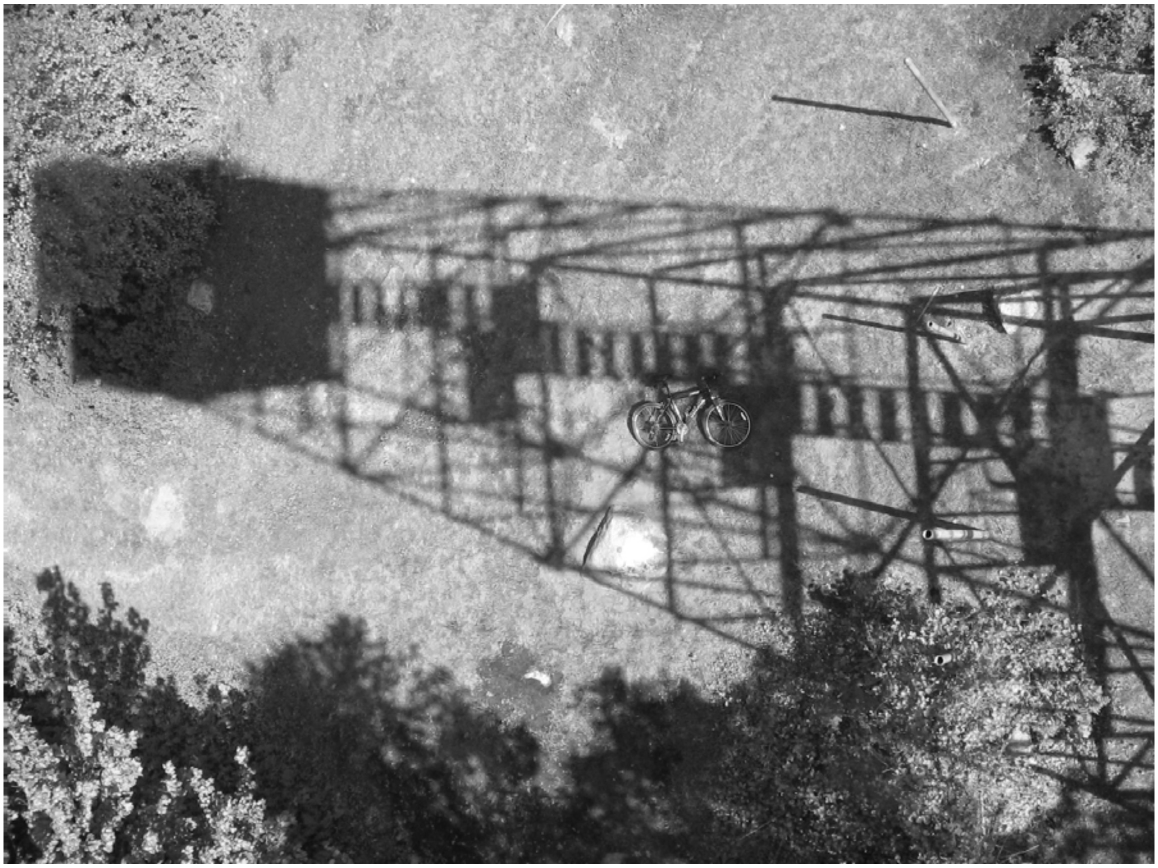
HARVARD FOREST

SUMMER RESEARCH PROGRAM



Abstracts from the 13th Annual
Harvard Forest Summer Research Program
18 August 2005

THIRTEENTH ANNUAL HARVARD FOREST SUMMER RESEARCH PROGRAM

18 August 2005

HARVARD FOREST
FISHER MUSEUM

Photography by Audrey Barker Plotkin and Kathryn McKain

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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 3000 acres of land in the north-central Massachusetts town of Petersham that 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 additional 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. The Harvard Forest administers the Graduate Program in Forestry that awards a masters degree in Forest Science and faculty at the Forest offer courses through the Department of Organismic and Evolutionary Biology (OEB), the Kennedy School of Government (KSG), 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 Department of Natural Resource Conservation 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 skilled Woods Crew undertake forest management and physical plant activities. The Coordinator of the Fisher Museum oversees many educational and outreach programs.

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

Summer Research Program

The Harvard Forest Summer Student Research program, coordinated by Edythe Ellin and assisted by Tracy Rogers and Jimmy Tran, attracted a diverse group of students to receive training in scientific investigations, and experience in long-term ecological research. All students worked closely with researchers while many conducted their own independent studies. The program included weekly seminars from resident and visiting scientists, discussions on career issues in science, and field exercises on soils, land-use history, and plant identification. An annual field trip was made to the Institute of Ecosystem Studies (Millbrook, NY) to participate in a Forum on Careers in Ecology. Students presented major results of their work at the Annual Summer Student Research Symposium in mid August.

Summer Research Students
2005

13TH ANNUAL HARVARD FOREST
SUMMER RESEARCH PROGRAM SYMPOSIUM
FISHER MUSEUM
18 AUGUST 2005

Aaron Ellison - Welcome

Session I: The Dynamic New England Forest (Rob McDonald, Moderator)

Speaker		Mentor(s)	Title
Kirsten Ward	Brigham Young University	Glenn Motzkin	Harvard Forest flora
Mathew Trumbull	Hampshire College	Audrey Barker Plotkin	Understory vegetation response following a simulated hurricane
Bennet Leon	Bates College	Audrey Barker Plotkin	Evolution of pit and mound micro-topography 15 years after a simulated hurricane
Ryan Barba	Assumption College	Rob McDonald	Forest recovery of harvested stand remains stable despite the presence of invasive species and aspects of land use history
Daniel Breese	Bennington College	Rob McDonald	White pine regeneration in upland forests of Massachusetts depends on specific conditions of land-use, canopy demographics, and harvesting intensity
Natalie Levy	University of California, Berkeley	Audrey Barker Plotkin	Woody detritus survey: initial results from the hemlock manipulation study
Linh Vuong	University of Puget Sound	Steve Wofsy and John Budney	Effects of selective logging on CWD: quantifying microclimate variability
David Diaz	Harvard College	Aaron Ellison and Noreen Tuross	Variation of natural abundance δ15N of forest soil and vegetation as a function of historical agricultural land-use

Session II: Invasives Part 1 – Invasive Plants (Kristina Stinson, Moderator)

Jens Stevens	Carleton College	Kristina Stinson and Kathleen Donohue	Maternal habitat effects on the understory invasive species *Alliaria petiolata*
Marit Wilkerson	University of Texas Austin	Kristina Stinson and Kathleen Donohue	Demographic attributes of the invasive species *Alliaria petiolata* at three spatial scales
Antonnine Cooper	Oakwood College	Betsy Von Holle and Kristina Stinson	Investigating the physiological responses of exotic plant species to historical invasion by *Robinia pseudoaccacia* (black locust)

Kristin Ivy	Grambling State University	Betsy Von Holle	Effects of land-use and soil characteristics on invasive plant abundance
Daniel Katz	Bard College	Rob McDonald	The effects of forest harvesting on invasive plants in Massachusetts

Session III. Physical and biotic dynamics of aqua ecosystems (Aaron Ellison, Moderator)

Laura Briscoe	College of the Atlantic	Aaron Ellison	Correlations between *Sphagnum* diversity and ant distribution in New England bogs
Cheryl Hester	Pueblo Community College	Aaron Ellison	Prey availability alters photosynthetic physiology in *Sarracenia* genus
Jonah Butler	New College of Florida	Jessica Butler and Aaron Ellison	A comparison of prey decomposition in sundews and pitcher plants
James Willacker	SUNY-ESF	Betsy Colburn and Bill Sobczak	Comparison of macroinvertebrate communities in two headwater streams of differing forest type
Safina Singh	Mount Holyoke College	Emery Boose and Julian Hadley	Hydrology of Prospect Hill Tract
Matthew Kaufman	Keene State College	Betsy Colburn and Bill Sobczak	Groundwater and surface water inter-actions in Bigelow Brook: initial results
Jennifer McInnis	Cornell University	Julian Hadley	The Effects of a swamp on the flux of carbon through the Harvard Forest

Session IV: Physiology, from Trees to Ecosystems (Jackie Mohan, Moderator)

Melissa Whitaker	Prescott College	Missy Holbrook and Brendan Choat	Influences of photosynthetic rates on ionic concentration and hydraulic resistance of xylem sap
Brian Warshay	Cornell University	Jackie Mohan	Physiological girdling of forest trees: developments of a new method
Emily Austin	Hampshire College	Kathleen Savage and Eric Davidson	Root respiration and nitrogen concentration: an excised root study of three tree species
Susan Cheng	Columbia University	Julian Hadley	Aboveground carbon storage in a young deciduous forest
Katherine Lenoir	Wellesley College	Jackie Mohan	Changes in herbaceous vegetation composition in response to soil warming

Session V: Invasives Part 2 – Effects of Hemlock Decline (David Orwig, Moderator)

Sarah Truebe	Stanford University	Wyatt Oswald	Mid-Holocene vegetation and climate Change in New England
Sascha Lodge	Kenyon College	Evan Pressier and Dave Orwig	Landscape survey of hemlock woolly adelgid and elongate hemlock scale abundance in hemlock forests of southern New England
Phil LaBranche	Holyoke Community College	Scott Costa	Hemlock woolly adelgid range expansion: field survey vs. limited range protocol
Kelly Walton	SUNY-ESF	Dave Orwig	Ten year revisit of stand dynamics associated with hemlock woolly adelgid infestation in southern Connecticut
Charles Boyd	Centre College	Dave Orwig	Foundation laid to monitor changes in stream and soil nitrogen dynamics following hemlock woolly adelgid and logging in hemlock-dominated watersheds
Grace Wu	Pomona College	Aaron Ellison	Ant interaction dynamics predict *Formicinae* species encroachment in the aftermath of hemlock woolly adelgid

Aaron Ellison - Closing

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Root Respiration and Nitrogen Concentration:
An Excised Root Study of Three Tree Species

Emily E. Austin

Carbon dioxide, the product of soil respiration, is an important greenhouse gas. Global climate change will affect the contributions of autotrophic and heterotrophic components to soil respiration. Reported contributions of autotrophic respiration to total soil respiration vary widely (5-85%). There is a correlation between root respiration and nitrogen concentration, [N], across species and ecosystems. This correlation may be used in the future to estimate root respiration at ecosystem level based on tree species composition and nitrogen availability.

The objective of this study was to examine the relationship between root respiration and root [N] among tree species and root size classes. Roots in three size classes were sampled: medium (2-4mm), fine (1-2mm), and very fine (<1mm) from three trees of each species: *Quercus rubra, Betula lenta*, and *Tsuga canadensis* for a total of 27 samples. The respiration was measured in a closed chamber system circulating air from the chamber headspace to an Infrared Gas Analyzer and % nitrogen using a total carbon and nitrogen analyzer. Decreasing root size showed significant increase in both root respiration (p=0.002) and nitrogen concentration (p=0.000). Tree species had a significant effect on root respiration (p=0.026), but there was no relationship with root [N]. The data show a significant correlation of increased respiration with increased nitrogen concentration (Fig. 1). The average root respiration data and published root biomass data from the Harvard Forest, were used to estimated the autotrophic contribution to total soil respiration in hardwood plots (≈28 %). These data confirm the correlation between root respiration and root [N].

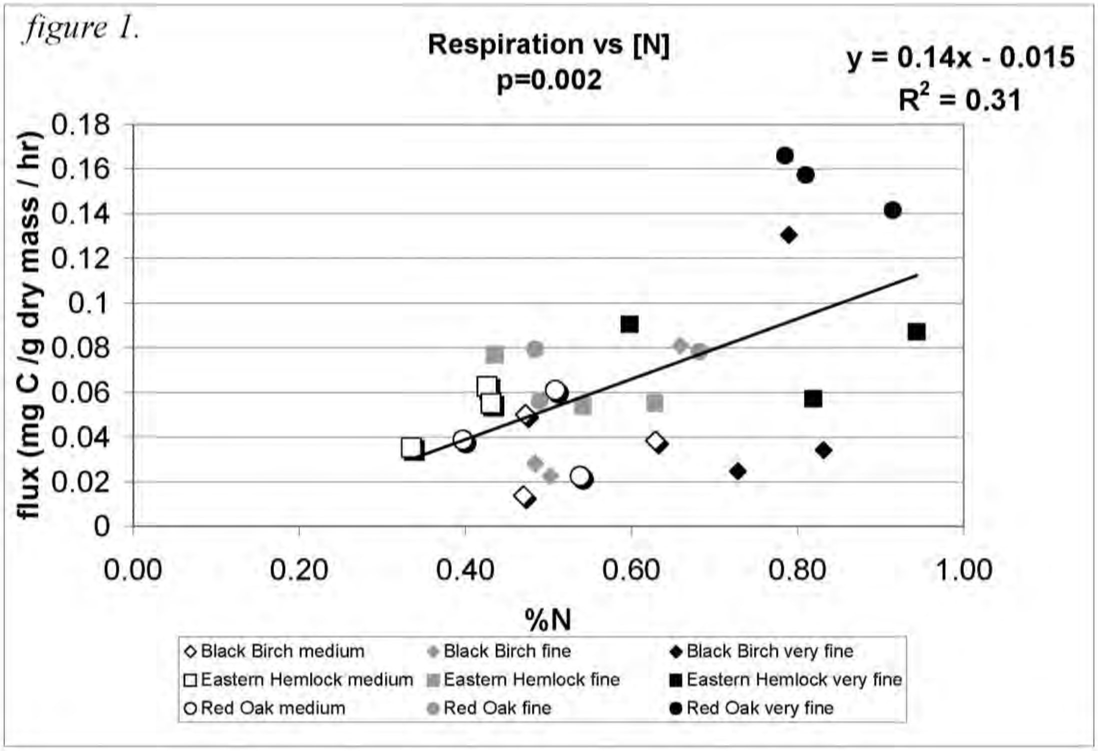


Figure 1. (Austin)

Forest Recovery of Harvested Stands Remains Stable Despite the Presence of Invasive Species and Aspects of Land Use History

Ryan C. Barba

After a heavy cutting event, a lower overstory density will yield more available sunlight to the forest floor and will immediately spark an overall forest recovery to the harvest. It was sought to determine whether forest recovery after a heavy cutting event follows any specific trends in terms of seedling, sapling, and tree densities, and determine what these trends were if they do exist. Additionally, it was sought to determine whether the presence of invasive species or aspects of land use history had any effect on these trends of forest recovery. Data were collected throughout Massachusetts, via ten sample points, at individual polygons that were known to be cut or not cut within the past twenty years, based on a statewide harvest database. Through the research and analysis of data, clear trends were identified in seedling, sapling, and tree densities despite great data variation. After an initial spike of seedlings of around 22,000 seedlings per hectare (which makes sense directly after a heavy cut), the number of seedlings present approached that of an unharvested site: about 12,000 seedlings per hectare (Fig. 1). Sapling levels also approached that of an unharvested site: about 1,000 per hectare. Additionally, it was clear that neither invasive species nor land use history has any significant effect on the approach of these densities to their original values, and thus no significant effect on a forest's ability to recover from a heavy cut.

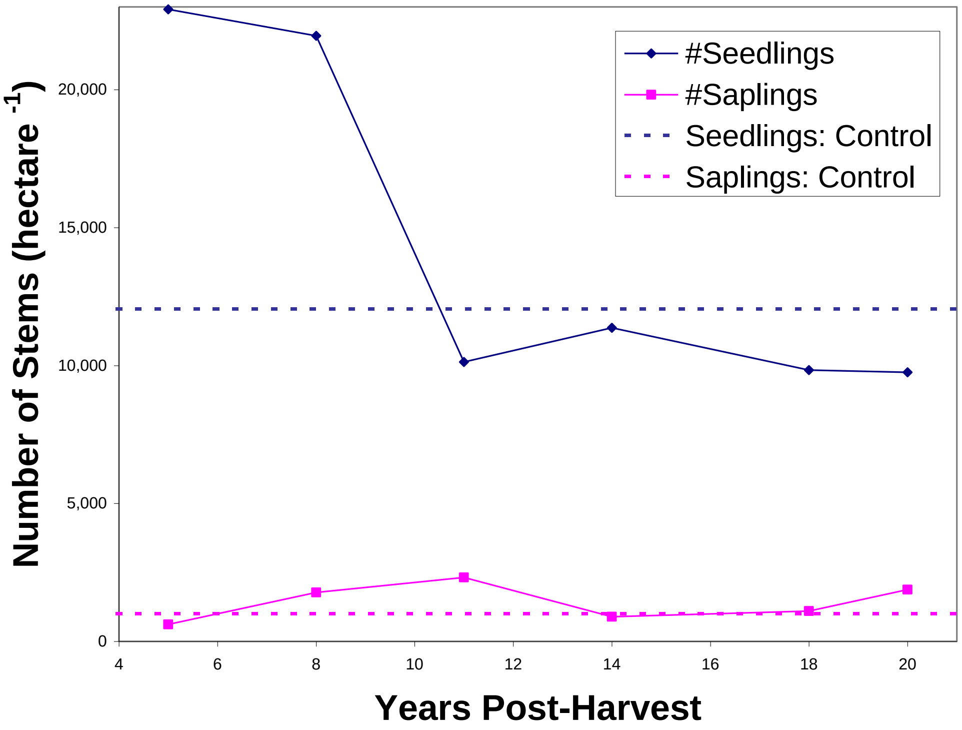


Figure 1. (Barba)

Foundation Laid to Monitor Changes in Stream and Soil Nitrogen Dynamics Following Hemlock Woolly Adelgid and Logging in Hemlock-Dominated Watersheds

Charles L. Boyd

The hemlock woolly adelgid (*Adelges tsugae*, HWA) is an exotic aphid-like insect killing hemlock populations in the eastern United States. Harvard Forest research has focused on studying the effects of HWA and logging on forest systems in New England. Research is now beginning to look at HWA's effect on aquatic systems. This is the first study that begins to look at the direct effects of HWA and HWA-induced salvage logging on stream nitrogen dynamics. Two infested watersheds, one urban site in Boston and one rural site in central Massachusetts, were selected for study. Both sites contain mature second-growth hemlock-dominated forests with first order streams. N availability was examined in the soils and N concentrations was sampled in the streams draining both hemlock-dominated watersheds. The urban watershed soils had 20 times greater NH4+ availability and 200 times greater NO3- availability than the soils of the rural watershed. Urban stream N concentrations were also higher than the rural watershed. The increased N influx in Boston is likely the result of greater N deposition.

Both sites have potential for valuable future research. Since the urban N data were collected, Arnold Arboretum clear-cut the hemlocks in four experimental urban plots. The pre-cut urban N data analyzed will serve as pre-treatment data for ongoing post-cut data. Although present, HWA has not yet significantly reduced hemlock health in the rural site. The data analyzed from the rural watershed will serve as baseline data for continuing data collection as HWA reduces hemlock health in this site.

Stumps remaining from hemlock clearcut on Hemlock Hill
at the Arnold Arboretum.(during spring 2005)

White Pine Regeneration in Upland Forests of Massachusetts Depends on Specific Conditions of Land-Use, Canopy Demographics, and Harvesting Intensity

Daniel A. Breese

White pine (*Pinus strobus*), a dominant, early-successional tree species, has been important to forest harvesting in New England since colonial settlement. However, white pine regeneration in upland forests is often lower in relation to other dominant species even after harvesting. Small canopy gaps created by tree removal typically select for moderately shade-tolerant species (e.g., *Acer rubrum*) at the expense of white pine. This study investigated white pine seedling densities in upland forests of western Massachusetts due to variation in past land-use, canopy demographics, and harvesting intensity. Data were collected in the summer of 2004 in 66 harvested and non-harvested sites across four major geographic regions of the state. Sites formerly cleared for agriculture had greater white pine basal area than sites that were continuously wooded. At the same time, sites with more white pine basal area had greater seedling density (Fig. 1). Harvesting intensity had no effect on seedling density as controls were not significantly different than all harvesting levels. Early colonization of abandoned fields most likely explains trends in white pine basal area and seedling densities, as sites with more mature white pine also have more reproductive trees. Lack of a harvesting intensity effect suggests that the small scale winter harvesting of forests in Massachusetts does not simulate the light regime and/or soil disturbance of abandoned fields or storm damage. This result contradicts the belief that more intense harvests will facilitate regeneration of economically valuable early-successional tree species.

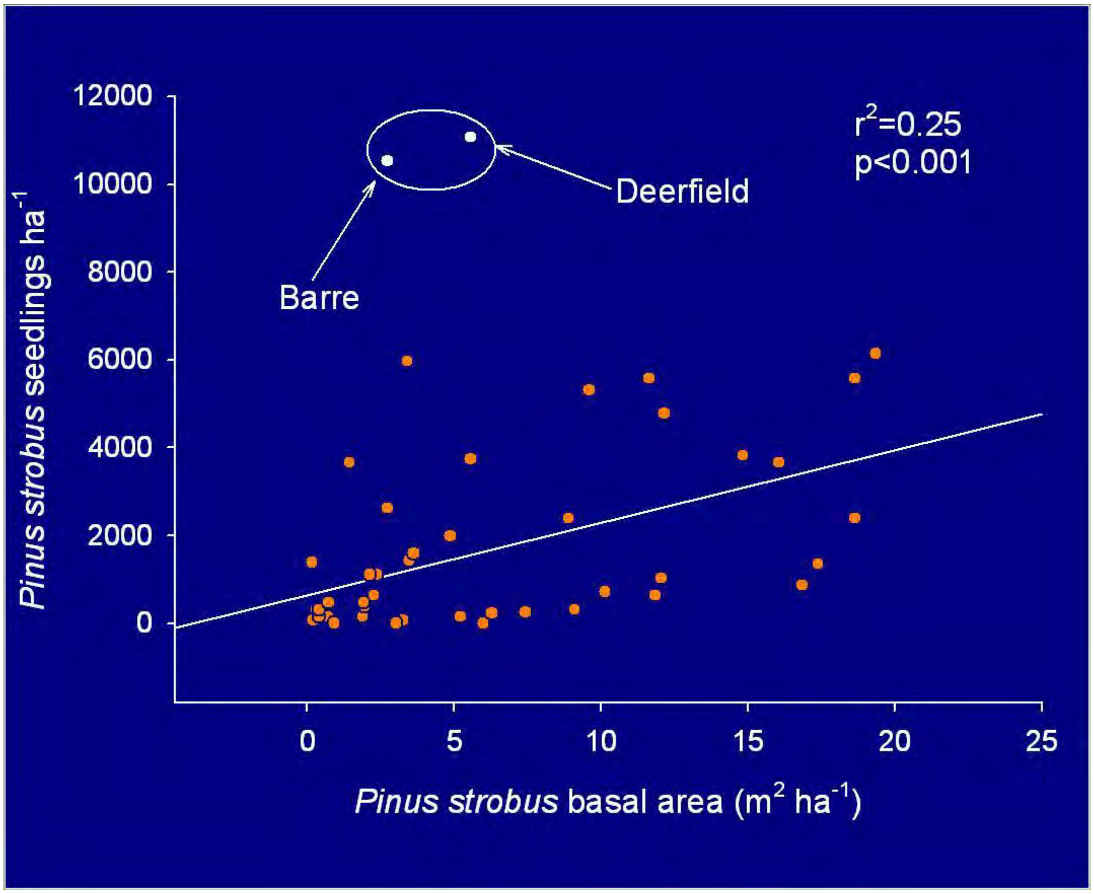


Figure 1. (Breese)

Correlations between *Sphagnum* Diversity and Ant Distribution in New England Bogs

Laura R. Briscoe

New England bogs are ecosystems characterized by *Sphagnum* moss. *Sphagnum* varies widely in form, often according to their microhabitat. Some species are used as indicators of pH, moisture and microtopographical regimes. To build on previous work exploring relationships between ants and plants in New England bogs, *Sphagnum* samples were identified to species and compared with ant distributions. Two hundred samples were collected along transects in each of three bogs (two in Massachusetts, one in Vermont). For each sample, *Sphagnum* was collected, ants were collected at baits, the microtopography of the hummocks, and the distance to the nearest pitcher plant were measured. All 600 *Sphagnum* samples were identified and included 10 species. Each bog had a different *Sphagnum* species composition, and a dominant species that made up >50% of the samples (Fig. 1). Eight species of ants were collected, most commonly associated with the dominant species of *Sphagnum* in each bog. A correlation was found between ants and *S. magellanicum*, the one species that was relatively abundant in all three bogs. Ants were commonly found nesting in this species and of the seven samples that contained ant nests, four were located in *S. magellanicum*, a relatively large and robust species often found on tops and sides of hummocks in older and drier portions of bogs. Further work is needed to map ant nests in relation to *Sphagnum* species to find stronger correlations.

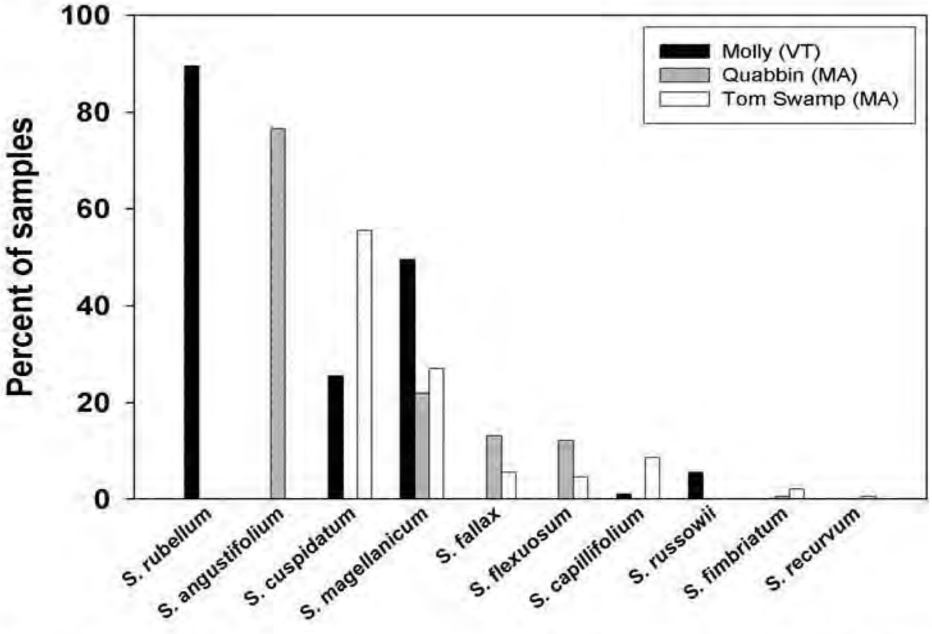


Figure 1. Percentage of *Sphagnum* samples collected from three New England bogs

A Comparison of Prey Decomposition in Sundews and Pitcher Plants

Jonah S. Butler

Carnivorous plants obtain the majority of their nutrients through decomposition of captured prey. The amount and rate of prey decomposition is important; plants that decompose prey at a faster rate and greater quantity can utilize prey-derived nutrients more rapidly. Rates of decomposition were compared in seven species of carnivorous plants, from two genera (*Drosera filiformis, Drosera intermedia, Sarracenia flava, Sarracenia leucophylla, Sarracenia jonesii, Sarracenia minor*, and *Sarracenia rubra*) . The common house fly (*Musca domestica)* was used as the prey source. Flies were dried and weighed before placing one fly in each leaf. There were 20 treated leaves within each species; leaves were randomly split into two harvests, one week and three weeks. Flies were carefully removed from leaves, dried and weighed, to assess the percent of prey decomposition. The two sundew species had similar decomposition rates with 36.9 %, and 44.5 % decomposition in *D. intermedia* and *D. fliliformis*, respectively. Within *Sarracenia*, taller plants appeared to have greater decomposition within the first week. The tallest species, *S. leucophylla* obtained the highest average decomposition in 1 week; decomposing 77.8 % of the fly mass (Fig. 1). However, at the second harvest smaller species achieved the greatest decomposition of prey. *S. rubra* decomposed an average of 86.9 % fly mass in week three. Different rates of decomposition within pitcher plants could be a result of a larger surface area and a greater amount of enzymatic glands, or the need for more rapid nutrient acquisition from prey due to physiological constraints.

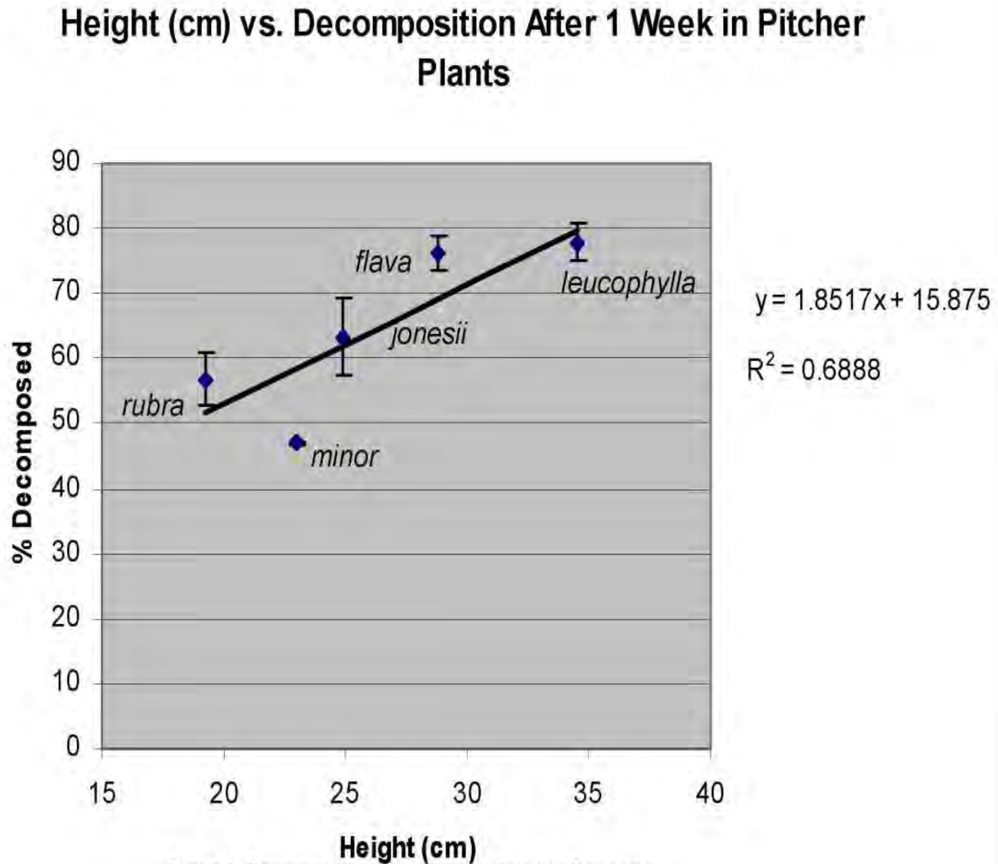


Figure 1: Decomposition as a function of height in *Sarracenia*.

(Butler)

Aboveground Carbon Storage in a Deciduous Forest 48 Years after Fire

Susan Cheng

Many temperate forests in the Northern Hemisphere are thought to be carbon sinks which slow the rate of increase in atmospheric CO_2. Forests store carbon belowground in organic ground matter and soil, or aboveground in wood. In order to estimate carbon storage in forest ecosystems, it is important to understand how a forest's carbon balance varies with age and fire history. Aboveground carbon storage was measured in a primarily deciduous forest dominated by red oak (*Quercus rubra*) and red maple (*Acer rubrum*) and affected by a 1957 fire on Little Prospect Hill at Harvard Forest in central Massachusetts. Annual radial growth was measured in trees with diameters greater than 10 cm in 24 plots at 100, 200, and 300 m southwest or northwest of an eddy covariance tower. Standard allometric equations from forestry literature were used to calculate carbon storage in each plot, and in areas inside and outside the burn area (Fig. 1). These results showed that a post-fire forest less than 50 years old stored aboveground carbon at a similar rate (about 1.5 Mg C/ha/yr) to a nearby 65 to 100 year old forest in recent years. A large decrease in carbon storage at the forest on Little Prospect Hill was most likely due to a gypsy moth invasion from 1979-1981. Aboveground carbon storage recovered to its 1977 level (about 1.3 Mg C/ha/yr) less than 10 years after the gypsy moth outbreak.

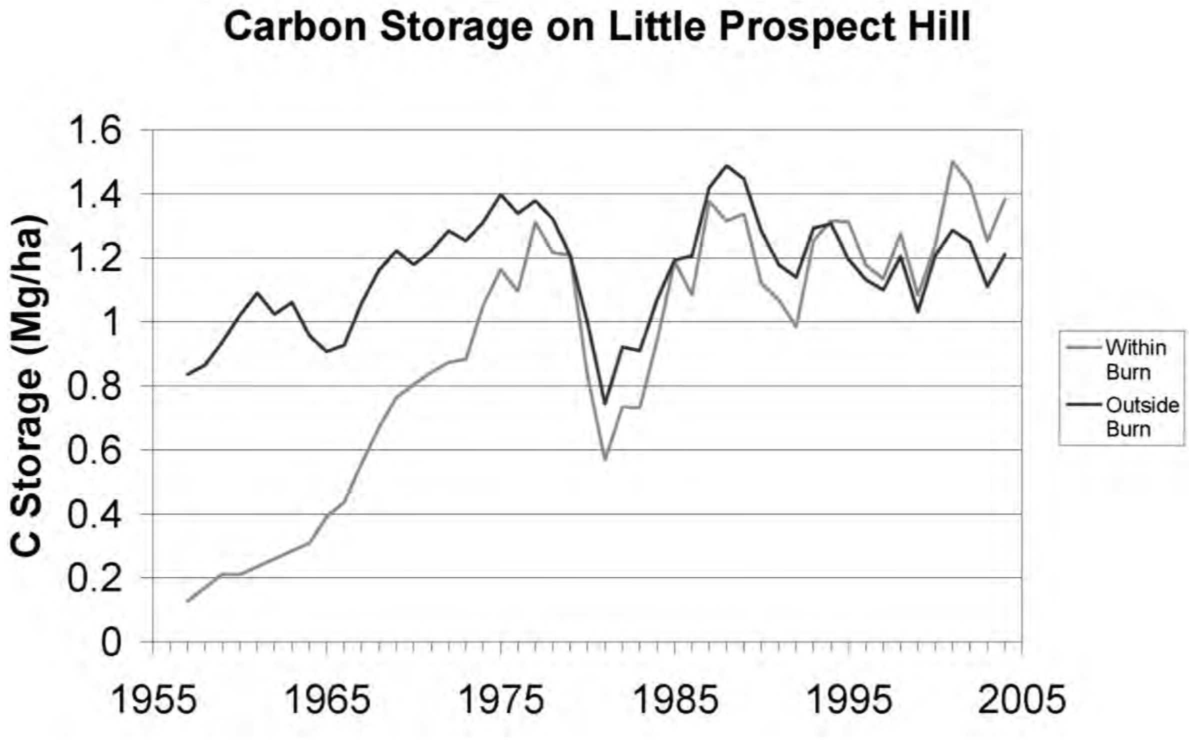


Figure 1. (Cheng)

Investigating the Physiological Effects of Invasive Plants in the Presence of Black Locust (*Robinia pseudoacacia*)

Antonnine R. Cooper

Since its introduction to New England in the late 18th century, *Robinia pseudoacacia* (black locust), a nitrogen fixing tree species native to the Ozarks and central Appalachian Mountains, has become one of the top 100 invasive woody plants in the world. Previous studies have found nonnative species to be ten times more abundant in *Robinia* stands than in native overstory stands which consist of pitch pine (*Pinus rigida*) and mixed pitch pine-oak (*Quercus velutina* and *Quercus alba*) communities. The native plots were located only 20m away from *Robinia* and yet showed significant difference in understory density of nonnative plants. As a result of Hurricane Bob, which ripped through New England in 1991, black locust stands decreased in size. However, the nonnatives in the soils where these trees once stood continued to thrive at a much higher abundance than that of the native stands. To find the difference in nonnative germination in Native, Legacy, and *Robinia* soil types, we compared physiological responses to light as well as the biomass of six nonnative species. Both the rate of photosynthesis measured at ambient CO_2 and the biomass of the nonnatives were significantly higher in *Robinia* and Legacy soil types than native soils. Nonnatives had greater water use efficiency and stomatal conductance in legacy and *Robinia* soils. These data suggest that the increased nitrogen in *Robinia* soils may contribute to the success of nonnative plants.

Variation of Natural Abundance δ15N in Forest Soils and Vegetation as a Function of Historical Agricultural Land-Use

David D. Diaz

Biogeochemical changes instigated by agricultural land-use are multiple and long-lived. Seemingly innocuous activities such as depositing animal manure as fertilizer and dragging a plow through the earth have produced dramatically altered regimes of nutrient cycling, the effects of which may still be discerned in the ecosystem composition and properties of contemporary forests, even after more than a century of abandonment and reforestation. The extensive historical and ecological research which has been conducted on the Prospect Hill tract of Harvard Forest in Petersham, Massachusetts, makes this an ideal location to explore the biogeochemical legacies of historical land-use. Distinct values for nitrogen isotope concentrations in forest soils and ferns have been previously documented, establishing the use of N-15 as a meaningful tool in examining the lasting effects of agriculture. To establish the history and trajectory of these changes in the forest following agricultural abandonment, the use of *Pinus strobus* tree rings may serve as a useful indicator of past variations in soil nitrogen. To evaluate the historical and contemporary effects of different agricultural land-uses on the nitrogen content of the forest, a survey of soil, vegetation (*Tsuga canadensis* needles, *Gaultheria procumbens*, and *Lycopodium obscurum*), and tree rings (*P. strobus*) is currently underway at the Harvard Forest. These samples will be analyzed for nitrogen isotope concentrations using an Isotope Ratio Mass Spectrometer (IRMS) and used to evaluate potential sources for the biogeochemical variation across land-use types.

Prey Availability Alters Photosynthetic Physiology in *Sarracenia*

Cheryl Hester

It has been widely accepted that there is a correlation between prey capture and photosynthetic rates among carnivorous plants; however, this theory has rarely been tested. This study expands the previous research by looking at a total of 10 species of pitcher plant, a majority of which have never been measured for photosynthetic rates. The theory predicts that the energy cost of producing a leaf that is specialized for the capture of prey (pitchers) versus a phyllode (photosynthetic leaf) is relative to the nutrient availability in the surrounding environment. If nutrients are limited the plants would devote more energy to producing pitchers for prey capture. Previous research had shown that this holds true for certain species when given an increase in inorganic nitrogen.

Photosynthetic rates and foliar chlorophyll were measured prior to feeding the first and second pitchers; feeding treatments consisted of six weekly additions of five levels of ground insects along with a controlled unfed plant for each species. Minimum and maximum levels varied by average size of each species, resulting in a total of nine levels across all species. At harvest, photosynthesis, fluorescence, chlorophyll, leaf area, and biomass were measured for the first, second, and an extra pitcher, along with a phyllode, if one was available. Photosynthesis (Fig. 1) and quantum efficiency both increased with amount of insects fed. The results support currently accepted theory; however, a longer-term study should be done to look at the delayed response of nutrient intake among pitcher plants.

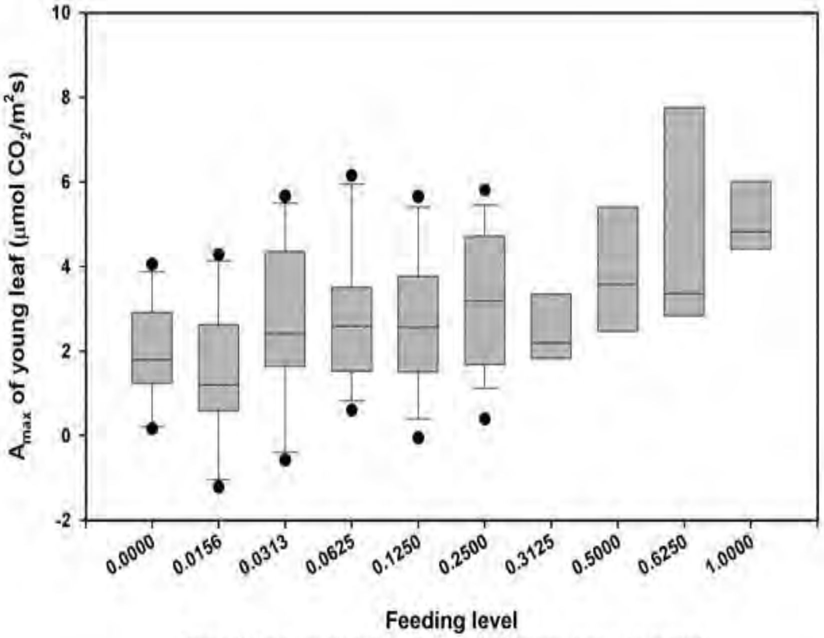


Figure 1. Relationship between amount of ground insect (in grams) fed each plant and maximum photosynthetic rate of the extra leaf.

(Hester)

Effects of Land Use and Soil Characteristics on Nonnative Plant Diversity

Kristin D. Ivy

Biological invasion is considered the second most serious threat to natural habitats, after habitat fragmentation and loss. To study the possible impact of land-use history on nonnative species, plant surveys were conducted on Martha's Vineyard, Massachusetts within seven different categories of land-use histories. Sites were categorized as either burned oak, scrub oak, tree oak, recently plowed agricultural land, previously plowed tree plantation, not plowed tree plantation or unplowed sandplain grassland. Plant censuses were conducted using a 20m x 20m plot at each site in July 2005. Percent cover was recorded for all plant species found. Each species was classified into cover classes as either <1%, 1-3%, 3-5%, 6-15%, 16-25%, 26-50%, 51-75%, or >75.

Mean richness and percent cover of exotic and native plant species were calculated for each land-use type. Exotic richness and cover data were also analyzed by tilling history as either tilled or non-tilled and for canopy cover as either open or closed canopy. Exotic species richness was significantly different across land-use histories. The richness and cover of exotic species increased with tilling disturbance and canopy openness. Exotic richness and abundance was higher in tilled forest and grassland communities and higher in open canopy habitat than forests.

Kristin Ivy, Robin Collins, Niña Cooper and Mentor Betsy Von Holle

The Effects of Forest Harvesting on Invasive Plants Massachusetts

Daniel S. Katz

Both forest harvesting and invasive plant species may have strong effects on forest composition and structure in Massachusetts. However, there has been relatively little study on how these two types of disturbances interact. This study tested whether harvesting facilitates either the initial establishment of invasive species or increases their abundance at sites where they already occur. Specific research questions included whether the time since harvesting or the harvesting intensity had any effect on this dynamic. The data used to answer these questions come from a larger scale study, the Forest Harvesting Project, for which 60 sites were sampled this summer in addition to the 82 sites sampled last summer. At each site cutting intensity, historical land use, and abundances for the 21 most common invasive species were recorded. By using the Fisher Exact Test on the first summer's data, it was determined that neither cutting intensity (p>.05) nor time since harvesting (p>.05) has a statistically significant effect on either the presence or abundance of invasive species. Historical land use (p=.0169) and soil substrate (p=.0114) did have a significant effect on both the presence and abundance of invasive species (Fig. 1). As predicted, sites which were heavily modified by human activity (like agricultural land) had higher frequencies and concentrations of invasive species, as did sites with richer soil substrates. The results imply that contemporary forest harvesting in Massachusetts does not have a significant effect on invasive species.

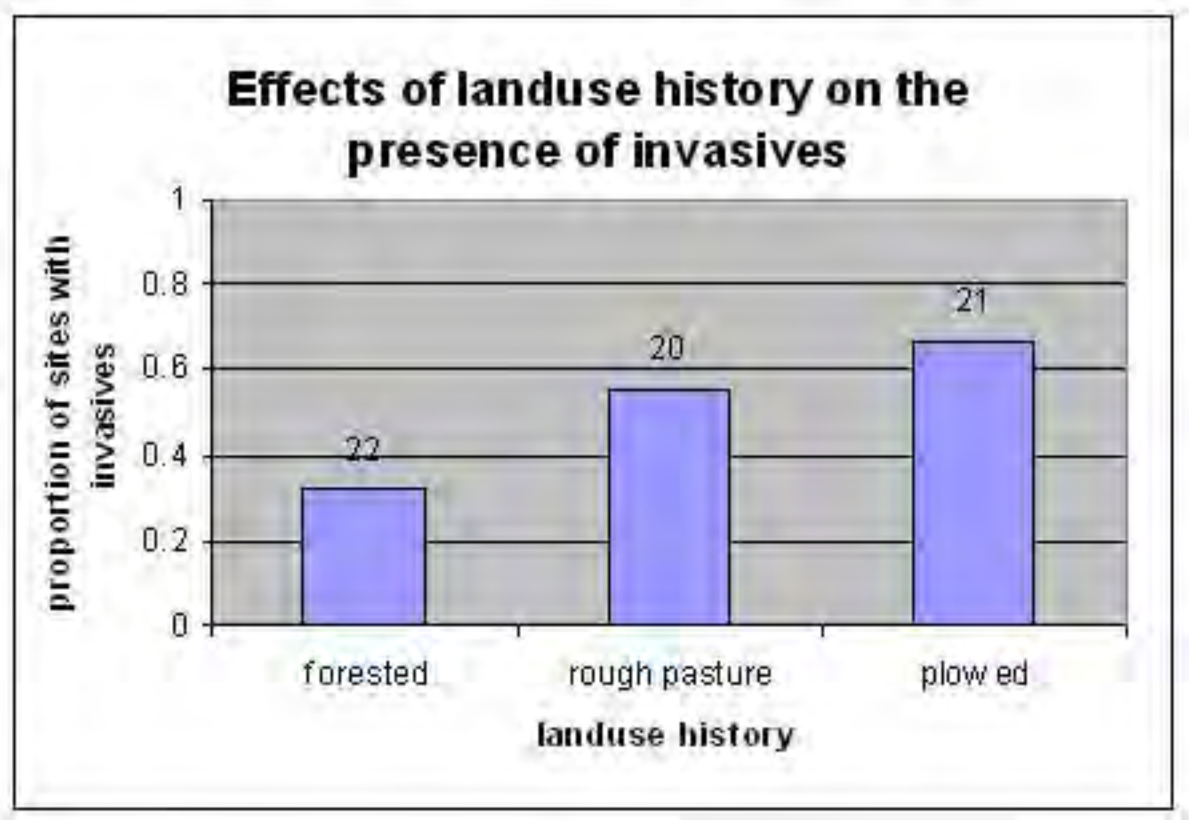


Figure 1. (Katz)

Groundwater and Surface Water Interactions in Bigelow Brook: Initial Results

Matthew H. Kaufman

This project comprises the first stages of an investigation of the groundwater and surface water interactions in Bigelow Brook, on the western side of Prospect Hill in Harvard Forest. The stream catchment, and particularly the riparian zone, is dominated by eastern hemlocks. The adjacent areas are the focus of other hydrologic studies. Groundwater and surface water interactions are being examined by monitoring a set of groundwater wells and piezometer nests installed immediately upstream of a recently constructed weir. The wells are arranged along three transects, at 20m, 45m, and 80m upstream of the weir. Each transect includes six wells ranging from 2m to 10m away from the stream, and one nest of three piezometers in the center of the stream channel. The wells are ~1m deep, and are used to determine the elevation of the water table (Fig. 1). The piezometers range from 20cm to 80cm deep, and are used to measure the strength of upwelling or downwelling of water in the stream channel. Water temperature can also be measured from each well, as well as conductivity, pH, and other water characteristics. These measurements can be used to help identify separate masses of water within the system. The initial results show the water table responding to rain events, as well as separate temperature signatures in the ground and surface water. So far, the piezometer data is inconclusive, as the water levels in the piezometers have not deviated from the surface of the stream.

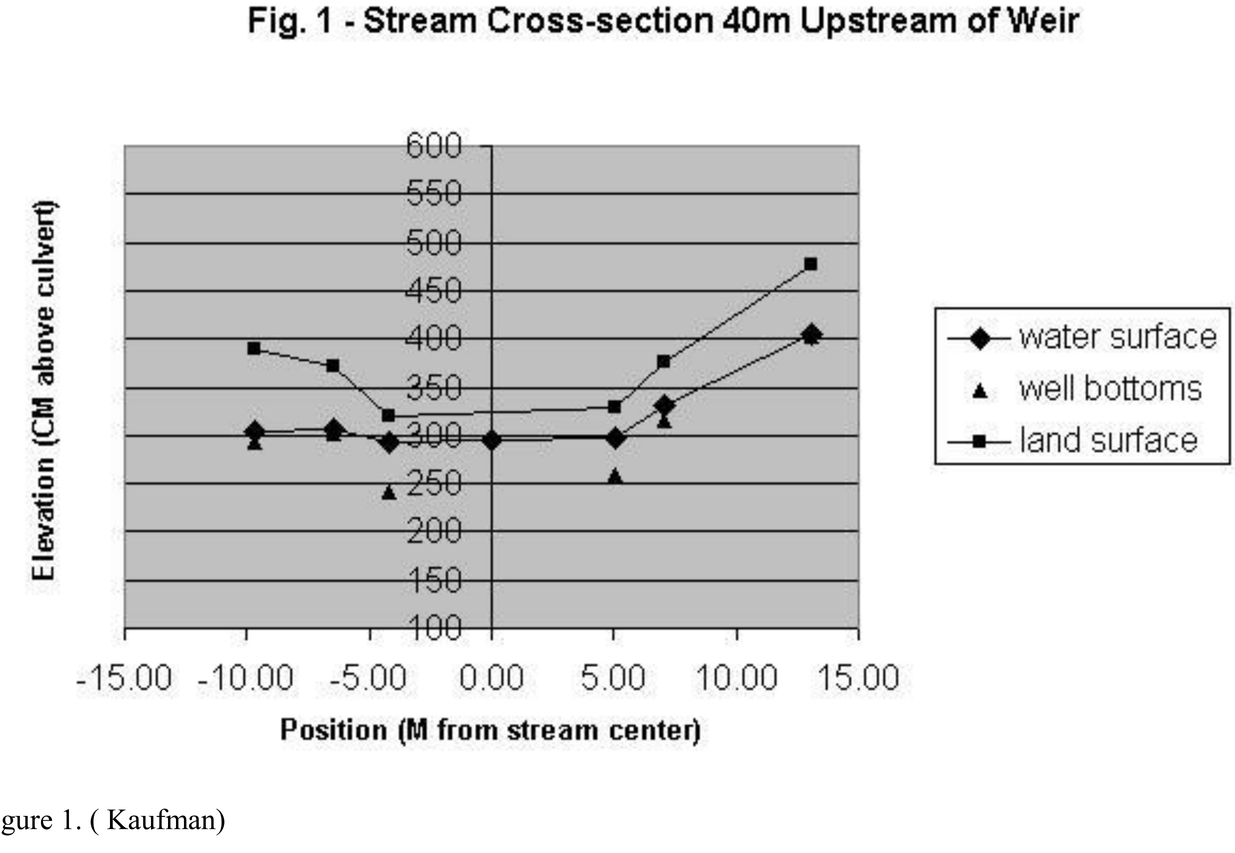


Figure 1. (Kaufman)

Hemlock Woolly Adelgid Range Expansion: Field Survey vs. Limited Range Protocol

Phil J. LeBranche

The study of range expansion is a critical part of invasive species research. Harvard Forest, as a long term ecological research site (LTER) in the path of hemlock woolly adelgid (HWA) expanding range, offers an unique opportunity. A REU student surveyed Harvard Forest tracts during 2004 and again in 2005 to monitor changes in HWA infestation. Furthermore, previous research (Costa and Baribault, unpublished data) suggested that dispersal of HWA crawlers was inversely density dependent at low population densities, which might facilitate range expansion. The overall population of HWA in Harvard Forest tracts was slightly lower in 2005 (0.54%) compared to 2004 (1.85%) indicating no growth in range; the number of infested trees were (41) and (12), respectively. While five tracts were previously found to be infested only three were noted in the current year. The relative precision at such low densities makes it difficult to ascertain the significance of the differences noted. A limited range protocol (LRP) was developed to assess the number of infested trees and associated HWA densities within 27 yards of the first infested tree found within a stand. Stands with a wide range of infestation levels were selected. At low HWA density, the proportion of infested trees relative to HWA population counts was inversely density dependent, and there was no density dependence at high population levels. These results lend support to the hypothesis that increased crawler dispersal at low densities may drive range expansion.

Changes in Herbaceous Vegetation Composition in Response to Soil Warming

Katherine J. Lenoir

This project studied the effects of warmed soils on herbaceous vegetation and *Acer rubrum* seedling growth at Barre Woods, in July 2005. Percent sunlight to plots was also compared to plant density and diversity (Shannon's and Margalef's indices). Herbaceous composition was studied (including graminoids, lycopodium, and ferns) by stem counts of all species present in randomly selected circle (3.14m^2 area) and square plots (1m^2 area) of experimentally heated and control megaplots (900 m^2). Herbaceous species composition of square plots was also sampled in 2002, before heating began, allowing for comparison of square plots in 2005 with pretreatment. Heated plots had cables running through the soil, to increase the temperature by 5ºC; heating has been turned on since 2003. Light was measured per plot by taking hemispherical photographs, which were then analyzed with Hemiview software for percentage of sunlight in sampled plots. *A. rubrum* seedlings were collected from heated and control megaplots and planted in a green house, in order to count number of germinating seedlings and growth rate of seedlings. There was no difference in herbaceous diversity between heated and control plots; however, the composition of species changed from 2002 to 2005. *Maianthemum canadense* density increased significantly, while *Lycopodium obscurum* density decreased significantly in the heated plot. The percent of light coverage in the forest did not correlate to diversity or density of herbaceous plants. *A. rubrum* seedlings from the control plot were heavier and germinated more often.

Evolution of Pit and Mound Microtopography 15 Years after a Simulated Hurricane

Bennet H. Leon

Microenvironments of tip-up mounds and pits are significant locations of tree regeneration after wind disturbance. In this study, sapling growth and pit-mound erosion were surveyed fifteen years after a simulated hurricane manipulation in a New England red oak-red maple dominated forest. Three dimensions were measured for each pit and mound to compare to initial data taken in 1990. All saplings were also recorded (defined as stems taller than 30cm) growing on pit-mound complexes.

Between 1990 and 2005, mound area increased 37%, while pit area decreased 9%. Mound height decreased an average of 36%, with greater decrease found on taller mounds. Pit depth decreased 39%. Pit and mound dimensions were found to strongly correlate with the original diameter at breast height of the fallen tree. Sapling abundance was highest on mound tops, and lowest in pits. While all sapling species were distributed evenly across microenvironments, birch (*Betula*) species were the most abundant.

Significant weathering and erosion has occurred since 1990, possibly affecting sapling distribution and abundance. No correlation was found between pit-mound area and number of saplings. This is in part due to erosion, which in many places has created an unstable substrate. The material eroded from mound tops has caused a number of effects: mound basal area increased while pit area and depth decreased, and has resulted in sapling mortality. The results support that pit-mound topography is a dynamic environment for forest regeneration after a significant windthrow.

Mentor Audrey Barker Plotkin, Bennet Leon, Mathew Trumbull and Natalie Levy

Woody Detritus Survey: Initial Results from the Hemlock Manipulation Study

Natalie J. Levy

The Hemlock Manipulation Study contrasts hemlock decline from hemlock woolly adelgid and logging. The woody detritus survey relates to the goals of the study by providing baseline data that can be collected periodically to investigate dead wood contribution to forest productivity, nutrient cycling, carbon storage, and habitat availability. The research question was: how do dead wood stocks vary among the different treatments of the hemlock study in terms of total mass, decay class, and species? Line-transects were used to sample Coarse Woody Debris (CWD, downed wood >7.5cm diameter) and Fine Woody Debris (FWD, downed wood from 0.6cm-7.5cm diameter). Snags and stumps were sampled along 4m wide strip plots that straddled the line-transects. CWD was most abundant in logged plots (Fig. 1); however FWD did not show a strong pattern by treatment. Snags and stumps also did not show a strong pattern by treatment. The most CWD was in decay class #1 in the logged treatment. The most snags and stumps were in decay class #1 across treatments. Hemlock dominated CWD composition, particularly in the logged treatment. Hemlock was the most abundant snags and stump species across all hemlock treatments. Results show that CWD stocks reflect the logged treatment, whereas snags and stumps reflect initial forest composition. In conclusion, the initial effects of the experiment can be seen as an increase in the amount of downed dead wood in the logged plots. This survey sets the stage to examine the long-term response of woody detritus to hemlock girdling and logging.

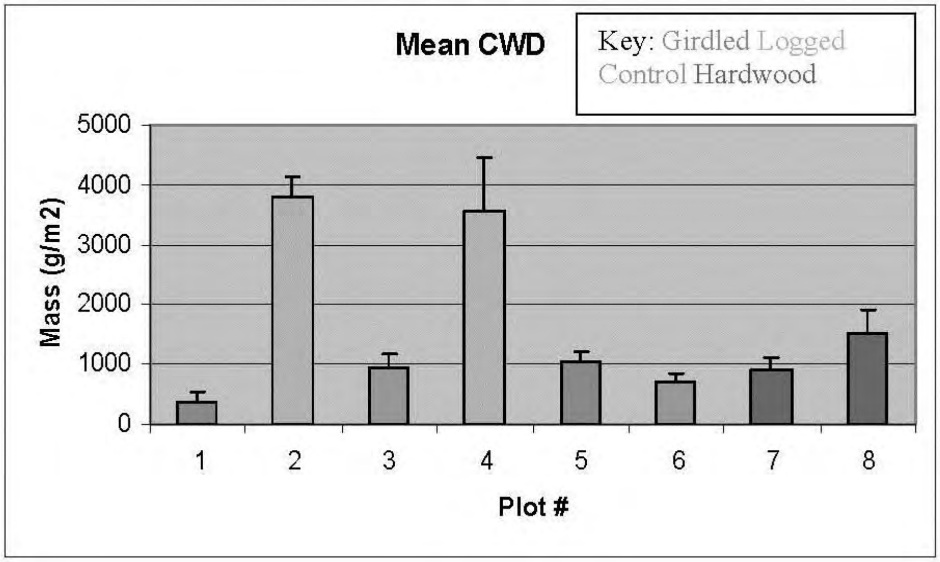


Figure 1. (Levy)

Landscape Survey of Hemlock Woolly Adelgid and Elongate Hemlock Scale Abundance in Hemlock Forests of Southern New England

Alexandra G. Lodge

The hemlock woolly adelgid (*Adelges tsugae*) (HWA) and elongate hemlock scale (*Fiorinia externa*) (EHS) are invasive insects that feed on and cause decline and mortality of eastern hemlock trees (*Tsuga canadensis*). This study resurveyed 78 hemlock stands in central Connecticut and 63 stands in central Massachusetts that were previously sampled. At each site two branches on each of 50 trees were randomly sampled for HWA and EHS density, rated on a scale of 0-3 (0=none; 1=1-10 organisms/m branch; 2=11-100/m branch; 3=100+/m branch). Overall stand canopy loss was also assessed on a scale of 1-4 (1=0-25% loss; 2=26-50% loss; 3=51-75% loss; 4=76-100% loss). Canopy loss increased with increasing HWA density, with the most damaged stands located in southern Connecticut and undamaged stands in northern Massachusetts. HWA density decreased with increasing latitude (Fig. 1), possibly due to climatic limitations. EHS decreased with increasing longitude potentially indicating the front wave of the northeasterly expansion of the range of EHS. HWA density has decreased at almost all sites since the previous samplings, but the total number of infested sites has increased. EHS distribution and density have increased dramatically since the previous sampling – in 1997-1998, 22 of 78 sites in Connecticut were infested with EHS, but EHS was present at all sites sampled in Connecticut in 2005. These sites should be resurveyed in the future to monitor changing HWA densities and their affect on canopy loss and to further examine trends of the northern spread of HWA and EHS.

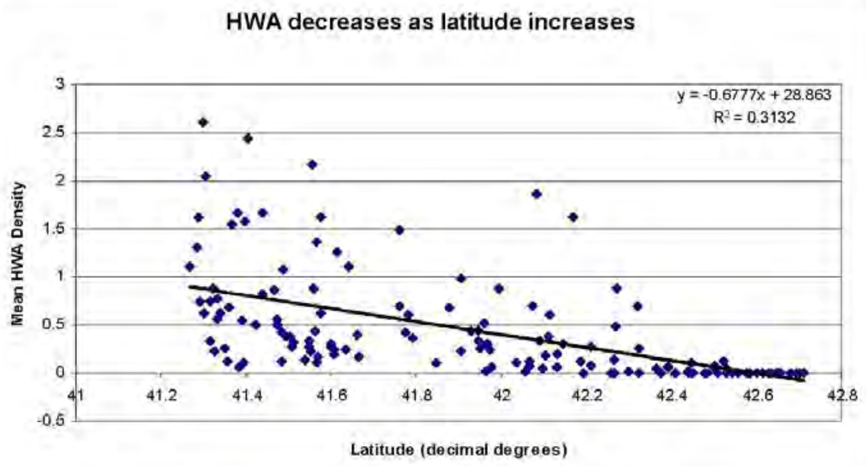


Figure 1. The effect of latitude on hemlock woolly adelgid density in hemlock stands in southern New England.
ANOVA, F=64.6289, p<0.0001

(Lodge)

Why Does the Beaver Swamp at the Harvard Forest Appear to Release so much CO_2 into the Atmosphere?

Jennifer P. McInnis

Careful examination of CO_2 exchange data from 1992 to 2003 at the Harvard Forest Environmental Measuring Site (EMS) shows consistently higher CO_2 flux from the NW, where there is a beaver swamp. To better understand the CO_2 budget of the swamp, CO_2 concentrations and CO_2 fluxes from water to air in summer 2005 were measured. The stream entering the swamp contained 3000-4000 ppm dissolved CO_2, much less than in the swamp (above 6000 ppm) suggesting that much of the CO_2 in the swamp is produced by internal decomposition and respiration. Dissolved CO_2 and O_2 in the swamp were inversely related during mid-day, suggesting significant aquatic photosynthesis. Precipitation and increased wind speed were followed by lower dissolved CO_2 levels. CO_2 flux was measured from water to air in a floating wind tunnel attached to an infrared gas analyzer. Wind speed 3 cm above the water (in the range of 0.5 to 0.7m s-1) and wave height (0.32 to 0.95 mm) were positively correlated with CO_2 flux from water to air (1.6 to 6.5 µmol m-2 s-1). The wind tunnel data suggests that water-to-air flux in the swamp could strongly influence CO_2 flux measured at the EMS tower. The swamp may store CO_2 and preferentially release it to the atmosphere during strong winds, generating very large surface-to-air fluxes, if the CO_2 flux increases with wave height above 1 mm. Strong NW winds during the passage of cold fronts through New England could cause of large releases of CO_2 from the beaver swamp.

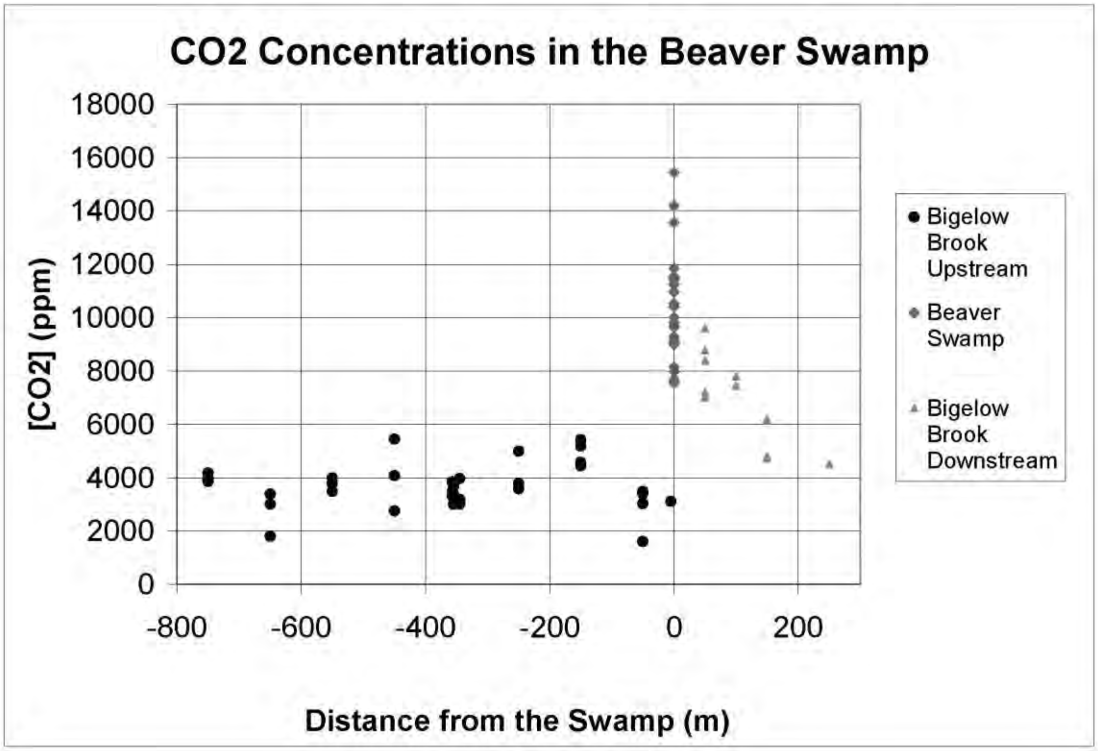


Figure 1. (McInnis)

The Harvard Forest Flora: 1938-2005

Kirsten R. Ward

The vascular flora of Petersham was previously examined in the mid-1930's by Hugh Raup and in the late 1940's by Earl Smith. The latter study, together with herbarium collections, credit 611 species to the Harvard Forest. Over the past two summers vascular plants from the 33 compartments of the Harvard Forest were identified by on-site and laboratory analysis. A total of 676 vascular plant species were identified, 180 of which were not previously attributed to the Harvard Forest (see Fig. 1 for comparison of the current inventory with the historic flora). Compartment diversities ranged from 48 species, in the most uniform habitats, to 240 species in compartments with greater habitat diversity, including fertile outcrops and extensive wetlands. The historical and current lists of the woodland flora are generally consistent, with a few salient differences. Of the 125 most common species documented in this current survey, only two were not reported previously. One common newly reported species is the invasive *Lonicera morrowii*, found in 39% of the compartments. The other common newly reported species is a woodland herb *Chimaphila maculata*, reported in 46% of the compartments. The present abundance of *C. maculata* may reflect the changing landscape of Harvard Forest from cleared to extensively reforested lands. *Berberis thunbergii*, another invasive, is also among the 125 most common species documented in the current survey. The Harvard Forest plant inventory, combined with historical checklists, documents current flora, enables the examination of changes in the flora over the past 80 years and serves as a framework for further ecological and natural history investigations. Examples of such future studies include the analysis of the importance of roadways in the dispersal of plants throughout the landscape, the replacement of native flora by invasive species, and the relative importance of factors such as soil fertility and hydrology, site historical use, herbivory and seed dispersal in controlling species distribution and abundance.

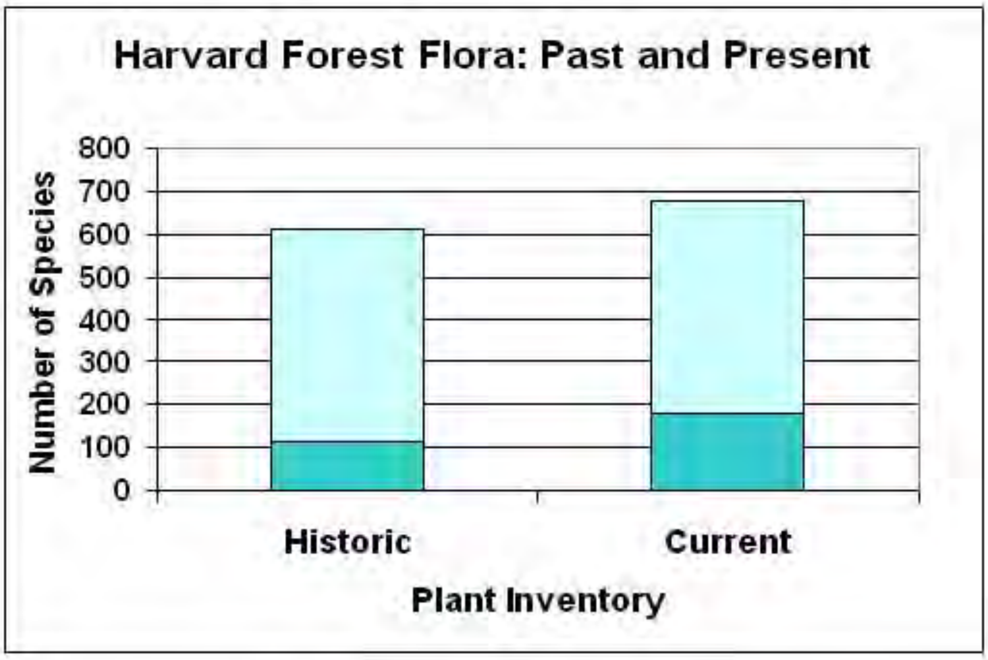


Figure 1. (Ward) Number of species found across Harvard Forest, historic and current. Dark portion of the bar represents the number of species found in the historic or current survey only; light portion of the bar shows the number of species found in both surveys.

Hydrology of Prospect Hill Tract at Harvard Forest

Safina Singh

This summer Long-Term Hydrological Studies were initiated at Harvard Forest. The objectives of this study were to examine the response of stream flow, evapotranspiration and ground water to precipitation events; to observe the effects of wetlands on stream discharge and to estimate the water balance of the Prospect Hill Watershed at Harvard Forest. The watershed consists of three minor watersheds called Nelson Watershed (44 ha), Lower Bigelow Watershed (65 ha) and Upper Bigelow Watershed (24 ha). Stream discharge measurements were collected from weirs and pipes at Nelson Brook and Bigelow Brook; wetland water stages from gages at the respective sites and ground water depths from the Lyford Wells. In addition the data from eddy flux towers called Hemlock Tower and Little Prospect Hill Tower were analyzed for evapotranspiration. It was found that stream discharge, water stages at Black Gum Swamp, Beaver Swamp and ground water wells were highly correlated with precipitation events. The stream discharges at the watersheds were proportional to their sizes (Fig. 1). However, Nelson Watershed showed a delayed release of water displaying the greater buffering effect of Black Gum Swamp covering 25% of the Nelson Watershed in comparison to Beaver Swamp covering 5% of Lower Bigelow Watershed. Also, the water table at Beaver Swamp fluctuated remarkably with rain events. The eddy flux data showed lower evapotranspiration by hardwoods during spring than in summer which is consistent with the foliation of hardwoods in summer. However, the daily averages of stream discharge, evapotranspiration, ground water and precipitation did not sum up to zero but -0.9mm for spring and 0.1mm for summer suggesting either overestimation or underestimation of inputs and outputs of the system in the water balance calculations.

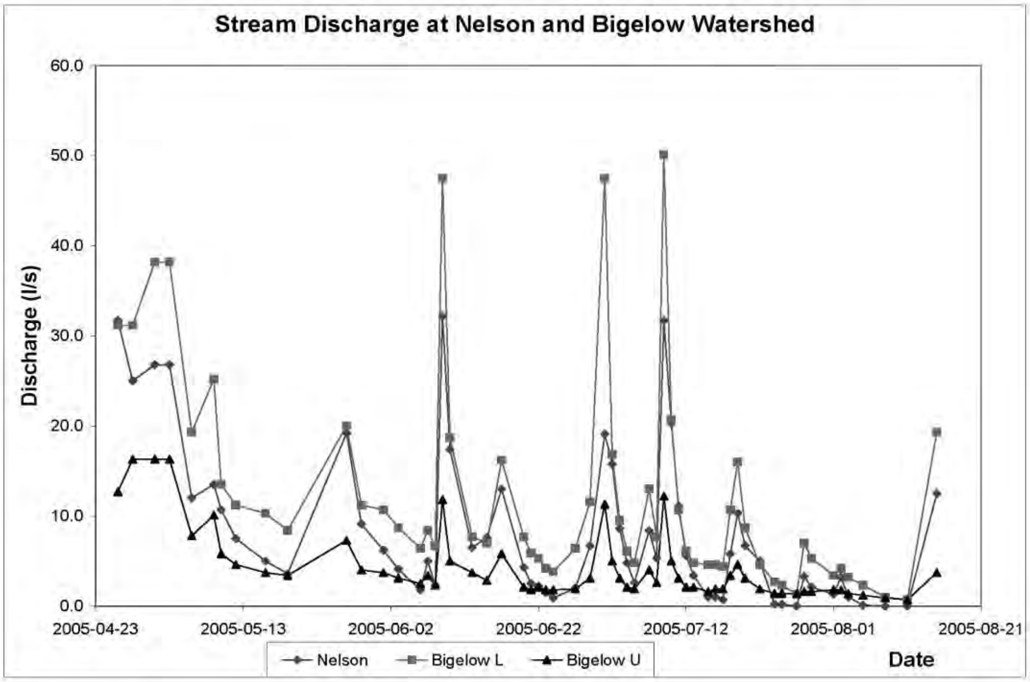


Figure 1. (Singh)

Maternal Habitat Effects on the Understory Invasive Species *Alliaria petiolata*

Jens T. Stevens

Alliaria petiolata (Bieb) Cavara and Grande (Brassicaceae), commonly known as garlic mustard, is an invasive herb native to Eurasia and found in forest edge and understory habitats across eastern North America. In understory habitats, *A. petolata* is known to have negative impacts on native plant species and tree seedlings. In this study, it was tested whether the maternal environment of individuals affects understory populations of *A. petiolata*. We reciprocally transplanted plants from sun, intermediate and forest "maternal habitats" into each of the same three "growth habitats." The different habitat classifications reflected variation in light levels and soil temperatures. Data were collected on biomass, phenology, fitness, and survivorship. In the forest "growth habitat," plants from maternal forest habitats had higher germination rates than plants from maternal sun habitats (Fig. 1). Furthermore, the subpopulation of sun maternal plants had a lower growth rate in the forest than in the sun, while the subpopulation of forest maternal plants showed no difference. However, plants from maternal sun habitats tended to have higher reproductive biomass and relative fitness, and were under stronger selection pressure to grow larger. These data suggest some survival advantages to forest-reared seeds, but their fitness attributes may be inferior to sun-reared seeds. Effective management of invasive *A. petiolata* populations should address both the edge and the understory components.

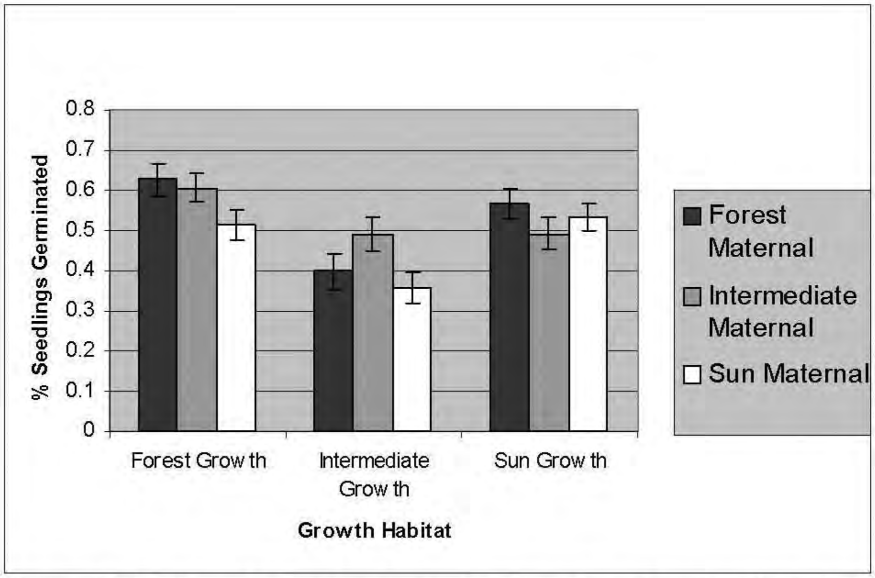


Figure 1: Maternal effects on germination. Forest maternal plants had significantly higher germination percentage than sun maternal plants in the forest understory (ANOVA, F=4.09, P=.021).

(Stevens)

Mid-Holocene Vegetation and Climate Change in New England

Sarah A. Truebe

Lake sediment records across northeastern North America feature a decline in abundance of eastern hemlock (*Tsuga anadensis*) ~5400 years before present (BP). The decline is usually attributed to a pest or pathogen, but recent evidence points to a potential climate signal. The hemlock decline was investigated at Benson Pond in western Massachusetts by analyzing organic content (via loss-on-ignition, LOI) and pollen preserved in the sediments. LOI showed two sustained periods of high organic content, with the hemlock decline occurring at the beginning of the more recent period. These sections of the Benson core were quite peaty, perhaps indicating low lake levels between 6500-6000 BP and then again at the hemlock decline at 5400 BP. When the hemlock abundance record from Benson was compared with those from nineteen other New England lakes, however, it was noticed many records demonstrated two peaks in hemlock abundance, one ~6600 BP and another just before 5400 BP (Fig. 1). These peaks in hemlock abundance never co-occur with the Benson LOI peaks, implying that conditions may have been too dry for hemlock populations to sustain themselves between 6500-6000 BP and after 5400 BP. This suggests a possible climatic forcing for Mid-Holocene hemlock abundance and the hemlock decline in New England. Further investigation into ponds like Benson will aid us in interpreting the climate/pest/disturbance history of New England vegetation. Ideally, that knowledge can then be applied to current climate change and the hemlock woolly adelgid infestation impacting hemlocks today.

Peaks in Mid-Holocene Hemlock Abundance

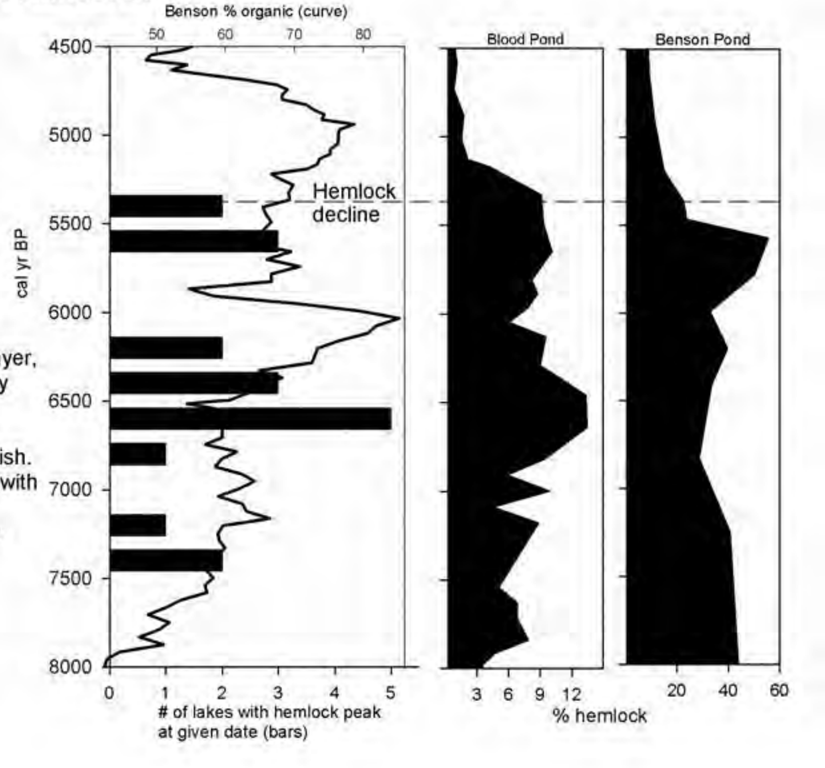


Figure 1: The bar graph is a histogram of the timing of peak hemlock abundance in 20 New England lakes. There appear to be two groups of peaks: one ~6600 BP, and the other just before the hemlock decline (5400 BP). An example of each hemlock peak type is shown here—at Blood Pond hemlock abundance is highest at 6600 BP; at Benson Pond, abundance is highest just before the decline. The Benson Pond core contains a peaty layer, apparent in the organic content curve as a peak between ~6500-6000BP. This peat layer, perhaps indicative of low lake levels and dry conditions, falls directly between the two groups of hemlock peaks, suggesting that conditions were too dry for hemlock to flourish. The hemlock decline of 5400 BP coincides with another organic content peak in Benson, potentially indicating another interval of low effective moisture then as well.

(Truebe)

Natalie Levy, Mathew Trumbull and Audrey Barker Plotkin

Understory Vegetation Response Following a Simulated Hurricane

Mathew A. Trumbull

The hurricane experiment at Harvard Forest was designed to monitor long-term changes in vegetation dynamics after simulated windthrow. In 1990, canopy trees were pulled over with a winch in the experimental area (50 x 160 m), to mimic the effects of the 1938 hurricane, resulting in 80% canopy damage. Little is known about the way that the understory vegetation responds following a catastrophic hurricane. This study analyzes the understory vegetation dynamics 15 years after the manipulation.

Composition and percent cover of understory vegetation was assessed in 1990 (pre-manipulation), 1991, 1992, 1995, 2000, and 2005. Survey plots were sited along four transects – three in the experimental site, and one in the control. Along each transect 24 permanent plots were established for a total of 96, 10m² (5 x 2 meters) plots (shrubs) and nested, 1m² circular sub-plots (herbs).

Several new colonizing species appeared soon after the manipulation. Some are no longer present but a few species have persisted. Among the persistent, *Rubus allegheniensis* and *Rubus idaeus* increased in percent cover dramatically following the manipulation until around 1995 and since have shown a steady decrease (Fig. 1). *Trientalis borealis* and *Dennstaedtia punctilobula* showed significant increases in percent cover but have also declined since 1995 (Fig. 1). Fern, herb and shrub totals in the manipulation site follow a similar trend. The percent cover of many species that initially increased greatly in the manipulation site have recovered to pre-manipulation conditions, indicating that understory changes are mostly transient following a severe wind disturbance.

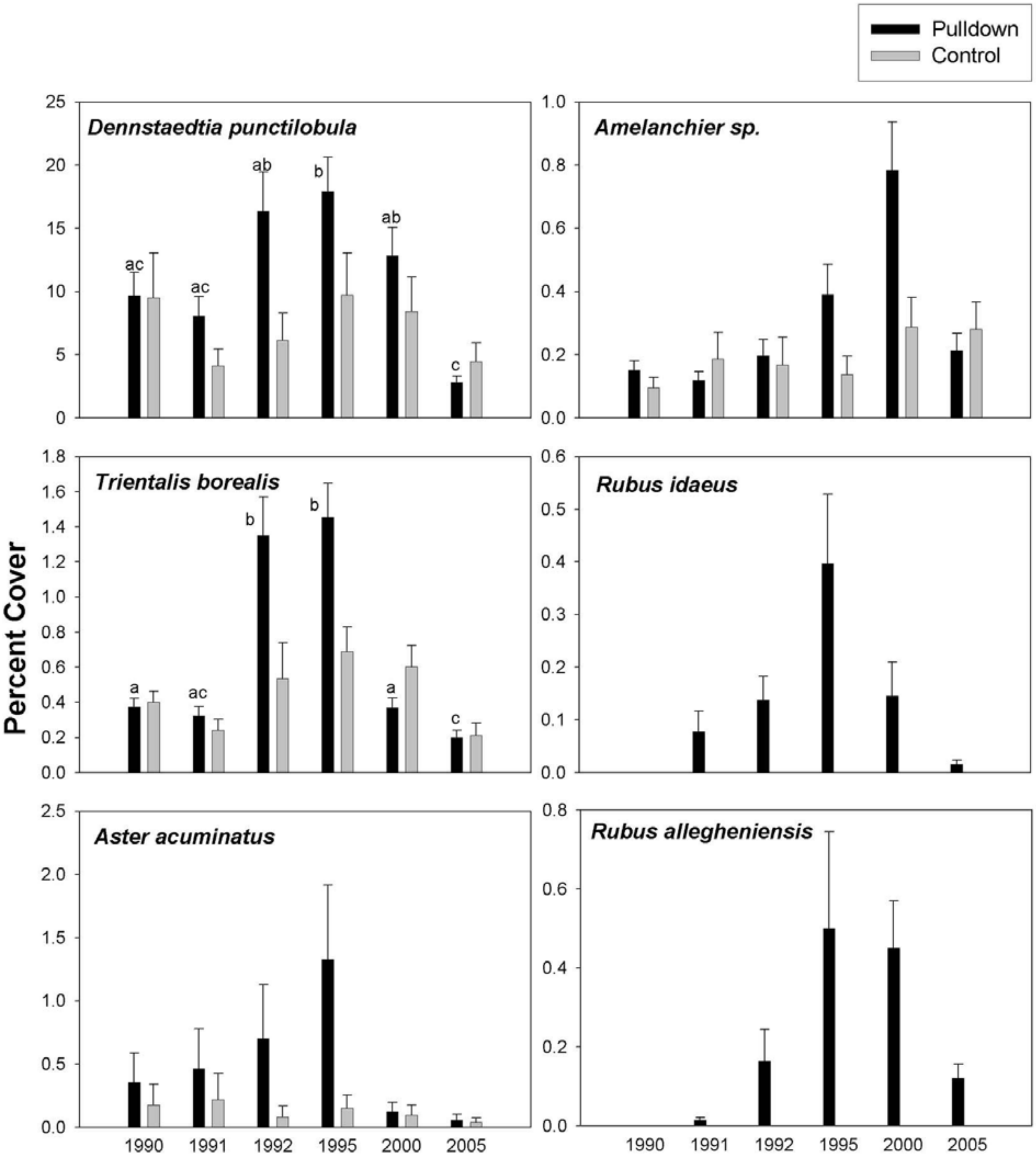


Fig. 1. Average percent cover of herb and shrub species in the experiment and control before (1990) and after (1991, 1992, 1995, 2000, 2005) the experiment, for select species. Error bars are +1 S.E. For *Dennstaedtia punctilubula* and *Trientalis borealis*, experiment means (solid bars) that do not share the same lowercase letter differ significantly ($p < 0.05$).

(Trumbull)

Effects of Selective Logging on Microclimate and CWD in a Northern Temperate Forest

Linh Vuong

Understanding the effects of forest management on CWD respiration and sequestration is critical to assessing overall effect of CWD on ecosystem balance. To quantify the effects of selective logging on microclimatic conditions, an automated system was installed in a selectively logged Simmes tract and a 70 year old maturing Harvard forest plot (control). Over the course of the 2005 growing season, continuous measurements were made of short-wave radiation, relative humidity, and temperature for soil, air, and three CWD decay classes. Routine manual quantifications of CWD moisture were taken. Log temperatures and air temperature were significantly higher in selectively-harvested forest ($p<0.01$). From the greater difference in log temperature compared with air temperature difference, it can be inferred that higher short-wave radiation entering the thinner canopy contributes to drier conditions observed in the logged plot. The control site had substantially higher relative humidity, wood moisture, and soil moisture than the cut site ($p<0.01$). Decay class three was also significantly wetter than decay class one across both sites (Fig. 1). Applying Wendy Liu's exponential respiration model, Respiration= exp(a+b+ln(Moisture)+C(Temp)) to our data, it was discovered that higher moisture levels correspond to higher respiration rates in the cut site, suggesting that CWD in the cut site is losing carbon more rapidly than the control site (Fig. 2). CWD was not dry enough in the cut site to offset the difference in temperature between the sites. Although selective logging considerably increases CWD stocks initially, the corresponding changes in microclimate resulting from a reduced canopy compromise the maintenance of C in the logged site.

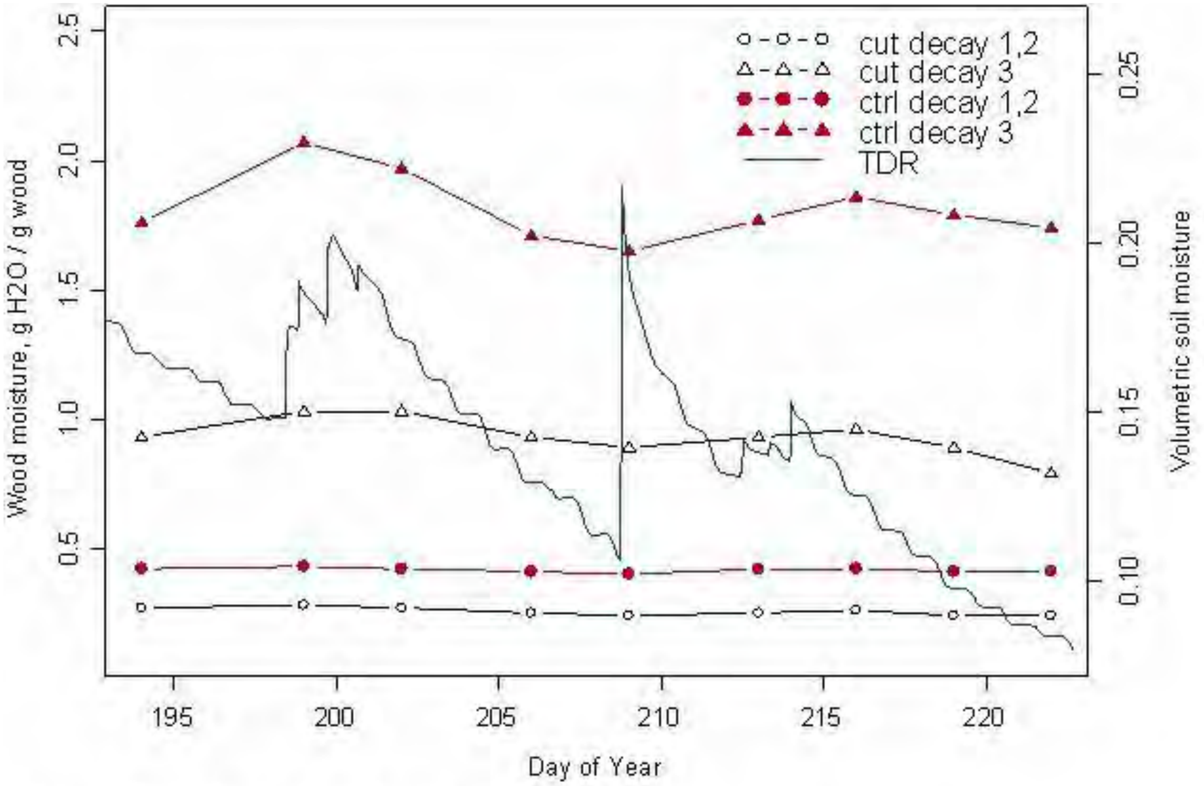


Figure 1. Wood and volumetric soil moisture vs. Time

(Voung)

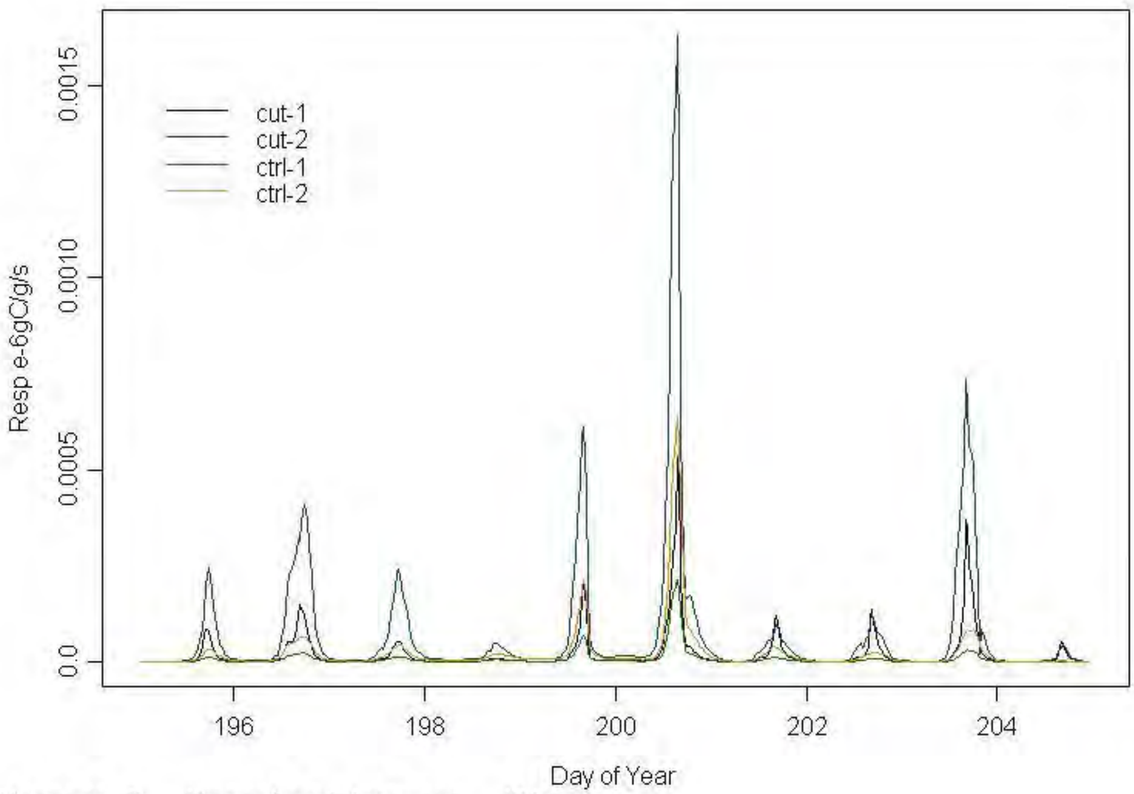


Figure 2. Respiration vs. Time
(Voung)

View of the EMS tower from the walk-up tower

Ten Year Revisit of Stand Dynamics Associated with Hemlock Woolly Adelgid Infestation in Southern Connecticut

Kelly M. Walton

Hemlock woolly adelgid (HWA) is an invasive insect from Japan that has slowly spread across the eastern United States since it entered Virginia in 1950. HWA is a little understood pest that is causing a gradual decline of eastern and Carolina hemlocks on the east coast. To increase understanding of forest dynamics following long- term HWA infestation, eight hemlock stands were visited in south- central Connecticut. At each site the mortality of hemlocks was counted and the understory vegetation dynamics examined by counting percent cover of herbs, shrubs, and seedlings in one m^2 plots. Also, hemlock and hardwood trees were cored to look for growth trends in response to continued hemlock deterioration. The mortality of hemlocks is dramatic, with seven of the eight sites having near or above 80% mortality in 2005, compared to two of eight sites in 1995. In the understory many of the plots show an increase in hayscented fern or black birch. Most of the hardwoods are showing sudden increases in radial growth and hemlocks show dramatic decreases to a fraction of a millimeter per year since HWA infestation in the late 1980s and early 1900s (Fig. 1). The overall outlook for hemlock forests in south- central Connecticut is continued deterioration, high mortality, and extremely low radial growth on remaining live hemlock trees. The forest is being transformed from sparse vegetation to high fern and black birch cover as the hemlocks die, causing a shift toward a hardwood dominated forest in the future.

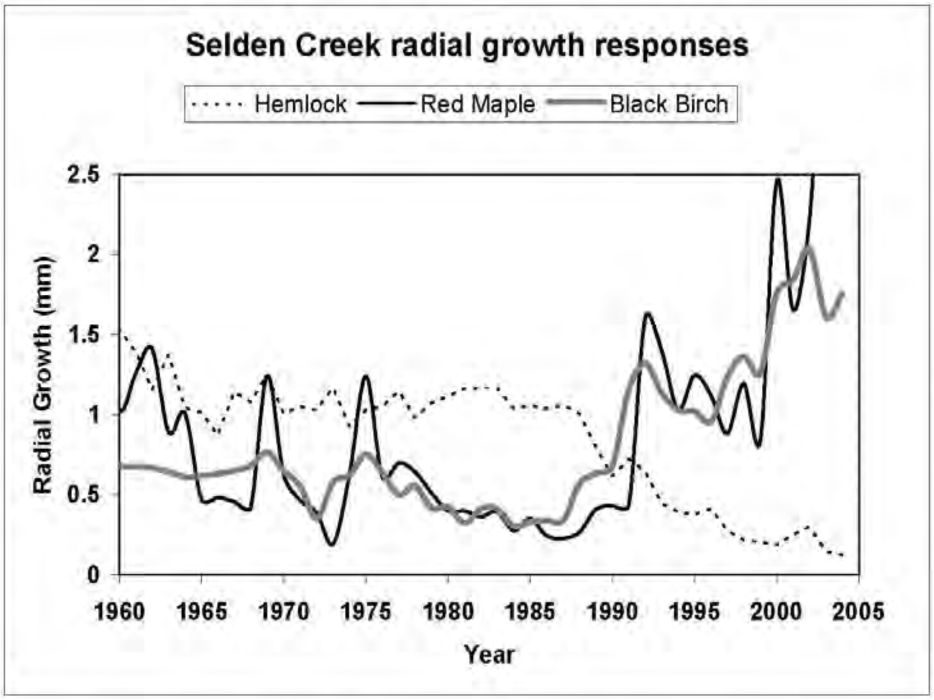


Figure 1. Radial growth response of various trees to HWA infestation in southern Connecticut.

(Walton)

Physiological Girdling of Forest Trees: Developments of a New Method to Understand Soil Respiration

Brian A. Warshay

The global carbon cycle has become an important part of ecological study since it was discovered that the burning of fossil fuels contributes to global warming. It is understood that the largest terrestrial pool of carbon is stored in the soil and that a portion of that pool is respired yearly from the soil. Little is understood about how much of that carbon dioxide flux is from heterotrophic microbial respiration or root respiration. Studies on root respiration have been done, but most are highly invasive and likely disturb the soil-root-mycorhizzal continuum. Our method can be done both in situ and is noninvasive. Physiological girdling, or cold blocking, temporarily chills the cambium of trees by wrapping them with tubes of cold circulating water. In this way it is possible to slow the rate of photosynthate flowing from the leaves to the roots thereby significantly decreasing root respiration. Soil CO_2 flux is measured before, during and after treatment to establish a percent change and is compared to a nearby control plot of similar forest composition. This method will allow us to calculate the percent of soil respiration that results from root respiration and will further allow us to quantify root respiration versus soil microbe respiration. When this method is put into use in soil warming experiments it will be possible to discern how soil microbe respiration reacts to heated conditions without root respiration. This information will enhance our ability to predict future feedback mechanisms in forests resulting from global warming.

Influence of Photosynthetic Rates on Xylem Ionic Content and Hydraulic Resistance

Melissa R. Whitaker

Water transport through vascular plants is believed to be an entirely passive process, with stomata providing the only mechanism by which plants could control the movement through the xylem. However, it has recently been shown that the hydraulic resistance of detached stem segments is affected by the concentration of ions, such that higher KCl concentrations can significantly increase the flow rate of water over a very short time scale. This alteration results from interactions between ions and the hydrogels located in the bordered pit membranes between xylem vessel elements. Ions shrink these hydrogels, thereby increasing the diameter of the channels between vessels and decreasing xylem hydraulic resistance. This mechanism has profound implications for plants to mediate flow rates in response to environmental variation, though the extent to which plants employ this mechanism is unknown. To investigate the regulation of hydraulic resistance within the canopy, sugar maple (*Acer saccharum*) saplings were sampled at three sites within the Harvard Forest. Photosynthetic rates were measured on branches in sun and shade, and sap from these branches was collected and analyzed for $K+$ concentration. A correlation between photosynthetic rates and $K+$ content of xylem sap was observed. Branches in direct sunlight and with higher photosynthetic rates contained significantly ($p<0.05$) higher concentrations of $K+$ in their sap than branches from shady or predawn conditions. This supports the suggestion that plants actively mediate hydraulic resistance within the canopy, providing them with a mechanism for adjusting their hydraulic architecture in response to microclimatic heterogeneity.

Demographic Attributes of the Invasive Species *Alliaria petiolata* at Three Spatial Levels

Marit L. Wilkerson

This study researched the role of landscape and habitat factors on demographic attributes of the invasive plant, *Alliaria petiolata* (garlic mustard), in northeastern forests. The Prospect Hill tract at Harvard Forest was surveyed and found that six invasive species, including garlic mustard, are most abundant in sites with agricultural land use history. Also local populations of garlic mustard were monitored in sun, intermediate, and forest habitats at Harvard Forest over a period of three years. Using census data from four life-stages in 90 1m^2 quadrants, demographic population matrices were constructed and found that population growth rate (λ) was greatest in sun populations and lowest in intermediate habitats. Survivorship between life-stages depended mainly on yearly fluctuation and less on type of habitat. The reasons for the higher λ of sun populations were higher seed production ($p<.0001$) and a higher survivorship from first- to second-year plants. At a broader scale, public protected forests were surveyed for presence of garlic mustard in two valley ecoregions of western Massachusetts (Fig. 1). We mapped each discrete population and recorded the percent cover of first- and second-year plants and distance of incursion into forested habitat. The two ecoregions differed in the percent cover of first-year plants ($p=.0336$) and in total percent cover of garlic mustard ($p=.0279$). The mean distance of incursion into the forest did not differ between regions ($p=.8262$). This study used different spatial scales to show that garlic mustard invasion is influenced by landscape, habitat, and population characteristics.

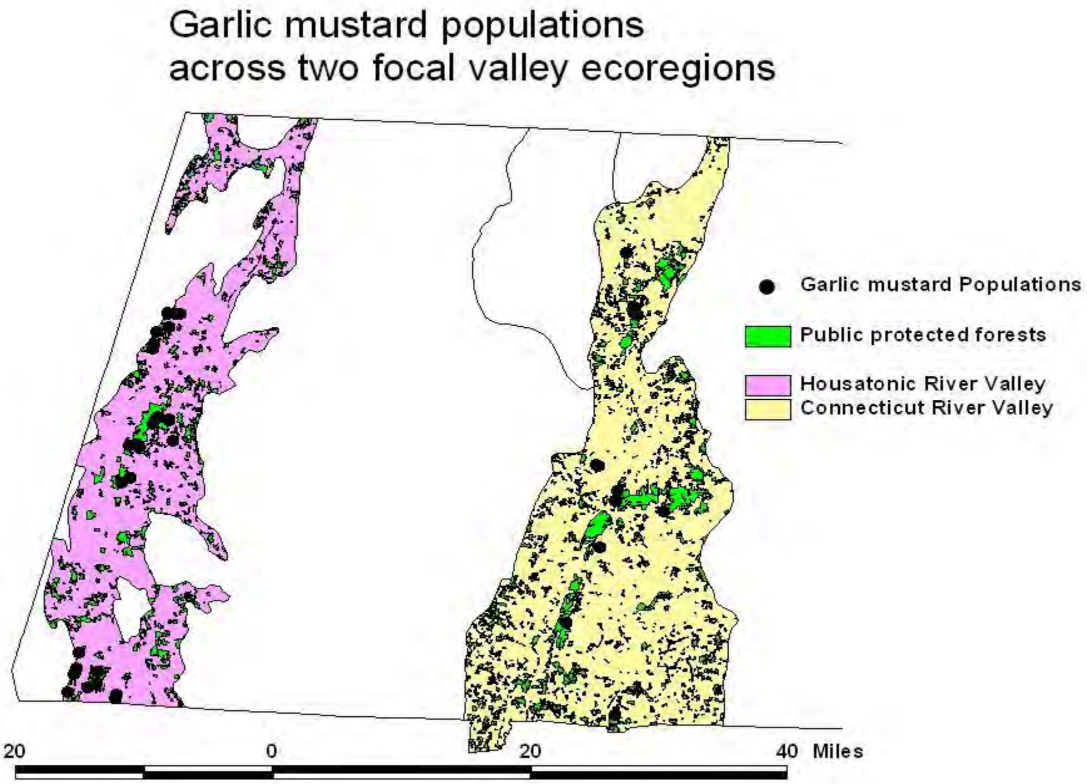
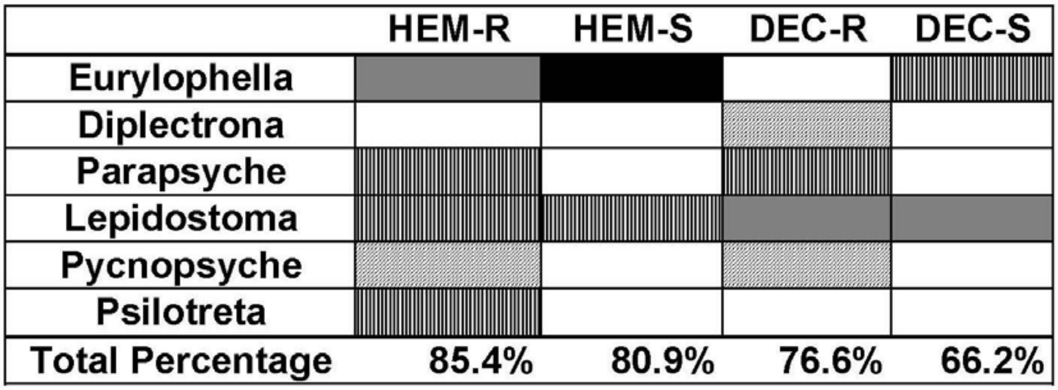


Figure 1. (Wilkerson)

Comparison of Macroinvertebrate Communities in Two Headwater Streams of Differing Forest Type

James J. Willacker, Jr.

Eastern hemlock (*Tsuga canadensis*) is a common riparian species in the eastern United States that is being replaced across its range by deciduous species as a result of the invasion of hemlock woolly adelgid, an exotic forest pathogen. The conversion of forests from hemlock to deciduous species may have serious implications for headwater streams flowing through these forests. This study examined the macroinvertebrate communities of two headwater streams in central Massachusetts, with differing hemlock influences. Macroinvertebrates were sampled from riffle and soft-bottomed habitats in each stream using a ½ m^2 quadrat and kicknets. Samples were live picked in the field and sorted by genus and functional feeding group. Total taxa richness and taxa unique to each stream were greater in the deciduous stream relative to the hemlock stream. The increased number of unique taxa in the deciduous stream was primarily a result of increased diversity of the orders Coleoptera and Diptera. Differences in the distribution of functional feeding groups between streams were only found among filterers. Differences were found in the distribution of dominant taxa (Fig. 1), with the mayfly *Eurylophella* sp. predominating in the hemlock stream and the caddis fly *Lepidostoma* sp. dominating in the hardwood stream. Overall findings suggest that there are differences in the macroinvertebrate communities of hemlock and deciduous streams; however, a year round study is necessary to determine the extent of these differences.



	HEM-R	HEM-S	DEC-R	DEC-S
Eurylophella	▓	■		▥
Diplectrona			░	
Parapsyche	▥		▥	
Lepidostoma	▥	▥	▓	▓
Pycnopsyche	░		░	
Psilotreta	▥			
Total Percentage	85.4%	80.9%	76.6%	66.2%

Figure 1. Distribution of dominate taxa in two habitat types of hemlock and deciduous streams.

■	>50%
▓	20-50%
▥	10-20%
░	5-10%

(Willacker)

Ant Interaction Dynamics Predict Formicinae Species Encroachment in Aftermath of the Hemlock Woolly Adelgid

Grace C. Wu

Past studies of ant diversity in southern New England revealed consistent correlations between ant species and forest type. One notable trend suggests that species of the genera *Formica* are virtually nonexistent in predominantly hemlock forests. However, the hemlock woolly adelgid will provide openings for large-scale hardwood succession, possibly ensuing in simultaneous shifts in ant community composition. This shift prompted the investigation of a driving force in species composition determination: competition dynamics. To do so, behavioral interaction of eight species were studied, with representatives from hemlock and hardwood stands (Table 1). Of these eight, *F. subsericea* and *F. subaenescens* are primarily found only in hardwood forests. Different species were placed pair-wise in 0.25x3 cm tygon tubing for two minutes after initial interaction. Ten trials were conducted for each pair and observations were scored as dominance (bite, chase, open mandibles), subordination (avoidance, spasm), or coexistence (no apparent change). The dominance index, simply the percentage of the trials in which the particular species is dominant, revealed that four of five *Formicinae* species comprised the four highest indexes (Table 1). Chi-square analysis of coexistence: avoidance: attack ratios confirmed dominant behavioral similarity between species of *Camponotus* and *Formica* (Table 1). These results predict that with hardwood succession, *Formicinae* species would dominate in competitive behavior, possibly leading to a decline in the abundance of the subordinate *Myrmicinae*, most notably *A. rudis*. Further studies of interaction in a natural environment would be valuable, just as ecosystem-wide repercussions of *A. rudis* decline and *Formica* intrusion also warrant future investigation.

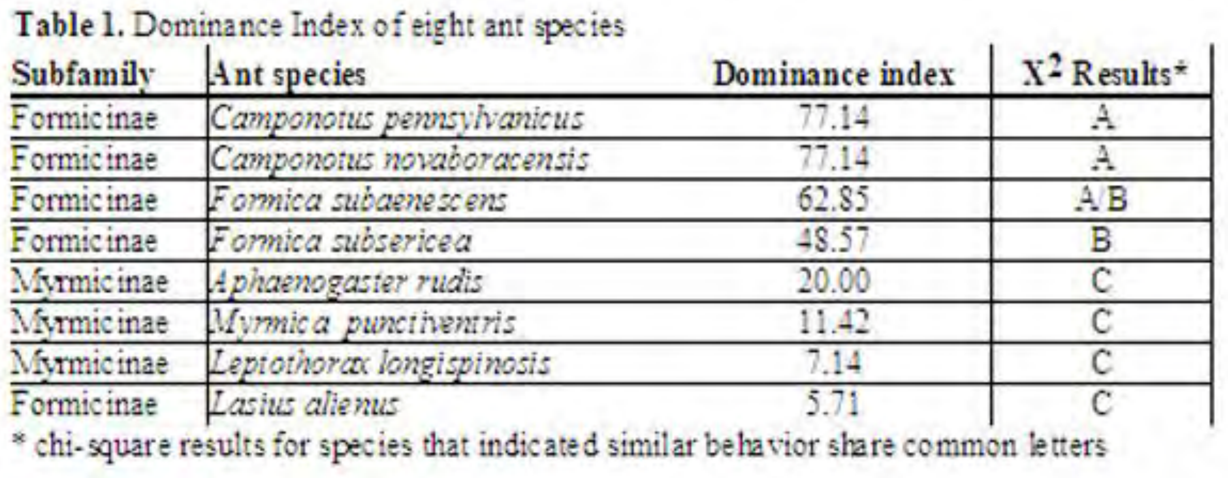


Table 1. Dominance Index of eight ant species

Subfamily	Ant species	Dominance index	X^2 Results*
Formicinae	*Camponotus pennsylvanicus*	77.14	A
Formicinae	*Camponotus novaboracensis*	77.14	A
Formicinae	*Formica subaenescens*	62.85	A/B
Formicinae	*Formica subsericea*	48.57	B
Myrmicinae	*Aphaenogaster rudis*	20.00	C
Myrmicinae	*Myrmica punctiventris*	11.42	C
Myrmicinae	*Leptothorax longispinosis*	7.14	C
Formicinae	*Lasius alienus*	5.71	C

* chi-square results for species that indicated similar behavior share common letters

(Wu)

2005 STUDENT SUMMER PROGRAM
SEMINARS AND WORKSHOPS

June 2nd	Seminar 1. Land-use History	David Foster
June 9th	Seminar 2. Invasive Species Overview	Kathleen Donohue
June 11th	Invasive Species Inventory Field Day	
June 14th	Seminar 3. Plant Identification	Glenn Motzkin and John O'Keefe
June 16th	Seminar 4. Ethics in Science	Kathleen McShane
June 22nd	Ethics Panel	David Kittredge, Hugh Lacey and Elizabeth Farnsworth
June 23rd	Harvard University Field Trip	Kathleen Donohue
June 28th	Student Mid Summer Presentations	
June 30th	Student Mid Summer Presentations	
July 6th	Quabbin Field Trip	John Burk
July 7th	Seminar 5. Plant Physiology	Missy Holbrook
July 11th & 12th	Institute of Ecosystems Studies in Millbrook, New York	
July 14th	Seminar 6. Graduate School Panel	Dave Kittredge, Tony D'Amato Jess Butler and Wyatt Oswald
July 19th	Seminar 7. Carbon Cycling	Steven Wofsy
July 21st	Seminar 8. Old Growth Forests	Tony D'Amato
July 26th	Seminar 9. Scientific Writing	Aaron Ellison
July 28th	Seminar 10. Scientific Presentation	David Orwig
August 2nd	Optional Seminar: Quabbin Field Trip	John Burk
August 18th	Summer Research Symposium	

Fisher House

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170 E. 6th Street #911
Claremont, California 91711

PERSONNEL AT THE HARVARD FOREST 2005

Michael Bank	Post-doctoral Fellow
Laura Barbash	Research Assistant
Audrey Barker Plotkin	Research Assistant
Emery Boose	Information & Computer System Manager
Richard Bowden	Bullard Fellow
Jeannette Bowlen	Accountant
John Burk	Archivist & Librarian
Posy Busby	Research Assistant
Jessica Butler	Research Assistant
Laurie Chiasson	Receptionist/Accounting Assistant
Elizabeth Colburn	Aquatic Ecologist
Brian DeGasperis	Research Assistant
Elaine Doughty	Research Assistant
Edythe Ellin	Director of Administration
Aaron Ellison	Senior Ecologist
Ed Faison	Research Assistant
Elizabeth Farnsworth	Bullard Fellow
Richard Forman	Landscape Ecologist
Charles H. W. Foster	Associate
Christian Foster	Laboratory Technician
David Foster	Director
Lucas Griffith	Woods Crew
Julian Hadley	Ecophysiologist
Brian Hall	Research Assistant
Linda Hampson	Staff Assistant
Amber Jarvenpaa	Summer Cook
Sultana Jefts	Research Assistant
David Kittredge	Forest Policy Analyst
Paul Kuzeja	Research Assistant
Oscar Lacwasan	Woods Crew
James Levitt	Director, Program on Conservation Innovation
Heidi Lux	Research Assistant
Brooks Mathewson	Research Assistant
Robert McDonald	Post-doctoral Fellow
Jacqueline Mohan	Post-doctoral Fellow
Glenn Motzkin	Plant Ecologist
Gidon N'eman	Bullard Fellow
John O'Keefe	Museum Coordinator
David Orwig	Forest Ecologist
Wyatt Oswald	Paleoecology Lab Coordinator
Julie Pallant	System and Web Administrator
Michael Scott	Woods Crew
Richard Schulhof	Research Assistant
Judy Shaw	Woods Crew
Pamela Snow	Environmental Educator
Kristina Stinson	Research Associate
Travis Stolgitis	Woods Crew
Jill Thompson	Bullard Fellow
P. Barry Tomlinson	E.C. Jeffrey Professor of Biology, *Emeritus*
Betsy Von Holle	Post-doctoral Fellow
John Wisnewski	Woods Crew
Steven Wofsy	Associate
Tim Zima	Summer Cook

Harvard University Affiliates

Douglas Causey	MCZ*
Peter del Tredici	Arnold Arboretum
Kathleen Donohue	OEB**
N. Michelle Holbrook	OEB
Paul Moorcroft	OEB
William Munger	EPS***
Maciej Zwienicki	OEB

* Museum of Comparative Zoology
** Organismic & Evolutionary Biology
*** Earth & Planetary Sciences

Raup House

The Institute of Ecosystem Studies

A FORUM ON OPPORTUNITIES IN ECOLOGY

Tuesday, July 12, 2005
9:30 a.m. - 3:30 p.m.
at the IES Auditorium

This forum provides undergraduate and graduate students the opportunity to hear firsthand about a wide range of career paths in ecology, including:

- Academia
- Media
- Education
- Consulting
- Applied Ecology
- Industry
- Government
- Research
- Policy
- Activism
- Environmental Law
- Conservation

In the morning session (9:30 a.m. - 12:30 p.m.), speakers representing each field will discuss the rewards and motivations involved in their work.

In the afternoon session (1:30 p.m. - 3:30 p.m.), speakers will join small groups for informal discussions about issues of concern to the student participants.

The forum is open to all students at no charge. Interested individuals should register for the afternoon program by calling *Heather L. Dahl, Research Program Coordinator at* (845) 677-7600
x 326 or email DahlH@ecostudies.org. No registration is necessary for the morning session.

There will be a break from 12:30 p.m. -1:30 p.m.: please bring your own lunch and beverage.

Institute of Ecosystem Studies
Route 44A (181 Sharon Turnpike)
Millbrook, New York 12545
845-677-7600 x326
www.ecostudies.org

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to get lost!

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Common Room
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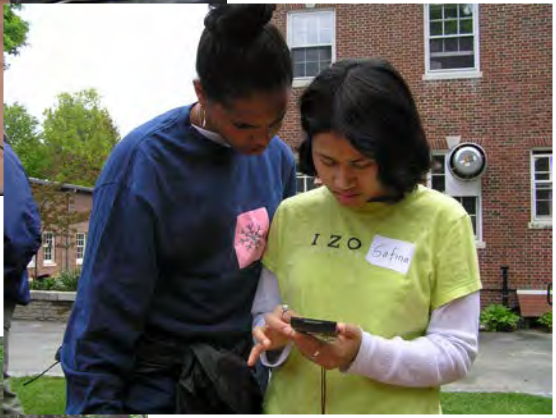
Proctor, Tom Mulcahy

Learning Map and Compass at Orientation



Kristin Ivy and Safina Singh

Franklin and Marshall Students, Kathleen Logothetis,
Nick Kuzma and Stephanie Strouse with Mentor Tim Sipe

Jens Stevens and Marit Wilkerson

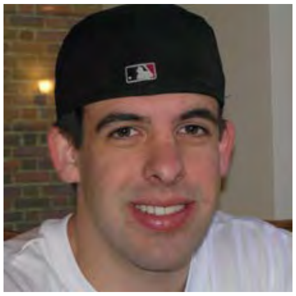
Brian Warshay, Joe Blanchard,
Mentor Jackie Mohan and Katherine Lenoir

Jonah Butler at Harvard Pond

Mentor Evan Pressier and Sascha Lodge

Charlie Boyd in Torrey Lab


Emily Austin

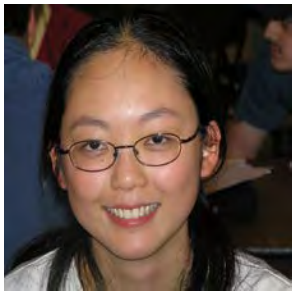

Ryan Barba

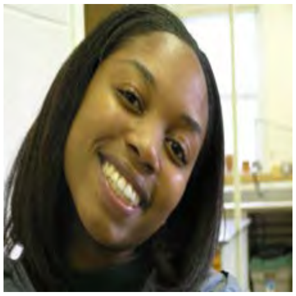

Charlie Boyd


Daniel Breese


Laura Briscoe


Jonah Butler


Susan Cheng


Niña Cooper

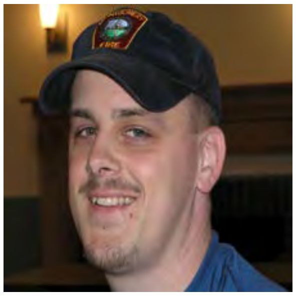

Dave Diaz


Cheryl Hester


Kristin Ivy


Dan Katz


Matt Kaufman


Phil LeBranche


Katherine Lenoir


Bennet Leon


Natalie Levy


Sascha Lodge


Jenny McInnis


Kirsten Ward

Safina Singh

Jens Stevens

Sarah Truebe

Mat Trumbull

Linh Vuong

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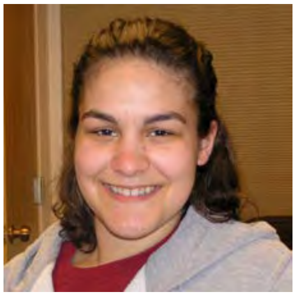
Grace Wu

Nick Kuzma



Kathleen Logothetis

Stephanie Strouse

Kathryn McKain

Tom Mulcahy