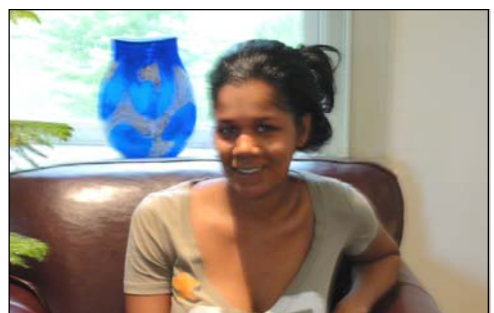


Laura Hancock
Christopher Newport University
Mentor: Kristina Stinson

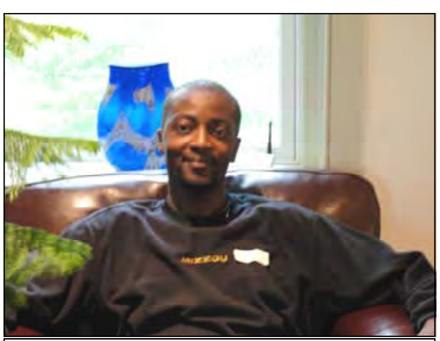
Kelden Pehr
MIT
Mentor: Jeff Blanchard



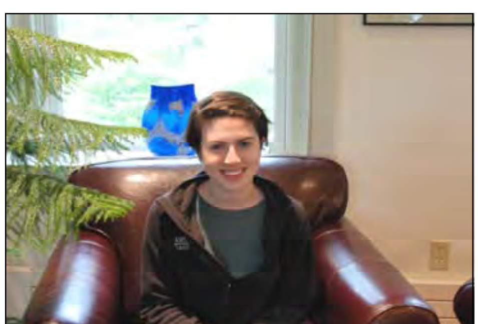
Libby Felts
Harvard University
Mentor: Andrew Richardson



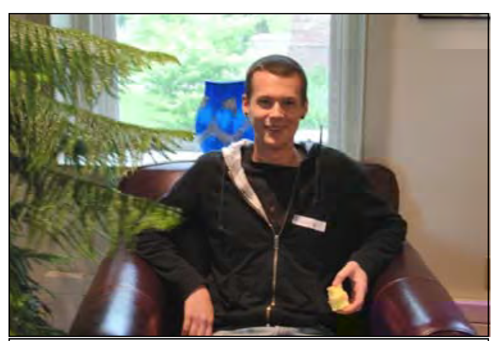
Ashley Golphin
Kent State University
Mentor: Nathan Phillips



Moussa Bakari
Lincoln University
Mentor: Jim Tang

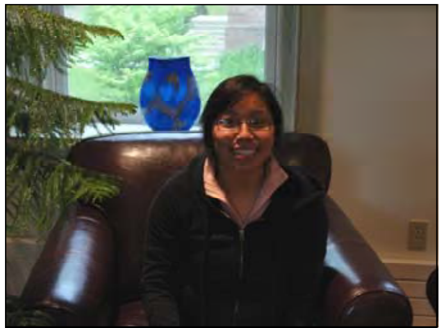


Bridgit Darby
Boston University
Mentor: Andrew Richardson



Michael Marquis
Arizona State University
Mentor: Shannon Pelini

Deepa Rao
MIT
Mentor: Laura Meredith



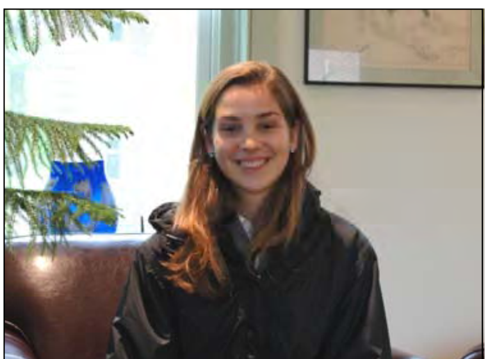
Alanna Yazzie
San Juan College
Mentor: Lindsay Scott

Isaac Lavine
Lafayette College
Mentor: Andrew Richardson

Stephan Bradley
Lincoln University
Mentor: Nathan Phillips

Alena Tofte
Harvard University
Mentor: Jim Wheeler

Rachel Norman
UNC Chapel Hill
Mentor: Andrew Richardson

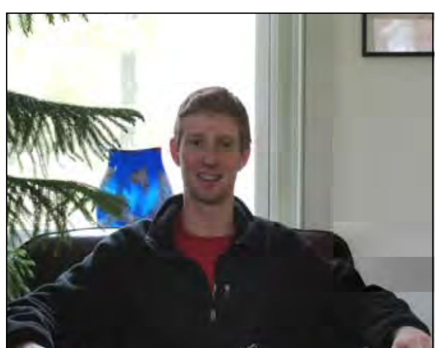


Julianna Brunini
Harvard University
Mentor: Jim Tang

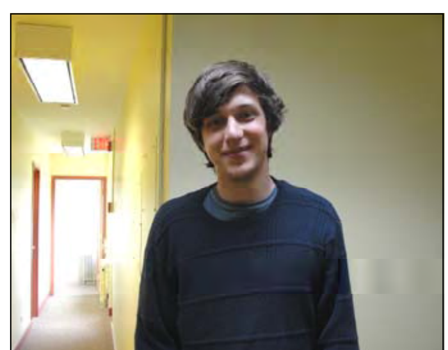
Rachel Brooks
University of Vermont
Mentor: Aaron Ellison

Sofiya Taskova
Mount Holyoke College
Mentor: Emery Boose

Kevin Towle
Notre Dame University
Mentor: Shannon Pelini



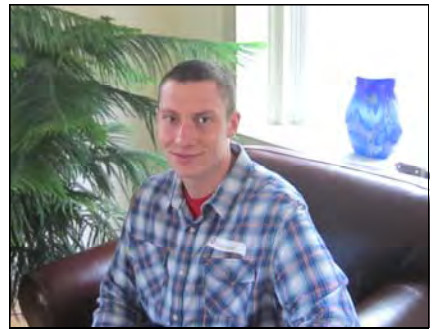
Jakob Lindaas
Harvard College
Mentor: Leland Werden



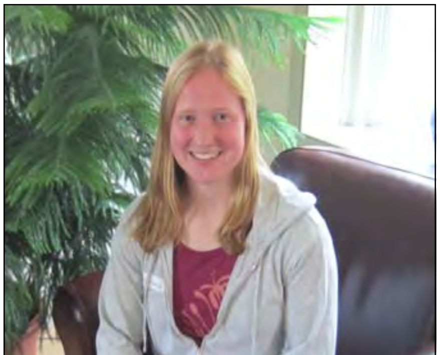
Sam Safran
Middlebury College
Mentor: Kristina Stinson

Tara Mahendrarajah
UMass-Amherst
Mentor: Jeff Blanchard

Natashia Manyak
UMass-Amherst
Mentor: Israel Del Toro



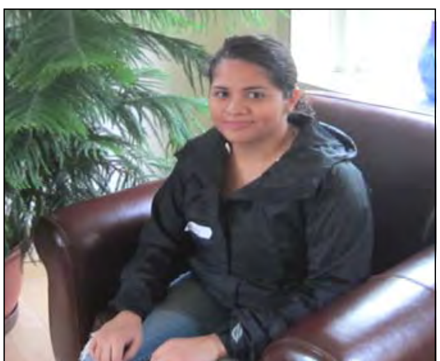
Andrew Kaldunski
Ripon College
Mentor: Emery Boose



Katharine Chute
Harvard College
Mentor: Chris Williams

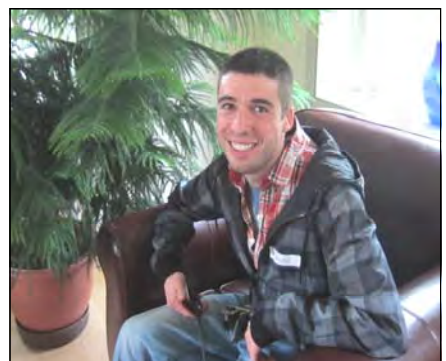
Linn Jennings
Mount Holyoke College
Mentor: Kristina Stinson

Marcus Pasay
Clark University
Mentor: Chris Williams



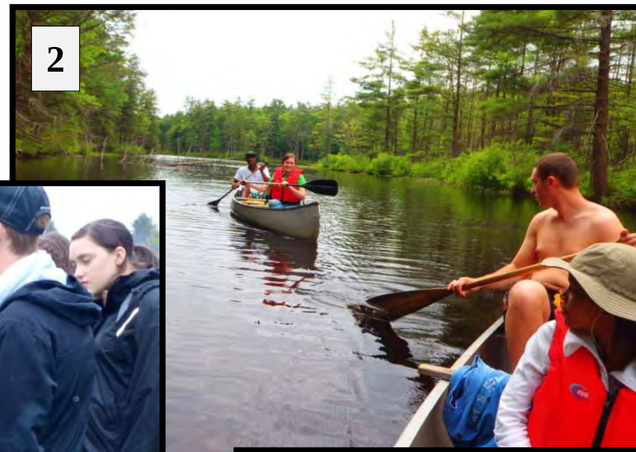
Leticia Delgado
Northern Arizona University
Mentor: Jim Tang

Relena Ribbons
UMass-Amherst
Proctor

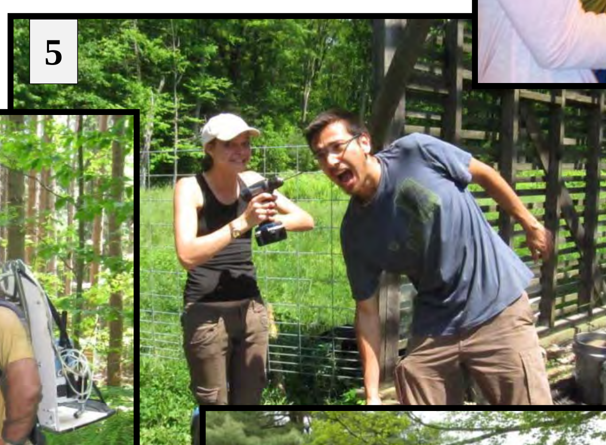


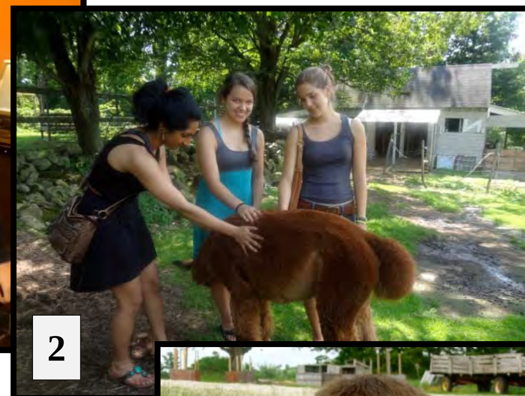
Moshe Roberts
Binghamton University, SUNY
Proctor

Summer 2011 Highlights

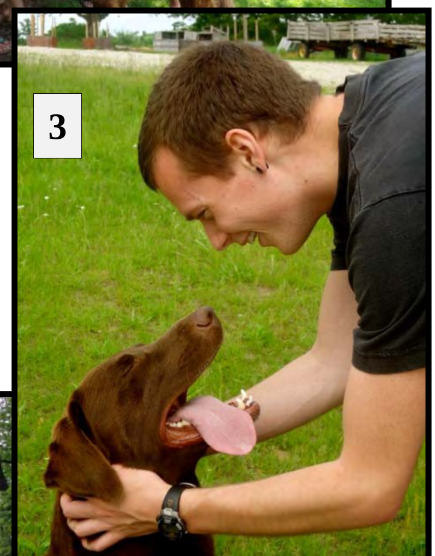


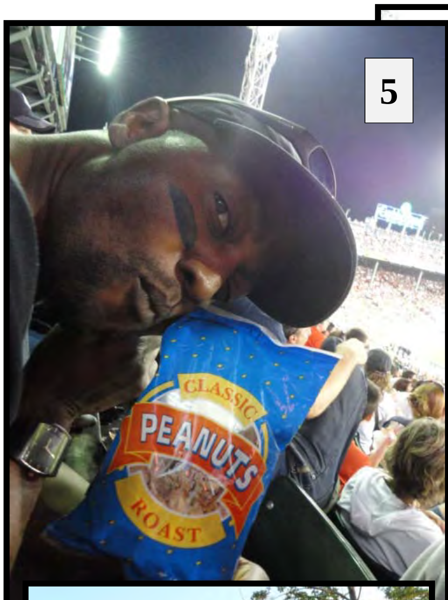
1. Day 1 Hike with Emery, 2. Canoeing (Ashley, Laura, Collette, Moshe, Andrew, Stephan) 3. Checking out a confiscated boa skin at the HMNH in Cambridge. 4. Marcus & Angie working hard, 5. Natashia and Izzie hardly working. 6. Slacklining! (Rachel, Laura, Drew). 7. Slacklining! (proctor Moshe)

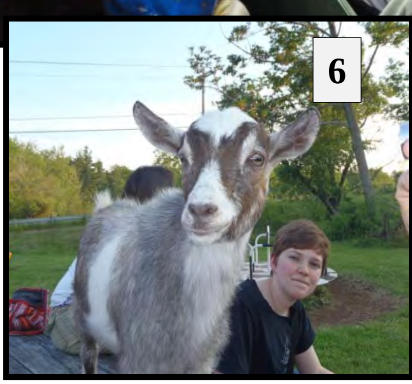




1. Isaac, Sam, Rachel, Michael, Deepa celebrating in Cambridge, 2. Deepa, Alena, Julianna making alpaca friends, 3. Michael and Shadow 4. Laura, Keke, Ashley, Collette, Leti, Lindsay, Moshe, Alanna & Kevin spot a moose, 5. Moussa enjoying peanuts at the Red Sox game, 6. Lindsay & her new friend, 7. Kevin, Rachel, Moshe, Alanna, Collette, Moussa, Lindsay at Fenway. 8. Collette, kayak,

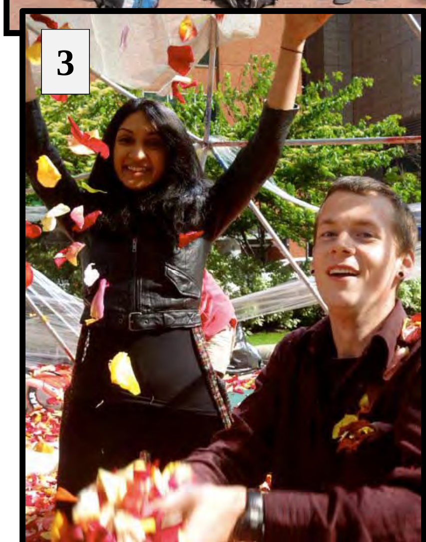




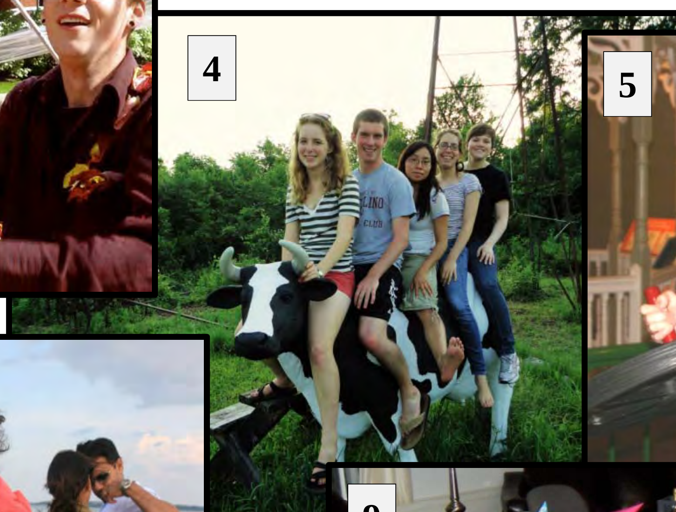


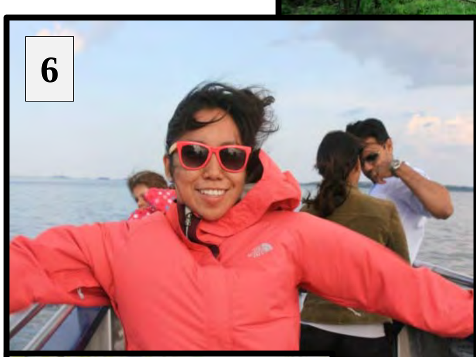
HF Summer 2011

2011

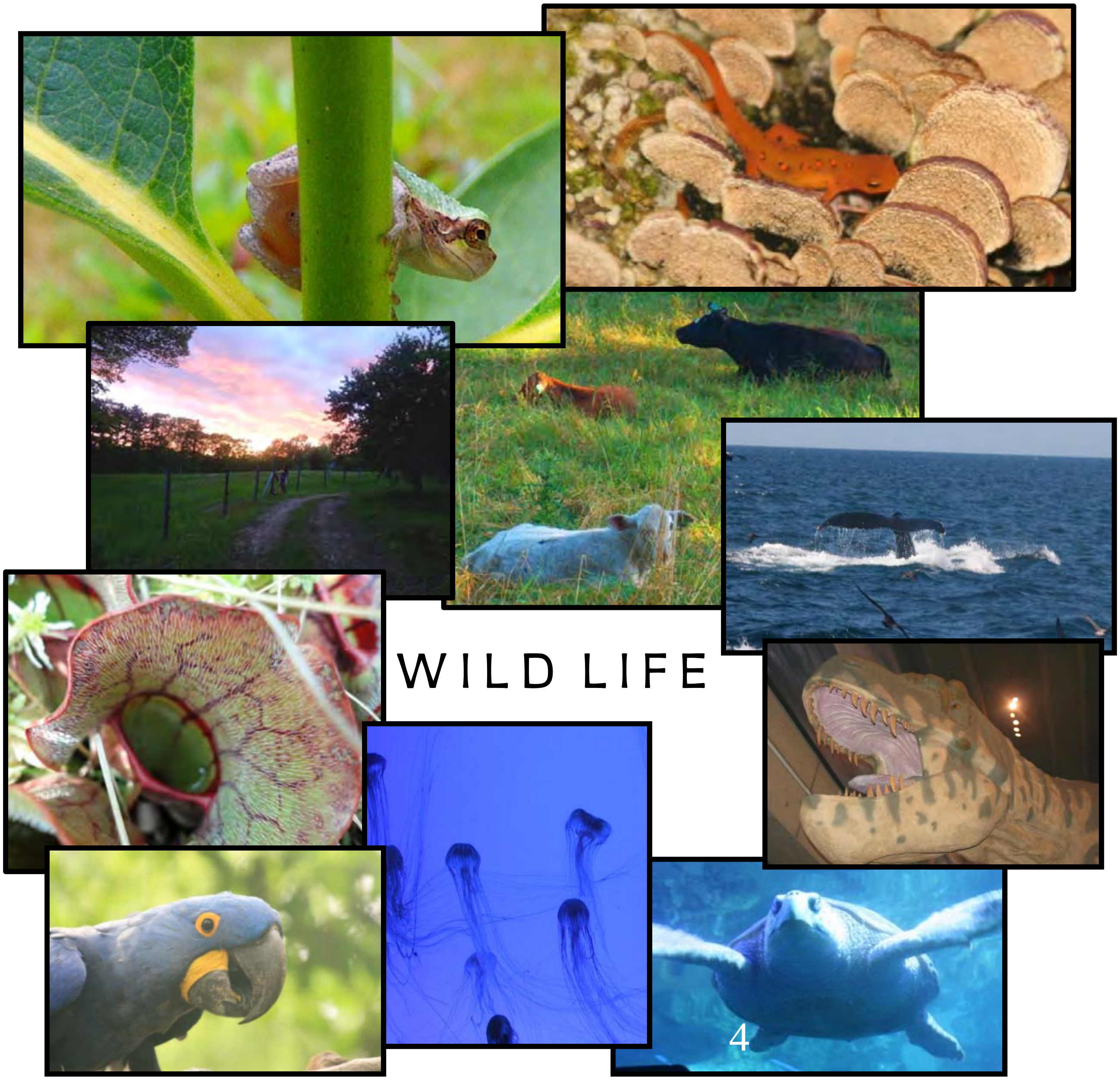


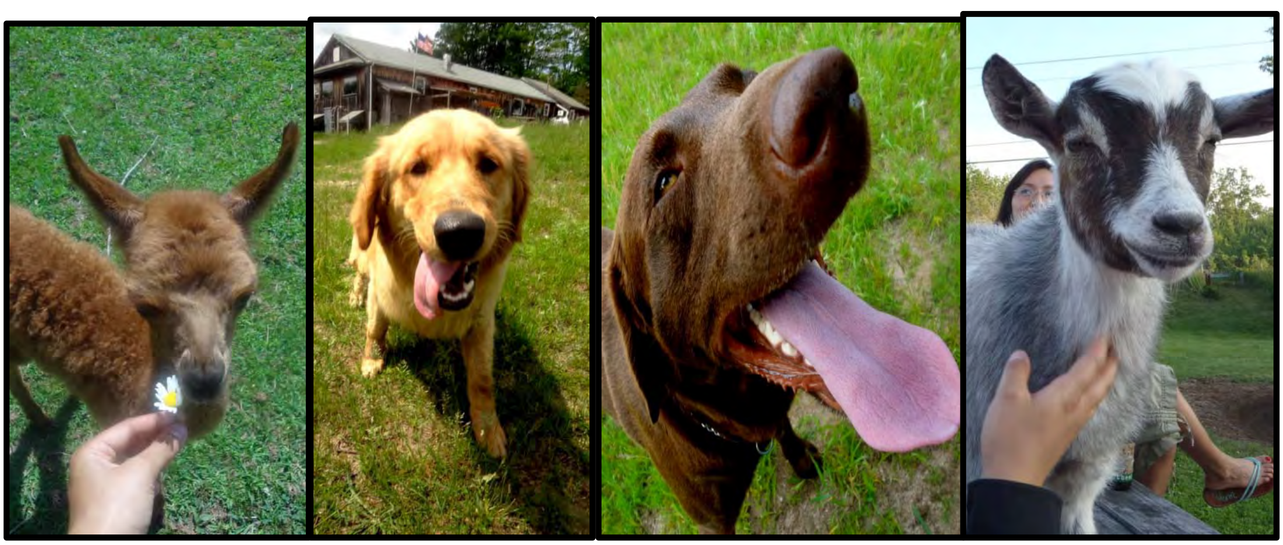
1. The mothership, 2. Go bruins! 3. Deepa & Michael, Figments Art Festival, 4. Rachel, Kevin, Alanna, Kelden, Lindsay ride a cow, 5. Laura at MOS, 6. Alanna on the whale hunt, 7. Garett made a friend, 8. Rachel, Drew, Moshe, Fire tower, 9. Party at Raup! 10. Leti, Keke, Libby hunting whales.

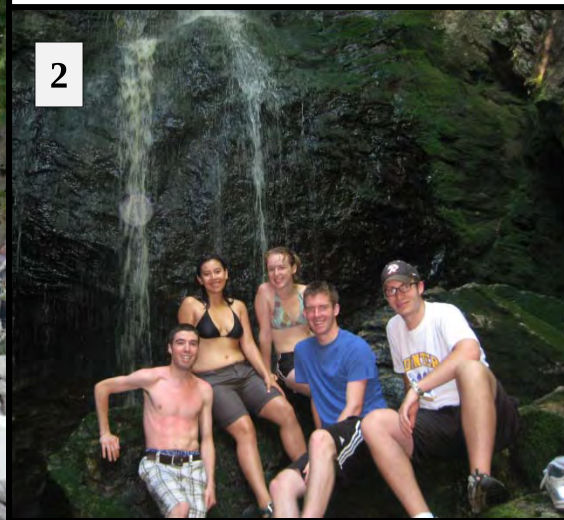




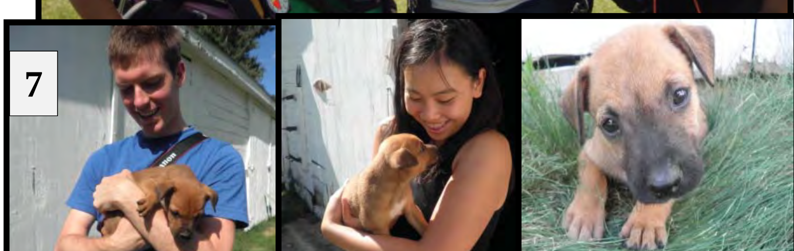
WILD LIFE



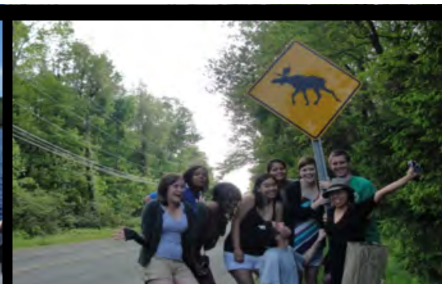




1. Mini-golfing! 2. Royalston Falls, 3. Local sight-seeing, 4. Paddleboating, 5. Skydiving 6. Beach in Boston, 6. Free Puppies!!!



Harvard Forest Summer Program in Ecology



2011