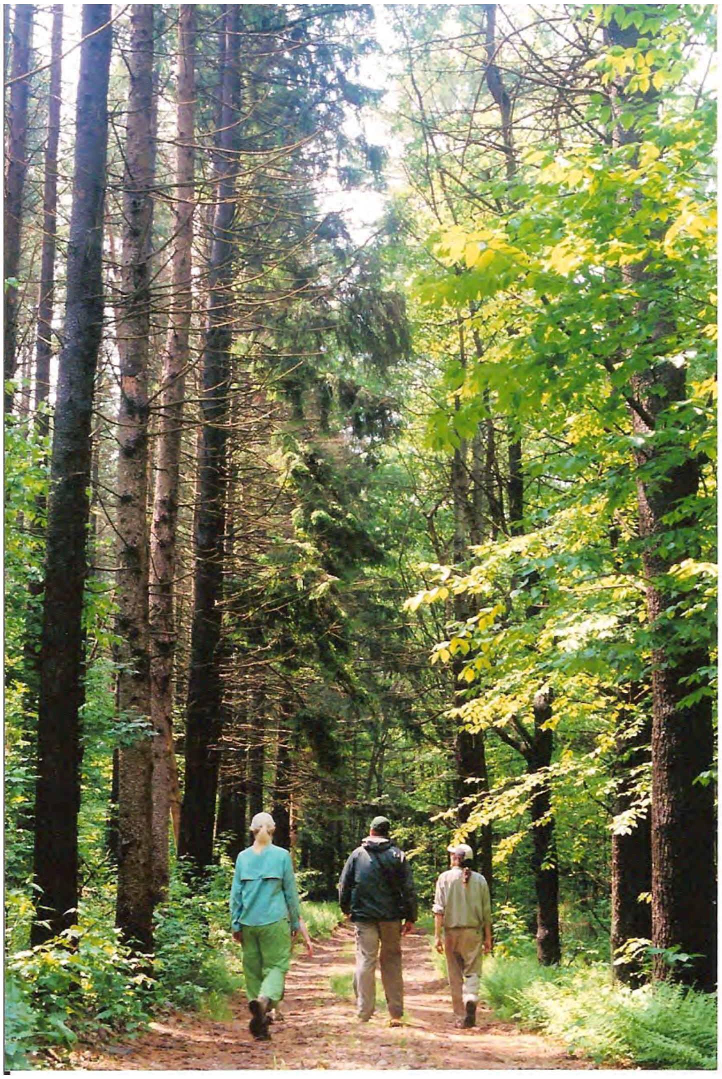
HARVARD FOREST

SUMMER RESEARCH PROGRAM



Abstracts from the 15th Annual
Harvard Forest Summer Research Program
16 August 2007

FIFTEENTH ANNUAL HARVARD FOREST SUMMER RESEARCH PROGRAM

16 August 2007

HARVARD FOREST
FISHER MUSEUM

Photography by Harvard Forest Staff and
2007 Summer Program Participants

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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. These acres include mixed hardwood and conifer forests, ponds, streams, extensive spruce and maple swamps, fields, and diverse plantations. Additional land holdings include the 25-acre Pisgah Forest in southwestern New Hampshire (located in the 5000-acre Pisgah State Park), a virgin forest of white pine and hemlock that was 300 years old when it blew down in the 1938 Hurricane; the 100-acre Matthews Plantation in Hamilton, Massachusetts, which is largely comprised of plantations and upland forest; and the 90-acre Tall Timbers Forest in Royalston, Massachusetts. In Petersham, a complex of buildings that includes Shaler Hall, the Fisher Museum, and the John G. Torrey Laboratories provide office and experimental space, computer and greenhouse facilities, and lecture room for seminars and conferences. Nine colonial-style houses provide accommodations for staff, visiting researchers, and students. Extensive records, including long-term data sets, historical information, original field notes, maps, photographic collections, and electronic data are maintained in the Harvard Forest Archives.

Administratively, the Harvard Forest is a department of the Faculty of Arts and Sciences (FAS) of Harvard University. Faculty associated with the Forest offer courses through the Department of Organismic and Evolutionary Biology (OEB), the 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 Departments of Biology, Natural Resource Conservation, and Computer Science at the University of Massachusetts, the Ecosystems Center of the Marine Biological Laboratory and the Complex Systems Research Center at the University of New Hampshire.

The staff and visiting faculty of approximately fifty work collaboratively to achieve the research, educational, and management objectives of the Harvard Forest. A management group meets monthly to discuss current activities and to plan future programs. Regular meetings with the HF-LTER science team, weekly research seminars and lab discussions, and an annual ecology symposium provide for an infusion of outside perspectives. The seven-member Facilities Crew undertake forest management and physical plant activities. The Coordinator of the Fisher Museum oversees many educational and outreach programs.

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.

Summer Research Program

The Harvard Forest Summer Student Research program, coordinated by Edythe Ellin and assisted by Hilary Crowell, attracted a diverse group of twenty 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. Students presented major results of their work at the Annual Summer Student Research Symposium in mid-August.

Summer Research Students
2007

15TH ANNUAL HARVARD FOREST SUMMER RESEARCH PROGRAM SYMPOSIUM

16 AUGUST 2007
FISHER MUSEUM
9:00 a.m. – 4:30 p.m.

9:00	Aaron Ellison			Welcome

Session I: Forest dynamics, conservation and management (Glenn Motzkin, Moderator)

9:15	Alex Ireland	Lehigh University	Foster	Bob Marshall's forest reconstruction plot: three centuries of ecological resilience to natural and human disturbance
9:30	Ben Mew	Oberlin College	Foster	Landscape-level collaborative approaches to protecting, understanding, and showcasing the Petersham portion of the Swift River Valley
9:45	Nicole Mercier	University of Maine	Barker Plotkin	Fatter boles, changing goals, native poles and overstory tolls of plantation forests
10:00	Peter Jenkins	College of the Atlantic	Jenkins & Record	Do bedrock and soil influence calciphile distribution in the West Champlain Hills?
10:15	Mary Clark	Sewanee University	Melillo & Mohan	Fine root responses to soil warming

Session II: Consequences of invasive plants and insects on the forest (Kristina Stinson, Moderator)

11:00	Sasha Mushegian	Harvard University	Stinson	Regional and historical effects on the distribution and performance of an invasive herb
11:15	Dunbar Carpenter	Harvard University	Stinson	Landscape-scale ecological drivers of *Alliaria petiolata* invasion in Western Massachusetts
11:30	Haley Smith	Oklahoma State University	Orwig	Impacts of invasive insects on eastern hemlock's physiological performance
11:45	Jan Ng	Harvard University	Barker Plotkin	Dead wood in the forest ecosystem: an ongoing study of the effects of eastern hemlock removal

Session III: The little things that run the world (Aaron Ellison, Moderator)

1:15	Kelly McBride	University of Vermont	Ellison	Ants of Massachusetts: A day in the life of an ant hunter
1:30	Mark Johnson	Wheaton College	Ellison	Ants of Massachusetts: Initial findings
1:45	Sonny Bleicher	Rochester Institute of Technology	Ellison	Ant assemblages in the Har (Mt.) Meron Nature Reserve in Israel
2:00	Kyle Chen	Harvard University	Ellison	Investigating the effects of clear-cutting on both ant and beetle abundance/diversity within plantation plots and transitional zones between plantations and their surroundings
2:15	Ernesto Rodriguez	Northern Arizona University	Ellison	Effects of deer browsing on ant populations in Black Rock Forest, Quabbin Reservoir, and Simes Tract
2:30	Kate Bennett	Teacher, Ashburnham-Westminster Regional School District	Ellison	Bringing field science experience to teachers and schoolchildren: a collaborative learning experience

Session IV: Physiology – from plants to ecosystems (Bill Sobczak, Moderator)

3:15	Amy Churchill	Stonehill College	Holbrook & Watkins	A site for sori: Consequences of fertile/sterile leaf dimorphism in ferns
3:30	Leland Werden	Boston University	Wofsy & McKain	Linking foliar nitrogen concentrations to long-term carbon uptake at Harvard Forest
3:45	Michele Rolph	Boston University	Sobczak	How can stream exports of N be used to understand forest nutrient retention?
4:00	Eowyn Connolly-Brown	Cornell University	Hadley	Factors influencing carbon dioxide flux at the Beaver Swamp
4:15	Aaron Ellison			Closing

Ant Assemblages in the Har (Mt.) Meron Nature Reserve in Israel

Sonny Bleicher

Land management affects the general ecology in a biome, and ants can be used as indicator species for these changes. Human induced land management regimes, including grazing and removal of woody species, hasten the desertification process, a problem threatening much of Israel's landmass. Ants are one group proposed as part of a study within the "LTER (Long Term Ecological Research) Israel" research project studying the effects of grazing and woody species removal on the general ecology along a rainfall gradient. Efficiency of multiple trapping methods (such as baiting and manual active collection) were assessed in terms of the diversity of species caught. Use of multiple trapping methods was shown to be statistically significant (using rarefaction). The changes in species diversity under different land management regimes were also tested. Species diversity was significantly different in relation to the different land managements, suggesting that ants can be used as indicator species, and therefore would be a good group to continue surveying. These findings can be used for fine-tuning the performance in the continuation of this long-term assessment. This data is given on partial results, and as such the results might vary by the end of the assessment.

Landscape-scale Ecological Drivers of *Alliaria petiolata* Invasion in Western Massachusetts

Dunbar Carpenter

Alliaria petiolata (garlic mustard) is an herbaceous biennial herb that has been present in the New England landscape for over a century. Recent work has shown that inter-regional differences in the herb's presence and performance exist in Western Massachusetts. Some of the discrepancy in performance may be explained by differences in land-use history, but there are also likely to be ecological factors affecting *A. petiolata*'s invasion pattern. Forest community structure, geophysical attributes, and habitat fragmentation are all likely to influence garlic mustard distribution. One-hundred-and-seventy-five 25×100 m roadside, forested plots across two ecoregions were visited in the summers of 2006 and 2007. *A. petiolata* presence and cover, dominant canopy species, slope, and soil moisture were recorded. Additional data on vicinity to water, and road and edge density were obtained for each plot using GIS datalayers from MassGIS. Chi-squared tests showed that *A. petiolata* does poorly in *Quercus*-dominated forests both in terms of presence ($p<.001$) and performance measured by cover ($p<.001$). *Acer saccharum* and *Fraxinus americana* dominated forest, on the other hand, have high degrees of *A. petiolata* presence ($p<.001$ in both cases). The prevalence of *Quercus* in one of the ecoregions, and *A. saccharum* and *F. americana* in the other may help explain the interregional differences in *A. petiolata* presence. *A. petiolata* also has a propensity to invade mesic to hydric soils and forests downhill from roads, ($p = .04$ for soil-moisture, and $p=.08$ for slope). Habitat fragmentation, as measured in this study, appeared to have little affect on *A. petiolata* presence or performance. From this it can be concluded that *A. petiolata* is not likely to be limited by a lack of available forest edge habitat, but that other ecological factors, particularly soil moisture and forest community composition, do appear to affect the distribution of this invasive plant.

Investigating the Effects of Clear-cutting on Both Ant and Beetle Abundance/Diversity within Plantation Plots and Transitional Zones between Plantations and their Surroundings

Kyle Chen

The effects of converting a habitat into a plantation has been shown to actively change the diversity of the stand by replacing understory as well as the life associated with it. In this experiment, both ants and beetles were investigated to possibly uncover a species that could be used as indicator for change in habitat within the plantations. In addition, the effects of plantations on surrounding areas were analyzed. Plots of 20 by 20 meters were constructed in varying plantation plots, with pitfall traps spaced 5 meters apart within the plot. At the end of the experiment, EcoSim was used to rarefy the final data. Due to this experiment being the pilot experiment of an ongoing project, there was no significant data collected on the possible predicting power of an insect on habitat type. What I found was that increases in vegetation such as *Rubus, Sambucus pubescens*, and *Mitchella repens*, that were signs of early successional habitat and disturbed forests, correlated with subsequent loss of canopy and basal area within the plantation and increased beetle diversity within the plantations by almost 3 fold. As a result, these data show that clear-cutting plantations into early successional habitats should increase beetle diversity. In addition, there was evidence that areas between plantation and non-plantation sites in spruce stands developed a unique habitat based on the absence of specialist species that remained in the plots and an increase of generalist species like *Pterostichus rostratus* within the transition zone. Although more data and an application of variables are needed to test the hypothesis, the cutting of plantations will no doubt have an affect on insect life, increasing vegetation and thus beetle diversity, as well as possibly eliminating transition zone habitats existing between plantation areas and non-plantation areas.

A Site for Sori: Consequences for Fertile/Sterile Leaf Dimorphism in Ferns

Amy Churchill

Plants allocate resources to maximize fitness, yet reproduction can result in physiological costs. Contrary to seed plants, which often partition fertile structures into costly flowers or fruits, ferns produce fertile structures on the lamina, or leaf surface. The leaf functions in both carbon fixation and reproduction and this may produce trade-offs between maximizing carbon gain and increasing fitness. Due to the pressures on leaf for maximizing fitness, fern species have evolved varying levels of fertile/sterile leaf dimorphism: from complete to monomorphic. To determine ecophysiological consequences of fertile/sterile leaf dimorphism three species were examined: the dimorphic sensitive fern *Onoclea sensibilis*, the hemidimorphic Christmas fern *Polystichum acrostichoides* and monomorphic marginal woodfern *Dryopteris marginalis*. We compared light response curves, water potential and aspects of hydraulic conductivity between fertile and sterile fronds. These data were combined with morphological measurements to understand how fertile and sterile leaves differ. Along the gradient of dimorphism we found that as the level of dimorphism increased the percent of fertile fronds produced decreased. A similar observation was made for fertile frond length which decreased with increasing dimorphism. We also found that there was no difference in xylem vulnerability between fertile and sterile fronds; however, the most dimorphic species exhibited the highest mid-day water potential and the monomorphic species the lowest. In fertile fronds, maximum photosynthetic rates decreased and respiration rates increased with a greater dimorphism. These results reveal that there are important tradeoffs to complete leaf dimorphism at both physiological and morphological levels. While dimorphic species have similarly safe fertile and sterile xylem, fertile fronds maintain water potentials below that, which would result in significant cavitation. Dimorphic species produce well protected, yet fewer, fertile fronds with high respiratory cost that may influence species success. The costs of such structures may account for the rarity of complete dimorphism in ferns.

Soil Warming Leads to Significant Reduction of Fine Root Biomass

Mary Clark

Climatologists predicts that by the end of the 21st century the mean global temperature will have risen 1.4° to 5.8° C due to an increase in greenhouse gases in the atmosphere. In order to investigate the effect of climate warming on carbon allocation in temperate forest ecosystems, fine root biomass was measured in a simulated warming environment. This experimental model was created by burying underground heating cables in temperate forest plots to raise the temperature of the soil 5° C above the temperature of the adjacent control plots. Two soil warming sites at Harvard Forest, in Petersham, Massachusetts, were used in this study. One site, with eighteen 6x6 meter plots, has been heated since 1991. The other site, with two 30x30 meter plots, has been heated since 2002. During April, June, and July 2007, soil cores were collected from heated and control plots at both sites. Cores were divided in to organic and mineral layers, and fine roots (<3mm diameter) were separated from each section and classified by diameter size classes (<1 mm, 1-2 mm, 2-3 mm). The roots were then dried and weighed. Samples from the heated plots had 40 to 60 percent less fine root biomass than samples from the control plots. Soil analyses at the same sites have shown that nitrogen availability has steadily increased during the years of heating, so the heated plots have significantly more available nitrogen than the control plots. In Northeastern forests, nitrogen scarcity is usually the primary limiting factor. Increasing nitrogen availability reduces the need for trees to grow expansive root systems, and carbon that trees had once allocated to fine roots can potentially be allocated to above-ground biomass. This study suggests a strong correlation between soil warming, nitrogen availability, and fine root growth. Further studies that measure fine root biomass year-round are needed for a better understanding of root growth and carbon and nitrogen allocation.

CO_2 in Streamwater Shows Strong Response to Light and Flow Rate in Small Wetland

Eowyn Connolly-Brown

We measured dissolved CO_2 levels at multiple locations in a headwater stream (Bigelow Brook) with a small wetland created by beavers in the Harvard Forest. Our results confirm McInnis's (2005 Summer Program) observation that the beaver swamp contains higher levels of dissolved carbon dioxide than upstream or downstream segments. CO_2 concentration of streamwater was measured continuously by spraying water through an air-filled chamber and measuring CO_2 in the air phase with an infrared gas analyzer. Chamber and water temperatures and wind speed were measured using thermocouples and a cup anemometer in order to calculate the air/water CO_2 concentration ratio and to examine causes of CO_2 variability. We found that the daily variation in CO_2 concentration in the stream was not well predicted by temperatures or wind speed, but strongly correlated with photosynthetically active radiation (PAR), which we obtained from the Harvard Forest meteorological station. Over longer periods, stream flow rate also had an impact due to dilution effects, because of the low CO_2 concentration in rainfall. We therefore conclude that the wetland's dissolved CO_2 concentration reflected the impact of both weather and microclimate factors including PAR over daily time scales and possibly soil temperature over longer time scales.

Bob Marshall's Forest Reconstruction Plot: Three Centuries of Ecological Resilience to Natural and Human Disturbance

Alex W. Ireland and Benjamin J. Mew

In 1924, Bob Marshall established a 0.15 ha plot in a *Tsuga canadensis* (eastern hemlock) - *Pinus strobus* (white pine) forest. We relocated the plot, re-measured forest structure, composition, age structure, and site features including decaying stumps, pits, and mounds. Using this plot, Marshall developed a historical approach to address important questions of long-term forest development and forest reconstruction. Marshall and Richard Fisher, his advisor, believed this forest, on sandy outwash soils, exhibited unusual compositional resilience to disturbance. Marshall's groundbreaking historical work confirmed that *T. canadensis* and *P. strobus* persisted on the site, despite repeated logging, since at least the early 1800s. Marshall's study site was experimentally harvested in the winter of 1924-25, severely damaged by the hurricane of 1938, and subjected to complete salvage logging and slash reduction operations in 1939. Our study evaluated the forest's response to this series of intense disturbances and documented that the modern *T. canadensis* and *P. strobus* forest displays a structure and composition remarkably similar to that of 1924. Our results reinforced the conclusions reached by Marshall in the 1920s and confirmed that on these excessively drained soils mixtures of *T. canadensis* and *P. strobus* were remarkably resilient over time.

Table 1. Structural comparison of Bob Marshall's Plot in 1924 to 2007.

Statistic	**1924**	**2007**
Live stems (> 2.5 cm DBH)	270	278
Average diameter	19.1 cm (stump height)	17.3 cm (breast height)
Average age	86 years	59 years
Age range	70 – 270	38 – 84

Table 2. Compositional comparison of the 1924 group selection area to Bob Marshall's plot in 2007.

Statistic	**1924**		**2007**	
Percent of total stems	*T. canadensis*	70 %	*T. canadensis*	67%
	P. strobus	15%	*P. strobus*	24%
	hardwoods	15%	hardwoods	9%
Percent of total conifer volume	*T. canadensis*	86 %	*T. canadensis*	34%
	P. strobus	14%	*P. strobus*	66%

Do Bedrock and Soil Influence Calciphile Distribution in the West Champlain Hills?

Peter Jenkins

The flora of the West Champlain Hills is distinct from the flora of surrounding northern forests. These hills are islands for plants more characteristic of dry, calcium-rich areas than the moist acidic woods that dominate northern New York and New England. Little is known about dry-calcareous plant communities although such sites are of high conservation value because they are uncommon and support numerous regionally rare species. An understanding of the factors that influence species distribution and diversity in the West Champlain Hills may help to inform future conservation efforts. Many plants found on upper mid-slopes with a general southern aspect in these hills are indicators of some calcium enrichment. The bedrocks in the eastern Adirondacks are primarily granitic gneisses, which tend to be calcium poor. However, metanorthosite bedrock, which contains higher amounts of calcium, extends in a band from the High Peaks to Lake Champlain and forms a number of the West Champlain Hills. We suspected that the metanorthosites along with less common metagabbros and amphibolites would produce richer soils and support more dry-rich community representatives. To determine whether bedrock type influences vegetation, we identified and surveyed dry-rich communities on nineteen hills in Essex County, NY. Nine hills were metanorthosite, two were metagabbro, and eight were gneiss. We found no real difference between the numbers of calcium indicator species on gneiss hills vs. metanorthosite/metagabbro hills. Soil pH on these hills ranged from 4.5 to 5.7 and rich indicator species did show a preference for higher pH soil. The difference between soil pH on the different rock types was not significant. Contrary to our expectations this study indicates that bedrock type does not have much influence on the distribution and diversity of calciphiles in the West Champlain Hills.

Ants of Massachusetts: Initial Findings

<u>*Mark Johnston*</u>

Ants can be used as bioindicators for other elements in an ecosystem due to characteristics such as sensitivity to ecological changes, dependency on vegetation, and specialists requiring specific environmental factors. In this research we collected ants from 35 different sites across Massachusetts in differing habitat types, elevations, and locations. Each plot was 75x75m and represented one habitat type. From each plot we hand-collected for one person hour and sieved three litter samples. Over the three month collecting period, 66 ant species were collected. Relationships between species richness and habitat type and category were explored along with patterns occurring among elevation, latitude, and longitude. Using multivariate linear regression analysis, we showed that ant diversity across all habitat types is not correlated with elevation and latitude (dF=121, F=1.372, p=0.26). However, when categories of habitats, such as forests, were analyzed individually, species richness was shown to be correlated with latitude, longitude, and elevation. This survey of the ants of Massachusetts is the first state in a survey of the ants in all of New England. The gathering of this data across such a wide area will be extremely useful in future monitoring and research of management regimes, disturbance areas, and climate change.

Fatter Boles, Changing Goals, Native Poles, & Overstory Tolls of Plantation Forests

Nicole Mercier

Many of the remaining non-native plantations established in the early days of Harvard Forest will be harvested next winter. A suite of permanent vegetation plots was established throughout the plantations to assess vegetation structure in plantations and predict future dynamics in harvested and early seral habitats. Plantations sampled were established between 1916 and 1944. The specific objectives of this analysis were to determine the long term effects of thinning treatments on overstory structure and to characterize current tree regeneration and understory flora that will in large part determine the future composition of these forests as the overstory is harvested or senesces.

Intermediate stand treatments were carried out in some plantations through the 1940s, though plantation management effectively ceased by the 1960s. The general principles of thinning suggest that stands that have been thinned will allocate wood production to selected individuals, resulting in higher average stand diameters than unthinned stands. Graphical analyses show that thinned stands may have larger average stand diameters than untreated stands. The goals of Harvard Forest have shifted from demonstrating sustained timber yield to studying ecological dynamics. This may explain the lack of follow up thinning treatments, which if continued could have yielded larger diameter gains.

Plantations are generally considered to have low biodiversity; does species richness differ from native forest and among plantation overstory types? Analysis reveals that plantations have 20-30% lower species richness than native forests and spruce plantations generally have lower species richness than pine plantations.

Does understory community composition vary among plantation overstory types? An ordination analysis of understory flora cover generated consistent patterns that led to the conclusion that understory community composition is similar among spruce plantations whereas red pine plantations did not exhibit a strong pattern of similarity, possibly due to the diversity of management histories in the red pine plantations. (Fig. 1)

Does tree regeneration in the plantations reflect overstory plantation species composition? None of the non-native plantation species seem to be self-sustaining. Red pine seedlings and sapling are rarely found. The spruce regeneration is present only as seedlings, absent from sapling size regeneration. Whether the stands are harvested, the trend indicates that the sites will revert back to native tree species that seed in or emerge from established root systems.

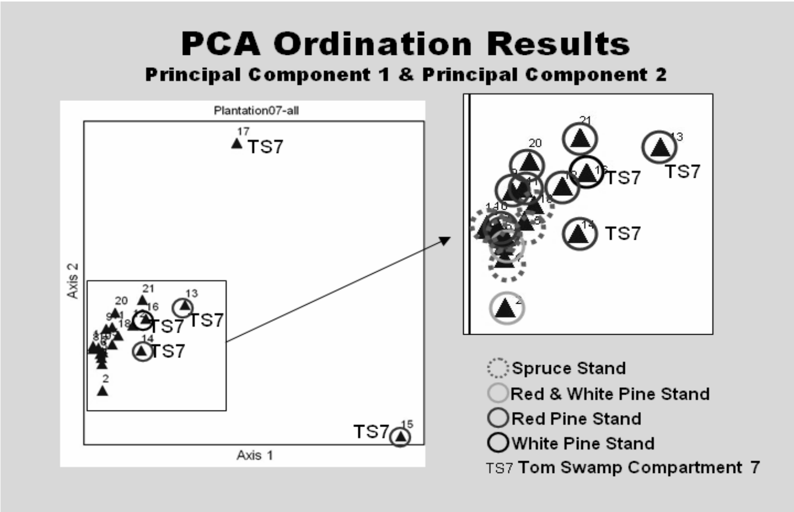

Figure 1. Analysis of understory community composition. Plots are coded by overstory type

Landscape-level Collaborative Approaches to Protecting, Understanding, and Showcasing the Petersham Portion of the Swift River Valley

Benjamin J. Mew and Alex W. Ireland

The landscape surrounding the Petersham portion of the Swift River Valley is ecologically diverse, rich in cultural history, and the current focus of innovative land protection efforts. Multiple organizations including the Trustees of Reservations, Massachusetts Audubon Society, the Harvard Forest, the Town of Petersham, and the Commonwealth of Massachusetts have worked, occasionally collaboratively, to protect over 50% of the land area. The innovative conservation efforts underway in the Swift River Valley landscape are remarkable and with further work could provide a model for such activities across New England. To contribute to increasing landscape-level understanding, management, and protection we compiled archival data, made field observations, and authored a proposal for increased collaborative research and development of an integrated trail network. The proposed trail will link existing ones, increase communication between landowners, educate visitors, and help the town achieve its goal of increasing ecotourism. By showcasing this beautiful landscape, educating people about its value, and increasing collaboration, we will inspire further land protection and environmental consciousness.

Regional and Historical Effects on the Distribution and Abundance of an Invasive Herb

Sasha Mushegian

The susceptibility of a site to invasion by nonnative species depends on its current ecological features and its historical land use. Certain environments might be more conducive to an invasive plant's success, and several recent studies have shown that former agricultural sites are more susceptible to invasion than sites that have been continuously wooded. We studied the invasive herb garlic mustard (*Alliaria petiolata*), in two regions with distinct ecological characteristics (the Connecticut River Valley and the Housatonic River Valley in Massachusetts), and two historical land uses (wooded versus cleared in 1830). We surveyed the presence and absence of garlic mustard in randomly selected 100 x 25 m forested sites along road edges and determined 1830 land use from historical records.

A significantly ($p<10^{-10}$) higher proportion of the random survey sites contained garlic mustard in the Housatonic River Valley than in the Connecticut River Valley, while there was only a marginally significant (p=.057) difference in garlic mustard presence among sites with different 1830 land use. Among sites that contained garlic mustard—both random survey sites and 9 previously known sites—ANOVA showed that land use history, but not ecoregion, was a significant determining factor in the amount of garlic mustard present, with bigger populations in sites that were open in 1830. Thus, the ecoregion appears to primarily determine the number of sites colonized, while land use history determines performance within colonized sites. This suggests that for garlic mustard, the role of 1830 land use is not in facilitating initial establishment, but in serving as a cause or indicator of environmental quality for proliferation of the invasion. It also suggests that mechanisms of dispersal may differ in the two regions. Further studies should be conducted to determine what aspects of ecology and historical land use are relevant the success of garlic mustard.

Dead Wood in the Forest Ecosystem: An Ongoing Study of the Effects of Eastern Hemlock Removal

Jan Ng

Widespread decline of eastern hemlock (*Tsuga canadensis*) as a foundation species in northeastern forests is set to have a pervasive impact on this landscape, but distinct effects on the forest ecosystem are as yet unknown. The Hemlock Manipulation Study contrasts hemlock removal by *Adelges tsugae* infestation (simulated by girdling) and preemptive logging treatments with hemlock and hardwood control plots. The coarse wood debris (CWD) survey within this study analyzes dead wood dynamics in the ecosystem. The 2007 survey represents a continuation of data collected post-treatment in 2005.

Dead wood mass was assessed in eight 0.8 ha forest plots along transects (coarse and fine downed dead wood) and strip plots (standing dead wood). Species, size, and decay class were noted for all surveyed material.

Girdled plots were found to contain the greatest amount dead wood, more than 85% of which (by mass) came from standing snags and stumps. In logged plots, ≈18,000 kg/ha of downed dead wood had shifted from decay class 1 (least decayed) to decay classes 2 and 3 between the 2005 and 2007 surveys. Girdled plots currently have ≈122,000 kg/ha more standing dead eastern hemlocks than hemlock control plots, whereas in 2005 the masses differed by less than 1,000 kg/ha. Large snags (pieces standing ≥2m tall and measuring ≥25cm in base diameter) comprised over 110,000 kg/ha of the ≈126,000 kg/ha total dead wood mass in girdled plots. By comparison, less than 2,000 kg/ha out of ≈8,500 kg/ha standing dead wood in logged plots, ≈13,500 kg/ha out of 14,000 kg/ha in hemlock control plots, and 2,500 kg/ha out of 8,500 kg/ha in hardwood control plots were large snags.

These data, upon integration with other surveys in the experiment, may clarify the impact that inputting large quantities of dead *T.canadensis* will have on northeastern forest ecosystem structure, habitat, and nutrient dynamics.

Effects of Deer Browsing on Ant Populations in Black Rock Forest, Quabbin Reservoir, and Simes Tract

Ernesto Rodriguez

Increase of deer density in American forests of the Northeast due to lack of predators has caused major ecosystem imbalances that influence other species. The focus of this project is to determine the effect, if any, of deer browsing on ant density and diversity in different forest canopies. The data obtained from this project will be used to determine the ant density and variety of seven plots on three Northeastern locations with canopies ranging from heavy to low oak composition.

We sampled two 95 by 95 and five 75 by 75 meter plots with different canopy structures and deer-browsing levels within the New England area. The ant-collecting methods included three litter samples as well as one-hour hand collections in all the sites, and they took place during the months of June and July of 2007.

The results of the study show that ant nests are more abundant in plots with oak-dominated canopies and low levels of understory compared to any other type of forest sampled. Also, a higher diversity of site species is found in oak dominated sites regardless of understory level. These results suggest that deer over-browsing directly influences some ant species by increasing their density while limiting others. Ants are one of the most important species of the forest because they recycle soils and keep forest pathogens at bay. Therefore, further studies about ants are needed in order to appreciate their important role in the ecosystem.

How Can Stream Exports of N be Used to Understand Forest Nutrient Retention?

Michelle Rolph

Headwater streams integrate nutrient, organic matter, and sediment fluxes from forested watersheds. I examined inorganic and organic N dynamics in Bigelow Brook, a headwater stream draining a mature, healthy hemlock forest in the Prospect Hill tract of Harvard Forest (Petersham, MA). Bigelow Brook's geomorphology, hydrology, and watershed ecology are well characterized and efforts are underway to estimate annual carbon and nutrient fluxes to downstream ecosystems. Preliminary research suggested that Bigelow Brook has surprisingly low concentrations of nitrate, despite the fact that New England receives high atmospheric N inputs. My project had three objectives: 1) to better document inorganic (NH_4^+ and NO_3^-) and organic N (DON) concentrations in Bigelow Brook, 2) to evaluate the bioavailability of organic matter fluxes, and 3) to evaluate inorganic and organic N retention across the forest soil and stream interface. The relative concentrations of NH_4^+, NO_3^- and DON varied with season. During the growing season, DON (0.056±0.003 mg/L) was surprisingly greater than inorganic N concentrations (NO_3^--N = 0.011±0.002 mg/L and NH_4^+-N = 0.024±0.001). Downstream fluxes of DON were closely linked to summer storm events suggesting a rapid flushing of organic matter from forest soils. These results suggest that Bigelow Brook's watershed routinely retains inorganic forms of N, yet is susceptible to large DON losses during storm events. Throughout the summer, percent bioavailability of organic matter never exceeded 20% suggesting that the majority of DON exported from the watershed is refractory and is transported to downstream ecosystems. Cation and anion resin bags were incubated in riparian soil to estimate NO_3^- and NH_4^+ accumulation, and soil cores were used to determine net N mineralization. These pending data will help to identify potential hotspots of biogeochemical activity and determine relative amounts of nutrients being stored in the riparian zone. Bigelow Brook needs to be the focus of future research that continues to quantify stream and riparian zone biogeochemistry to more fully understand controls on nutrient retention and loss from forested ecosystems.

Impacts of Invasive Insects on Eastern Hemlock Physiological Performance

Haley Smith

Eastern hemlock (*Tsuga canadensis*) stands throughout southern New England are being decimated by the hemlock woolly adelgid (HWA, *Adelges tsugae*) and the lesser known elongate hemlock scale (EHS, *Fiorinia externa*), invasive pests from Asia. Recent sampling efforts suggest that these 2 pests continue to migrate across the landscape. However, virtually nothing is known about how these pests impact hemlock physiology. Hemlock trees from northern CT and south-central MA with the following four infestation 'treatments' were examined in this study: uninfested control, infested with HWA, infested with EHS, and infested with HWA and EHS. Leaf-level gas exchange and foliar chemical content was examined in one-year old foliage from 12 to 25 trees of each treatment. Compared to uninfested foliage (5.9 µmols CO_2 m^{-2} s^{-1}), hemlock woolly adelgid and elongate hemlock scale alone had lower photosynthetic rates (5.1 and 4.8 µmols CO_2 m^{-2} s^{-1}, respectively). Foliage infested with both insects had even lower rates, averaging 4.4 µmols CO_2 m^{-2} s^{-1}.(Fig. 1) Density of EHS had no impact on photosynthetic rates, while HWA density was weakly correlated with photosynthetic rates, perhaps due to a defensive response. Leaves with HWA (both alone and with EHS) had higher foliar nitrogen than both EHS infested and non-infested foliage. Future work that takes into account infestation history and duration and minimizes site to site variability in samples will help clarify the long-term impacts of these invasive pests on physiological performance.

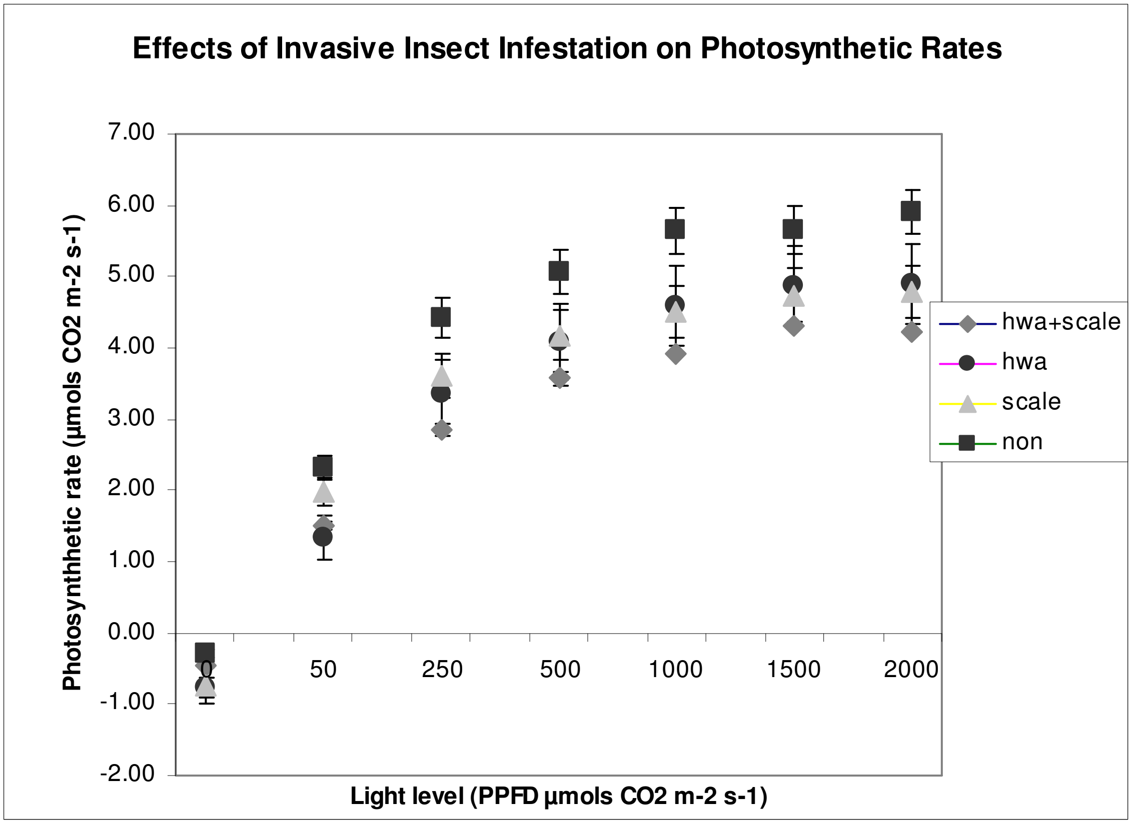

Figure 1. Infestation by HWA, EHS or both HWA and EHS lowers photosynthetic rate of hemlock fringe.

Linking Foliar Nitrogen Concentrations to Long-Term Carbon Uptake at Harvard Forest

Leland Werden

Measurements of CO_2 exchange and ground-based measurements of C pools at Harvard Forest have shown that C-uptake has systematically increased over the last 18 years, mostly due to the growth of red oak (*Quercus rubra*). This increase in C-uptake cannot be explained by climatic variables over the long term and is unexpected because it is believed that trees of this age have matured. Foliar N concentration is positively correlated with photosynthetic rates at the leaf level and could be one of the factors contributing to C-uptake. We investigated whether N has been involved in the observed increases in C-uptake by measuring N concentrations in fresh foliage samples collected from the footprint of the eddy-flux tower over several years since 1998. We found that that the mean foliar N concentration of hardwood species has increased significantly ($p < 0.05$) since 1998. No relationship was found between growth rates and foliar N concentrations of individual trees. Our results suggest that interannual variation in foliar N concentration follows a similar pattern of interannual variation in C sequestration, although a causal relationship between the two is not supported. N concentration measurements of other components of the forest are needed to develop a more detailed analysis of N-cycling at this site. Measurements in future years will help us to determine if canopy N concentration is in fact increasing at this site or if the early measurements taken for this study were made in an abnormally N-poor year.

2007 SUMMER STUDENT PROGRAM
SEMINARS AND WORKSHOPS

June 4th	Seminar 1. Land Use History	David Foster
June 6th	Seminar 2. Plant Identification	John O'Keefe & Glenn Motzkin
June 11th	Seminar 3. Graduate School Panel	Sydne Record, Brian DeGasperis, Jess Butler, & Tony D'Amato
June 20th	Seminar 4. Old Growth Forests	Tony D'Amato
June 26th & 28th	Mid Summer Presentations	REUs
July 9th	Career Forum	
July 12	Seminar 5. Scientific Abstract	Kristina Stinson
July 16th	Ethics Seminar and Panel Discussion	Ben Minteer, Elizabeth Farnsworth, Julie Richburg, John McDonald
July 20th	Harvard Museum of Comparative Zoology	Kathleen Donohue
July 23rd	Seminar 6. Fungi	Ann Pringle
July 25th	Quabbin Field Trip	John Burk
August 1st	Seminar 7. Scientific Presentation	Dave Orwig
August 16th	Summer Research Symposium	REUs

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- Landowner Incentive Program: Wildlife Habitat Enhancement at the Harvard Forest: Early Successional Habitat Creation and Invasive Plant Control

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Megan Bartlett
Harvard University
Holbrook/Watkins

Sonny Bleicher
Rochester Institute of
Technology - Ellison

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Harvard University
Stinson

Kyle Chen
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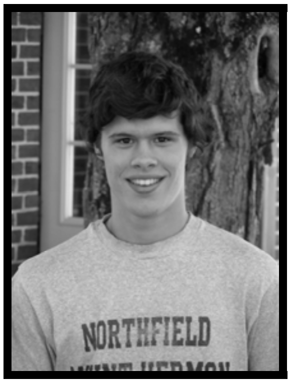
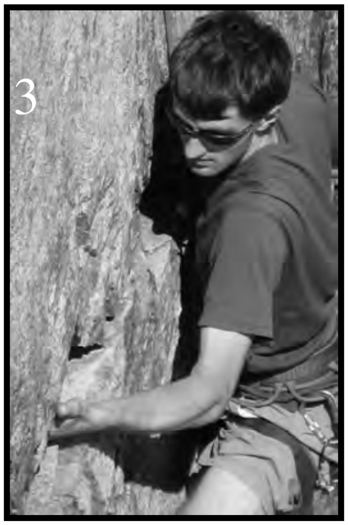
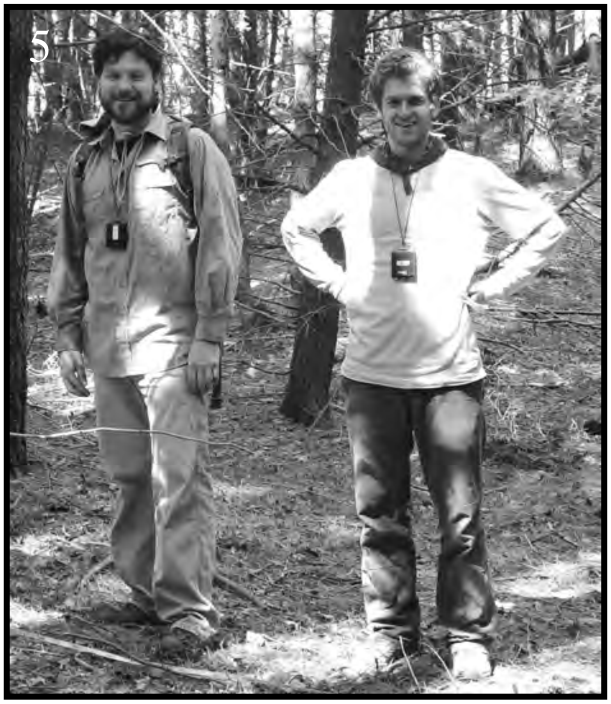


Leland Werden
Boston University
Wofsy



1. Eowyn Connolly-Brown at Harvard Pond, 2. Michele Rolph and Jan Ng at Acadia National Park, 3. Dunbar Carpenter climbing at Acadia, 4. Alex Ireland and Ben Mew, 5. Kyle Chen and Mark Johnston practicing orienteering.



1. Amy Churchill and Nicole Mercier at the Quabbin Reservoir, 2. Megan Bartlett studying ferns, 3. Peter Jenkins, Sasha Mushegian, and Ben Mew climbing 4. Mary Clark and Kelly McBride at the Museum of Comparative Zoology in Cambridge.

1. Orienteering with Glenn Motzkin, 2. Haley Smith in the field at Harvard Forest 3. Mary Clark, Haley Smith, Michele Rolph, and Amy Churchill at Museum of Comparative Zoology Ornithology Department 4. Nicole Mercier practicing extinguishing a fire.

1. Plant Identification with John O’Keefe; Sasha Mushegian, Ernesto Rodriguez, Michele Rolph, Leland Werden, and Ben Mew, 2. Sonny Bleicher practicing orienteering, 3. Michele Rolph climbing at Acadia National Park, 4. Dunbar Carpenter and Ben Mew.