HARVARD FOREST

SUMMER RESEARCH PROGRAM

Abstracts from the 14th Annual
Harvard Forest Summer Research Program
17 August 2006

FOURTEENTH ANNUAL HARVARD FOREST SUMMER RESEARCH PROGRAM

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HARVARD FOREST
FISHER MUSEUM

Photography by Harvard Forest Staff and
2006 Summer Program Participants

INTRODUCTION TO THE HARVARD FOREST

Since its establishment in 1907, the Harvard Forest has served as Harvard University's rural laboratory and classroom for research and education in forest biology and ecology. Through the years, researchers have focused on forest management, soils and the development of forest site concepts, the biology of temperate and tropical trees, plant ecology, forest economics, landscape history, conservation biology and ecosystem dynamics. Today, this legacy of activities is continued as faculty, staff, and students seek to understand historical and modern changes in the forests of New England and beyond resulting from human and natural disturbance processes, and to apply this information to the conservation, management, and appreciation of natural ecosystems. This activity is epitomized by the Harvard Forest Long Term Ecological Research (HF LTER) program, which was established in 1988 through funding by the National Science Foundation (NSF).

Physically, the Harvard Forest is comprised of approximately 3000 acres of land in the north-central town of Petersham, Massachusetts 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 seven-member Facilities Crew under take 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, whereas major research support comes primarily from the National Science Foundation, Department of Energy, 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 and the R. T. Fisher Fund.

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. 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
2006

14TH ANNUAL HARVARD FOREST
SUMMER RESEARCH PROGRAM SYMPOSIUM
17 AUGUST 2006, FISHER MUSEUM

Student	University	Mentor	Symposium Title
Aaron Ellison – Welcome			
Session I: Legacies of natural and human disturbance (Ben Wolfe, Moderator)			
Brynne Simmons	Johnson C. Smith University	Audrey Barker-Plotkin	Where seedlings and saplings prefer to grow: a study of areas affected by the 1938 hurricane, areas which simulate the 1938 hurricane, and areas which were neither affected by or made to simulate a hurricane
Alex Ireland	Clarion University	Wyatt Oswald	Post-settlement forest dynamics of a central New England basin examined by pollen, tree ring, and historically documented records
Kevin Burls	Mount Union College	Kristina Stinson	Recent and past land uses affect *Berberis thunbergii* performance
Rachel Stahr	Hampshire College	Ben Wolfe	Investigating the interaction between garlic mustard and ectomycorrhizal fungi
Chelsea Vario	University of New Hampshire	Serita Frey	Chronic nitrogen additions affect aboveground sporocarp diversity in a hardwood stand
Session II: Ecosystem physiology (Kathryn McKain, Moderator)			
Justin Frisino	SUNY Albany – University of Albany	Julian Hadley	Carbon content in woody debris and soil in a 200-year old hemlock forest compared to younger deciduous stands at the Harvard Forest in central Massachusetts
Alison Grantham	Mount Holyoke College	Steve Wofsy	Aboveground woody detrital biomass decreases and respiration increases 5 years after selective harvest
Frances O’Donnell	Harvard University	Steve Wofsy	Evidence for a carbon sink in a New England temperate forest five years after selective logging
Rebecca Orozco	University of Kansas	Jackie Mohan	Below ground root biomass response to soil warming
Stephanie Searle	Columbia University	Julian Hadley	High watering frequency of leaf litter causes a relative loss of carbon available to decomposition

Session III: Plants, populations and communities (Sydne Record, Moderator)

Kaya Schmandt	Brown University	Missy Holbrook	Annual plasticity in *Quercus rubra* leaf hydraulic systems
Megan Woltz	North Carolina State University	Kristina Stinson	Garlic mustard population demographics differ among forest habitats at the Harvard Forest LTER
Stephanie Day	Howard University	Aaron Ellison	Historical and contemporary research into *Sarracenia* moth associates
Laura Briscoe	College of the Atlantic	Jerry Jenkins	The flora of Harvard Forest: Bryophytes
Alex Arguello	St. Mary's College of Maryland	Aaron Ellison	A comparison of ant biodiversity and distribution between Simes Tract and Black Rock Forest

Session IV: Implications of an invading insect for terrestrial and aquatic ecosystems (Bill Sobczak, Moderator)

Rachel Osborn	Hampshire College	Aaron Ellison	Ants and soil respiration in a hemlock removal experiment at the Harvard Forest
Christine Rollinson	Oberlin College	Dave Orwig	The effectiveness of chemically treating eastern hemlock trees to fight hemlock woolly adelgid infestations
Timothy Rowell	College of the Holy Cross	Bill Sobzack	Do increases in light intensity following the hemlock woolly adelgid invasion alter stream temperature and periphyton growth?
Lori Simpers	Susquehanna University	Bill Sobzack	Hemlock woolly adelgid damage along headwater stream corridors in central Connecticut and Massachusetts
Safina Singh	Mount Holyoke College	Bill Sobzack	Summer organic matter budget for a hemlock dominated stream

Aaron Ellison – Closing

A Comparison of Ant Biodiversity and Distribution Between Simes Tract and Black Rock Forest

Alex Arguello

Ants are known for their roles in alteration of soil composition, seed dispersal, and decomposition efforts, making them extremely important components of ecosystems world-wide. It will be essential in the next few years to obtain ant biodiversity inventories of the Northeastern United States as environmental transitions, such as deforestation from logging, invasion of Hemlock Woolly Adelgid, and global warming, begin to take effect. Extensive research is being conducted studying interactions between local ant populations and environmental factors, both natural and artificially induced, within the Hemlock Removal Experiment within the Simes Tract at the Harvard Forest, MA. Beyond these experimental plots, however, there is little knowledge of area-wide ant assemblages and ant biodiversity.

To measure total ant biodiversity of two Northeastern sites, we sampled seven 100-m, and one 50-m, long transects under a variety of different habitats (hemlock, hardwood, swamp, and rocky slope) at Simes Tract and sixteen 65-m long transects under a mainly hardwood canopy at the oak-removal experimental site at the Black Rock Forest in Cornwall, NY. Pitfall traps were inserted into the ground roughly every 5-m along each transect. We captured ants using aforementioned pitfall traps, Sandies® Pecan Shortbread cookie baits, and litter and hand sampling methods. Each transect was sampled twice at Simes Tract and once at Black Rock Forest between June and August of 2006. A total of 25 ant species and 32 ant species were found at Simes Tract and Black Rock Forest, respectively. Ant species between the two sites were found to be 42.5% similar, using the Jaccard index. *Aphaenogaster rudis, Camponotus pennsylvanicus, Formica neogagates*, and *Myrmica punctiventris* were the species most commonly encountered. These records, along with future Northeastern ant biodiversity studies, will prove to be invaluable for tracking shifts in ant community composition and in aiding forest management decisions.

The Flora of Harvard Forest: Bryophytes

Laura Briscoe

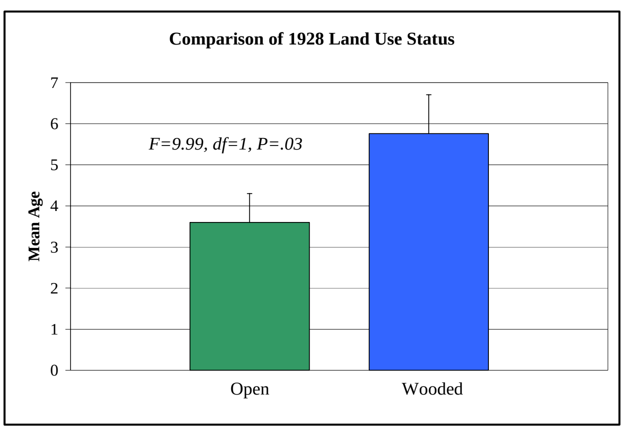
This year we began the bryophyte inventory, an extension of the Harvard Forest Flora project to include mosses, liverworts and hornworts. These nonvascular plants comprise many unique communities that respond directly to different habitats and ecological conditions. Historically the moss flora of Massachusetts has not been thoroughly studied, and this holds true for the Harvard Forest. Aside from small fractions of other projects, the bryophytes of Harvard Forest have never been fully surveyed. In this initial inventory effort, we completed six transects in five Harvard Forest compartments, and collected extensively off transects, completing species lists in three other areas. We collected in a variety of habitats: streams, stream banks, swamps, the Swift River, and rocky ledges. We surveyed fifty 1x2m quadrats per 100m transect. Bryophytes were identified by on-site and laboratory analysis. Out of the nine areas most thoroughly surveyed, 56 percent of the species recorded were only found in one area. Out of all the quadrats surveyed, 38 percent of the species recorded were only found in 10 or fewer quadrats. This in no way implies that these species are necessarily rare, but suggests the thoroughness required to fully assess the bryophyte biodiversity of the forest. To date the forest is credited with 138 species: 105 mosses, 32 liverworts, one hornwort. Forty-nine of these species were found in only one of the nine areas surveyed. Massachusetts' bryoflora stands at 356 species and 16 varieties. The completion of this study will require the same kind of detailed transect work, especially in habitats not yet explored.

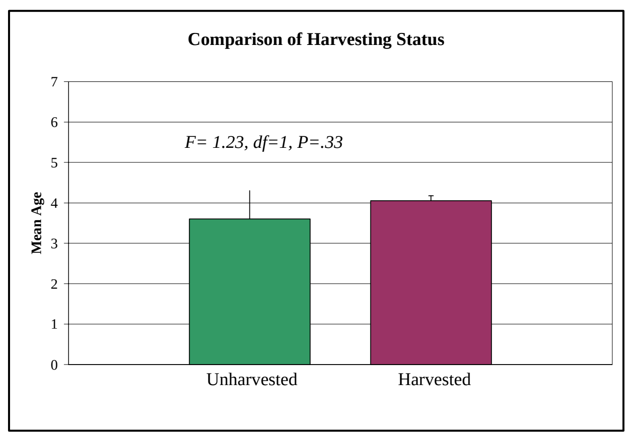
Recent and Past Land Uses Affect *Berberis thunbergii* Performance

Kevin Burls

Invasive species management requires a firm understanding of the biology of the study organism and how different historical and environmental variables affect its performance. Previous work has shown that early 20th century land use affects the abundance and distribution of Japanese barberry, *Berberis thunbergii*, but that recent harvesting has no significant effects. This study examined how past land use and recent harvesting affect barberry's age structure, recruitment rates, growth rates, density, percent cover, and fruit production. We examined barberry populations in the Prescott Peninsula of the Quabbin Reservoir under different 1927 land uses and under different recent harvesting treatments and sampled stems for age and diameter. Environmental data, percent cover, and fruit production data were also gathered in early 2006. Results showed that barberry stems that are in continuously wooded forest stands are older than stems from previously opened lands, but that recent harvesting seems to have no impact on average age. Neither past land use nor recent harvesting had an impact on recruitment rates, growth rates, density, percent cover, or fruit production. Environmental variables did not have a strong impact on any of the demographic variables we examined. These data suggest that continuously wooded sites are acting differently demographically while recent harvesting has little effect on the population structure. This offers potential management implications when assigning priorities to different barberry populations.

Figure 1. Comparison of stem average age between land use and harvesting treatments.





Historical and Contemporary Research into *Sarracenia* Moth Associates

Stephanie Day

Archival material provided by the Frank Morton Jones collection at Yale University was used to design a website about the functional knowledge of pitcher plants in the early 20th century. FMJ was an entomological naturalist who in his early career catalogued and investigated the various insects associated with the North American Sarraceniaceae. He, along with a couple of chemists (Hepburn and St. John), investigated the chemical composition, behavior, and effects of the pitcher fluid. Two species of moth larvae are known to consume different parts of the pitcher plant *Sarracenia purpurea*, *Exyra fax* and *Papaipema appassionata*. A more complete picture of the historical research done on pitcher plants and their associates allows current research to eliminate redundancy and explore new avenues. A survey of 12 Massachusetts bogs was performed to determine the presence or absence of these moths in these habitats. A 100 square meter plot was set up, with points at each meter, for a total of 100 points. At each point, we determined the microhabitat (high, low, flooded), hand collected ants, and also determined the nearest pitcher plant neighbor, taking census statistics at noting the presence or absence of moth damage to pitchers, flowers, or the rhizome. Water samples were collected at five points for nutrient analysis and moss samples were taken for identification. Bog ants nest disproportionately in high hummocks than in low or flooded areas ($p < 0.001$). High areas in the bog are less prone to flooding, providing a shelter during times of increased rainfall. *Papaipema appassionata* and *Exyra fax* do not show any preference for larger or smaller plants as measured by number of open pitchers ($p = 0.23$), rosette diameter ($p = 0.3597$), or the length of the longest leaf ($p = 0.635$). No selection for food size allows both species of moths to utilize more plants for propagation and to expand their ranges.

Carbon Content in Woody Debris and Soil in a 200-year old Hemlock Forest Compared to Younger Deciduous Stands at the Harvard Forest in Central Massachusetts

Justin Frisino

Both soil organic matter and wood in dead and decomposing trees ("coarse woody debris" or CWD) can influence forest carbon budgets, especially as forests become older and larger. We analyzed CWD, fine woody debris (FWD), live biomass and soil carbon in eleven 6-m radius plots in a 200-year old eastern hemlock forest. To estimate carbon storage in CWD we measured all woody debris over 7.5cm including stumps, logs and log snags. CWD was segregated into five decay classes with measured densities, which were multiplied by CWD volume to estimate CWD biomass. Tree snags were measured from their diameter at breast height (DBH) and allometric equations were used to determine their biomass. Biomass of fine woody debris was sampled by collecting all debris between 7.5cm and 1cm diameter within two 1-m^2 subplots within each plot and was dried at 75 ^{o}C. Biomass of all live trees above 10 cm DBH was estimated from allometric equations. Soil carbon to the top of the C horizon was determined from nine cores in each plot which were dried at 105 ^{o}C before all carbon was burned off at 550 ^{o}C. Carbon in all forest components was about 229 +/- 22 Mg C/ ha, and was composed of 120 +/- 8.6 Mg C/ha in live biomass, 2.48 +/- 0.5 Mg C/ha fine woody debris, 4.97 +/- .80 Mg C/ ha in coarse woody debris and 102.69 +/- 8.2 Mg C/ha in soil carbon. In a nearby 65-100 year old deciduous forest total ecosystem carbon (≈ 204 Mg C/ha) was slightly lower than in the hemlock forest, with part of the difference between the two forests due to lower soil carbon in the deciduous forest (around 90 Mg C/ha). Higher soil carbon in the hemlock stand may increase soil moisture retention and stabilize soil respiration.

Aboveground Woody Detrital Biomass Decreases and Respiration Increases in the Five Years Following Selective Harvest

Alison Mills Grantham

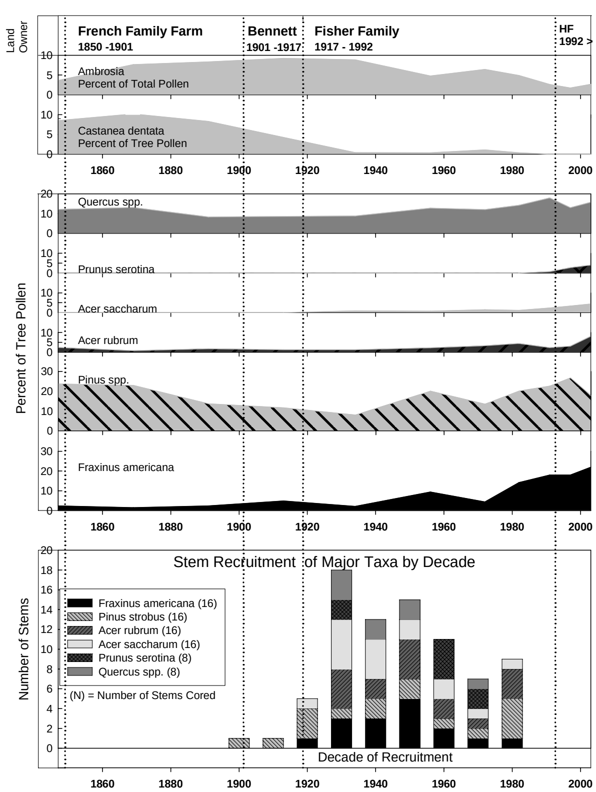
Coarse woody debris (CWD; diameter≥7.5cm) accounts for as much as 30% of net ecosystem exchange in the maturing second growth forests partially responsible for terrestrial carbon(C) uptake in North America. We investigated changes in aboveground woody debris (WD) once before, and three times following a 2001 selective harvest. We inventoried CWD dimensions on 33 Environmental Measurement Site (EMS; control) plots and on eight adjacent selectively harvested (cut) plots at Harvard Forest. We calculated CWD C content using decay class specific wood densities and dimension derived volumes. CWD biomass at the cut plots increased after the harvest, but decreased to nearly pre-harvest levels by 2006. The cut site volume remained static from 1999 through 2006. After the harvest in 2001, the volume in lower decay classes increased, while the volume in more decayed classes decreased. Between and 2001 and 2006, the distribution of decay classes at the cut site has approached pre-harvest levels, however, there is still more volume in less decayed classes. The control site had less initial WD volume and biomass. The control pool has consistently increased in volume and biomass in all survey years. We used a linear regression model to estimate CWD respiration for 2003 through 2006 based on decay class biomass and site-specific hourly air temperatures. At both sites the estimated CWD pool was larger than the measured pool in 2006. Fragmentation and leaching accounts for this difference. The larger difference at the control site suggests more fragmentation and leaching. CWD respiration was higher at the cut site than at the control site, but increased from year to year at both sites. Selective harvest related changes in WD pool dynamics have important implications for forest management and global C dynamics.

Post-Settlement Forest Dynamics of a Central New England Basin Examined by Pollen, Tree Ring, and Historically Documented Records. Harvard Forest, Petersham, MA

Alex Ireland

The processes by which forest composition changes through time are often linked to and altered by humans. In keeping with the tradition of land use history oriented ecology research at Harvard Forest, long term vegetation dynamics of an understudied basin were examined by palynology, dendrochronology, plot sampling, and historical document analysis. French Road Pond basin is situated within Prospect Hill Compartment 10 which came under university ownership in 1992, nearly ninety years later than the majority of Harvard Forest property. As a result, relatively little work has occurred in this area. French Road Pond basin under went early settlement, agricultural, and abandonment phases similar to those of most forested central New England landscapes. The combination of techniques employed in this study allowed forest succession to be examined in cultural context and connected to anthropogenic driving forces. Trends in pollen assemblage through time in conjunction with tree ring records bring to light 150 years of forest dynamics which yield maple, ash, and white pine associations on the landscape at present. Site specific post agricultural forest regeneration within FRP basin is attributable not only to site conditions, but also differences in land use and time of abandonment. Small scale land clearance and agriculture within the basin began as early as the late 18th century and continued in the western portion through the early 20th century. The patchwork nature of land abandonment within a relatively small basin has yielded a generally young, yet uneven aged forest. This study has served to increase collective knowledge of localized land use history and resulting forest regeneration which can be compared to similar studies conducted throughout Harvard Forest over the course of the previous century.

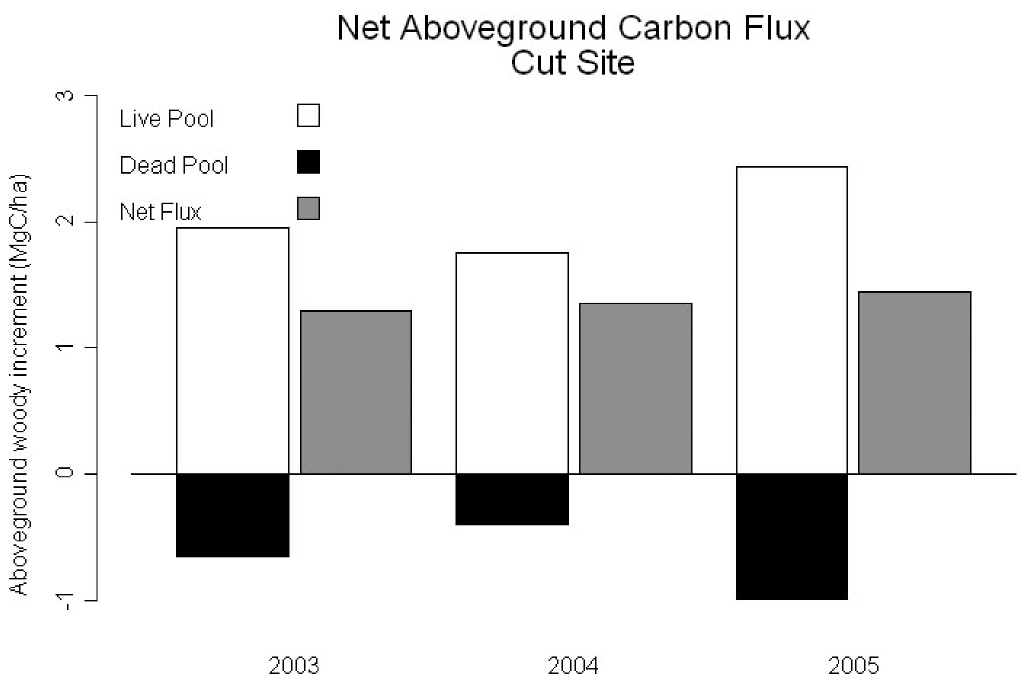
150 Years of Land Use History and Forest Dynamics Within FRP Basin



Evidence for a Carbon Sink in a New England Temperate Forest Five Years after Selective Logging.

Frances O'Donnell

Rising atmospheric carbon dioxide levels are mitigated by carbon sequestration in the terrestrial biosphere, including temperate forests in the northern hemisphere, which are a significant carbon sink. Many of the second-growth mixed hardwood forests that cover large parts of eastern North America are under management plans that include harvesting for economic gain. This study examines the effect of a selective timber harvest typical of the North Quabbin region in North Central Massachusetts on the storage of carbon in woody biomass. We used plot-based biometric measurements to estimate annual fluxes in the live and dead aboveground carbon pools from 2000 through 2005 in a tract of forest that was selectively logged in 2001. As a control, these measurements were compared to analogous biometric measurements done on an adjacent tract of forest in the footprint of an eddy flux covariance measurement site. Annual carbon storage due to tree growth has increased steadily since the harvest. While oak (*Quercus spp.*) dominated net increase in live biomass at both sites, eastern hemlock (*Tsuga canadensis*), American beech (*Fagus grandifolia*), and red maple (*Acer rubrum*), also contributed to biomass increase on the cut site. Carbon uptake by trees less than 30 cm in diameter at breast height was greater on the cut site on both a per area and per tree basis. Our data on annual fluxes in the live and dead carbon pools suggest that the aboveground carbon pool on the cut site was a carbon sink in 2003 through 2005 and increased slightly in net carbon uptake from 1.30 to 1.45 MgC/ha over that period. This was comparable to the magnitude of uptake on the control site, which had a three-year mean of 1.39 MgC/ha but was more variable because of the episodic nature of mortality on this site.



Below Ground Root Biomass Response to Soil Warming

Rebecca Orozco

The Intergovernmental Panel of Climate Change predicts soil temperatures to increase between 1.5°C and 5.8°C for the New England Region by the end of the century, due to the rapidly increasing levels of greenhouse gases. Soil dynamics such as root respiration and microbial activity are important in understanding climate change because soil is the largest terrestrial carbon pool. To better understand the implications of increased soil temperatures, a large scale soil warming experiment was begun at the Barre Woods experimental site at Harvard Forest in 2003. This experimental site consists of two "megaplots," one control and one heated, each 30m x 30m. The heated plot contains heating cables buried 10cm deep and 20cm apart that heat the soil 5°C above ambient soil temperatures. These plots, which are large enough to contain entire tree and herbaceous root networks, enable us to investigate whether increased nitrogen availability, due to warming alters carbon allocation between above ground and below ground biomass. To address this question, an estimate of the live fine roots, which are responsible for obtaining nutrients from the soil and respiring, were extracted from the organic layer of soil cores by flotation. Roots were then sorted into <1mm, 1-2mm, 2-3mm, and >3mm, size categories and dead or alive. After 24 hours at 105°C in a drying oven, each sample was weighed. Samples processed in June suggested the heated plot contained significantly fewer live roots than the control. However, samples collected in July had no significant difference between the two treatments and an overall lower root biomass than observed in June (Figure 1). These findings correlate with other studies in which root biomass varied throughout the growing season. Therefore, sampling for an entire growing season will enable us to obtain a more accurate estimate of the live fine roots and thus a greater understanding of increased soil temperatures on root biomass.

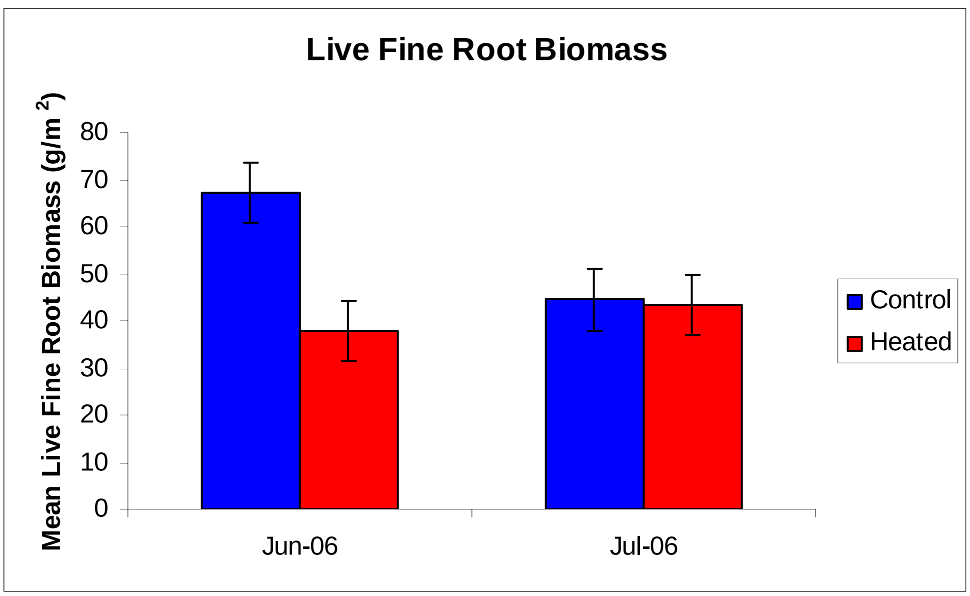


Figure 1. The mean live fine root biomass was significantly different in June between heated and control, but there was no difference between the two treatments in July. In addition, July had an overall lower root biomass than was observed in June.

Ants and Soil Respiration in a Hemlock Removal Experiment at the Harvard Forest

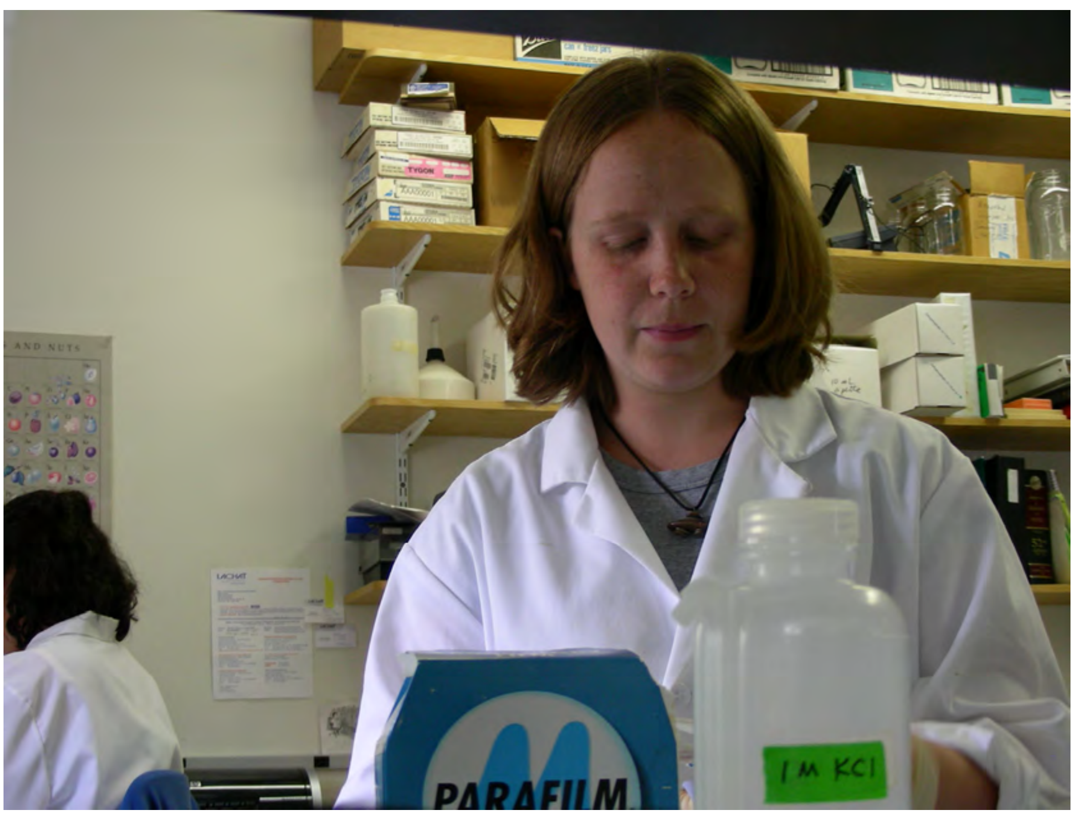
Rachel Osborn

Although Edward O. Wilson claims that "ants are the little things that run the world", we understand very little about how exactly ants or other soil-dwelling invertebrates influence ecosystem processes. Some work has suggested that ants may increase the production of carbon dioxide in the soil by aerating it, as well as moving organic matter and nutrients and encouraging plant and fungus growth. However, we do not understand how their roles will change as the eastern hemlock disappears from western Massachusetts because of invasion from the hemlock woolly adelgid and preemptive logging In order to determine what influence ants have on soil respiration in our changing landscape, we installed two 2× 2-m ant enclosures, disturbance controls and control plots in each of the eight large plots (hemlock control, hardwood control, girdled and logged plots) of the Hemlock Removal Experiment at the Simes tract at the Harvard Forest, Petersham, MA. We placed two pitfall traps in each plot and took three samples over the course of the summer to test if the ant enclosures are successful in excluding the ants. We measured the soil respiration in each plot once every two weeks using an Infra Red Gas Analyzer (IRGA) Licor model LI-6252. Although the exclosures, disturbance controls and controls did not have a significant effect on the overall abundance of ants in the plots, none of the most common soil-dwelling ants (*Aphaenogaster rudis, Camponotus pennsylvanicus Lasius alienus and Lasius umbratus*) were found in the exclosures during August. The production of CO_2 in the soil did not change across the four larger canopy manipulations or the exclosure treatments. However, it is likely that the experiment needs to continue for several more years before it any trends can be determined. Future research needs to be done on the abundance and distance of ant nests from the plots in order to determine if active nests influence soil respiration.

The Effectiveness of Chemically Treating Eastern Hemlock Trees to Fight Hemlock Woolly Adelgid Infestations

Christy Rollinson

Hemlock woolly adelgid (HWA) is an invasive pest from Japan that threatens many populations of eastern hemlock. As HWA infestation has become widespread and more severe, many efforts have been made to help stop the devastation and possible elimination of eastern hemlock trees in infested areas. Although there have been several attempts at biological control, chemicals are currently the most effective form of HWA management. These chemicals are either applied topically to infested foliage or systemically to the soil and roots or injected directly into the trunk. For this study, three sites in Massachusetts and one in Connecticut that have been treated using different methods were surveyed for treatment impact on HWA populations. At each site, both treated and nearby untreated trees were assessed for overall health and HWA infestation levels. Measures of tree health included vigor, transparency, density, and live crown ratio. Eight branch tips on each tree were examined for presence and degree of infestation of HWA and amount of new growth by the tree. At all four sites, chemical treatments were successful in keeping HWA infestations lower than on surrounding, untreated trees. The effects of treatments on overall tree health were not uniform. In sites with heavy infestations, treated trees exhibit much better health than their untreated counterparts. In these cases, treated trees tended to have much better vigor, transparency and new growth scores. In areas with more mild infestations, there is little visual difference in health between treated and untreated trees. Although the reasons for the lower infestation at these sites is unclear, it may indicate that these areas do not need to be as aggressively treated as sites that have much higher levels of infestation.



Do Increases in Light Intensity Following the Hemlock Woolly Adelgid Invasion Alter Stream Temperature and Periphyton Growth?

Tim Rowell

Hemlock woolly adelgid (HWA), an invasive insect from Asia that infests and kills eastern hemlock, continues to spread throughout the eastern United States causing hemlock forests to be replaced by deciduous forests. Many streams in the northeastern United States have riparian forests that are dominated by hemlock and may be impacted by the HWA. Previous research has documented low light levels reaching hemlock dominated streams, and these stream light regimes will likely be augmented following the HWA invasion. The primary objective of this study was to quantify differences in photosynthetically active radiation (PAR) reaching streams with healthy hemlock, infested hemlock, dead hemlock, and deciduous riparian zones. The secondary objective was to relate changes in stream light regimes to changes in stream temperature and periphyton (i.e., benthic algae) growth. PAR measurements were taken along stream reaches with riparian zones of healthy hemlock, infested hemlock, dead hemlock, and deciduous trees in Massachusetts and Connecticut. Stream temperature was recorded every thirty minutes for several weeks, and ceramic tiles were incubated in stream for periphyton colonization. PAR levels reaching the streams were found to be highest in streams with riparian zones of dead hemlock, followed by deciduous trees, infested hemlock, and finally healthy hemlock. Daily water temperature fluctuations were higher in deciduous stream reaches than in hemlock stream reaches, while temperature patterns in recently infested hemlock streams were not greatly altered. Periphyton biomass in a deciduous stream reach and an infested hemlock stream reach was markedly higher than in a healthy hemlock stream reach, however variation in periphyton biomass among streams implies that there are other factors besides PAR limiting periphyton growth in headwater streams. Changes in stream thermal regimes and periphyton biomass following the HWA infestation may significantly affect important stream functions such as nutrient retention and food availability

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Developmental Plasticity in the Hydraulic Properties of *Quercus rubra* Leaves

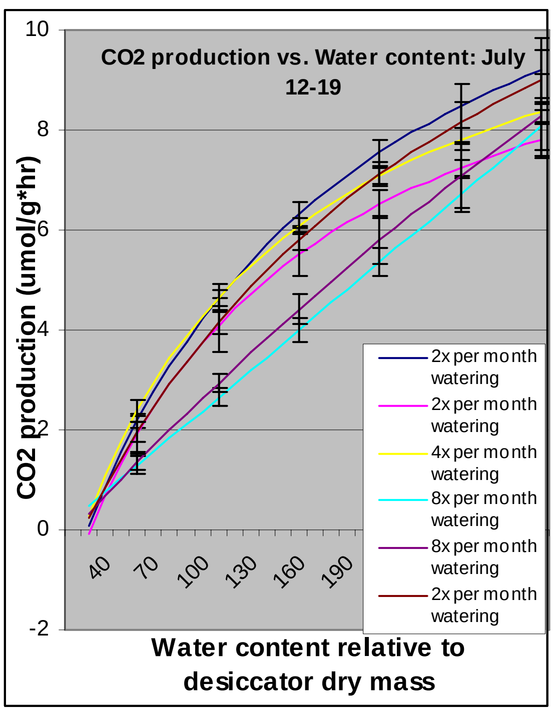
Kaya Schmandt

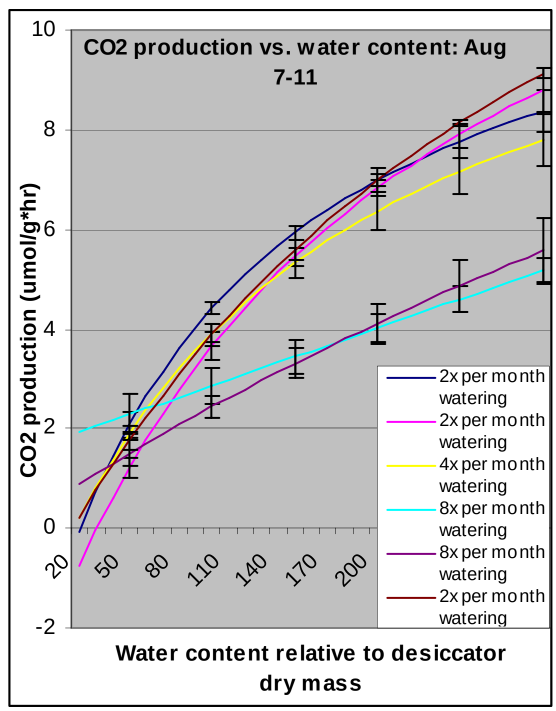
Water transport systems form a major component of a plant's carbon allocation, indicating that water supply occurs at a substantial resource cost. This raises the possibility that plants may modify their hydraulic investments based on their water status during development. Although a hydraulic system tailored to the specific environmental conditions experienced during a given growing season is beneficial if these conditions persist, too much sensitivity to current water availability puts plants at risk to changing conditions later in the year. Taking advantage of a particularly wet growing season, we compared *Quercus rubra*'s response to water stress in 2006 with data collected in 2003. We focused on the hydraulic properties of leaves because they form the key interface between liquid- and vapor-phase transport and thus play a critical role in linking stomatal and xylem function. We studied leaves' abilities to retain their hydraulic conductance at negative water potentials, as such resilience allows plants to photosynthesize efficiently in conditions with limited water availability and indicates how effectively they are able to function during drought. We calculated leaf hydraulic conductance (K_{leaf}) based on the speed with which leaves rehydrate, an approach that allowed us to estimate K_{leaf} across a broad range of leaf water potentials. We found that leaves in 2006 cavitated at less negative water potentials than those from 2003, suggesting that leaves respond to abundant water during development by investing fewer resources in their hydraulic systems. This relatively high degree of plasticity suggests that the cost of building a resilient hydraulic system may outweigh the risks associated with potential losses in carbon uptake should drought subsequently occur.

High Watering Frequency of Leaf Litter Causes a Relative Loss of Carbon Available to Decomposition.

Stephanie Searle

Recently fallen leaf litter composes the top layer of the soil column and is important to the carbon budget of forest ecosystems. Temperature and moisture have been shown to have important effects on respiration (CO_2 production) from the O horizon of the soil. In this experiment, we show that frequency, and less importantly, size of precipitation events affects respiration and loss of easily decomposable carbon in leaf litter. Six groups of four samples each were given irrigation treatments of varying frequency and size over a period of 8 weeks, and periodically measured for carbon dioxide increase. Dry weights for the leaf litter were obtained at the beginning and end of the experiment and compared to determine total carbon loss over the course of the experiment. An additional experiment was conducted to investigate the effect of temperature on leaf litter respiration. Over a temperature range of 13 to 36 ^{o}C, CO_2 production increased exponentially with temperature. The Q_{10} for CO_2 production decreased from 3.66 at a leaf litter moisture content of 39 % to 2.04 at a moisture content of 266 %. Using these relationships, we were able to correct our respiration measurements with respect to an air temperature of 25 ^{o}C. Leaf litter respiration usually followed a Michaelis-Menten relationship with respiration increasing more slowly with moisture content as moisture content increased. Unlike the infrequently irrigated samples, the frequently irrigated samples respired more slowly at high water contents at the end of the experiment than during earlier measurements, implying that the pool of easily decomposable carbon had been diminished relative to other treatments. Our results show that precipitation changes in the future may affect carbon cycling between leaf litter and the atmosphere.





Preferred Microenvironments for Tree Regeneration: Pit-Mound vs. Non-Pit-Mound

Brynne Simmons

When hurricane winds come in contact with forests, the results can appear catastrophic. Hurricanes play a major part in forest successional patterns in New England, causing trees to uproot or snap. In addition, these trees fall on and damage other trees. Uprooted trees create pit and mound microsites. After a hurricane, the forest canopy opens and more light is allowed to enter the forest floor. The extra light, plus the mineral soil exposed on pit and mound microsites, provide plenty of resources for seedlings and saplings to establish and grow. Pit and mound microsites may influence future species composition in hurricane damaged forests. I studied whether the number and species composition of seedlings and saplings found growing on the pit and mound microsites differed from undisturbed microsites.

In this experiment, pit and mound and undisturbed ground microsites were studied in two sites damaged by the severe 1938 hurricane, and two sites that were pulled down in 1989 and 1990 to simulate the 1938 hurricane. Each damaged site was paired with an undamaged control. Total area of each environment sampled was equal. Seedling and sapling diameter, and height were measured, and substrate was recorded. Fifteen species of saplings and seedlings were found across the study sites. Of the 487 seedlings and saplings measured for this project, 24% were saplings, whereas 76% were seedlings. Of the seedlings, 37% were first year germinants.

Overall, birches and maples preferred pit-mound microenvironments. Pines preferred the non-damaged microenvironments to regenerate (Figure 1).

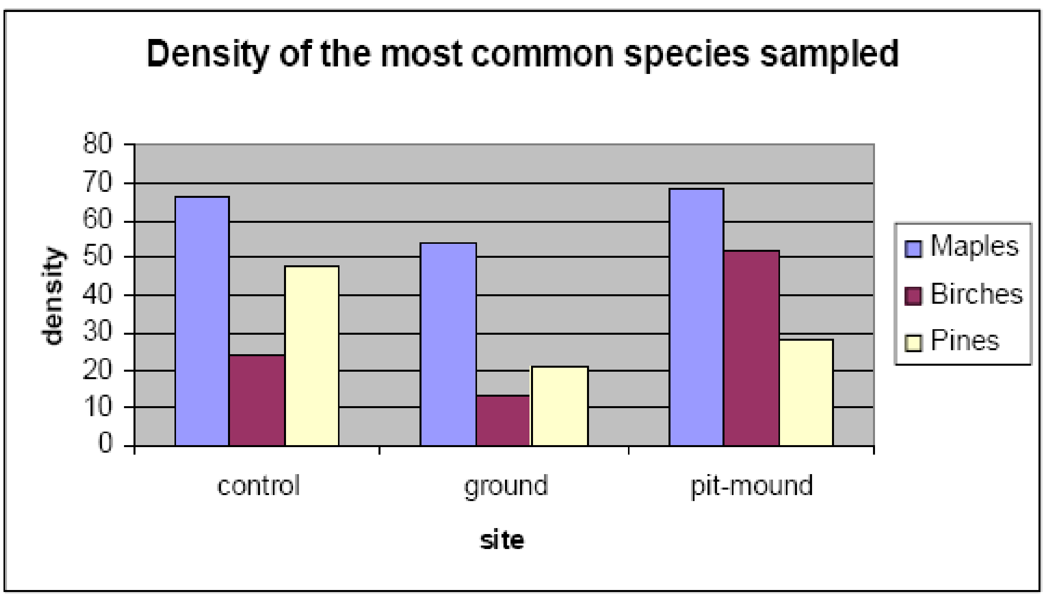


Figure 1. Birches strongly preferred pit-mound microsites. Maples and pines preferred pit and mounds to ground within damaged sites, but were also common in the undamaged controls.

Hemlock Woolly Adelgid Damage Along Headwater Stream Corridors in Central Connecticut and Massachusetts

Lori Simpers

This project focused on locating suitable study sites that will be used to determine the impact of hemlock woolly adelgid (HWA) damage and the death of riparian hemlock trees on headwater stream ecosystems. HWA is a widely-studied invasive pest that has been killing hemlock trees in the New England area, but the effects of hemlock mortality along stream corridors and coupled downstream ecosystems is largely unknown. This research was part of a larger project examining the physical and chemical changes in stream systems during and following hemlock decline. The purpose of this project was to identify severely impacted stream systems in Connecticut and Massachusetts for further detailed study. Damaged sites were identified using aerial photography and ArcView GIS with overlays of hemlock dominance and mortality. Potential sites were identified based on certain criteria and then visited in the field to determine suitability for further study. Severe hemlock mortality was observed in upland areas in Southern Connecticut, but there was surprisingly little HWA damage along stream riparian zones. Large stands of healthy hemlock remained in Connecticut and Massachusetts and there were usually some living hemlock trees in the riparian zones of even the most impacted streams. A large majority of damaged forests also had a considerable amount of deciduous trees that may mitigate the impact of hemlock mortality.

As a result, certain physical and chemical changes in the aquatic ecosystem due to hemlock death, such as changes in the light and temperature regime, may not be as severe in a mixed forest as it would if the riparian zone was entirely composed of dying hemlock trees. Streams in Devil's Hopyard State Park in Connecticut represent the best candidate sites for future study of damaged headwater streams. Based on the initial observations of this study, it seems likely that aquatic ecosystems will be impacted more slowly than upland forest ecosystems by HWA damage and the resulting hemlock mortality.

Summer Organic Matter Budget for a Hemlock Dominated Stream

Safina Singh

Construction of stream organic matter budgets allows: 1) comparison of streams having different carbon dynamics and watershed characteristics; 2) calculation of losses of carbon from watershed to downstream ecosystems; 3) additional carbon loss terms to be incorporated into forest carbon budgets; and 4) quantification of ecosystem impacts following forest disturbances (e.g., hemlock woolly adelgid invasion). The objectives of the study were to construct a summer carbon budget for a hemlock dominated stream, and to explore relationships between physical variables, such as stream discharge, and water chemistry. The study was conducted in a headwater stream (Bigelow Brook West) located on the Prospect Hill Tract of Harvard Forest in Petersham, Massachusetts. We constructed an organic matter budget for a 400 m stream reach that is dominated by hemlock and has a well characterized hydrological regime. A stream survey was conducted to assess important physical characteristics including stream area, habitat types, substrate types and surrounding riparian conditions. Water temperature, dissolved oxygen, pH, dissolved carbon dioxide, colored dissolved organic matter, stream depth and turbidity were measured continuously *in situ*. In addition, water samples were collected for analysis of nitrate (NO3-), ammonium (NH4+) and phosphate (PO4+) ions; and dissolved organic and inorganic carbon. Stream discharge was estimated using continuous depth measurements, and it was incorporated into existing hydrological model. Summer data collection enabled us to estimate many important organic carbon inputs (e.g., gross primary production), standing stocks (e.g., wood), and exports (e.g., dissolved organic matter). Some important findings were: 1) marked diurnal variation in discharge (Figure 1); 2) rapid storm response of stream discharge (Figure 1); 3) dissolved organic matter increases with storm events; 4) low primary production; 5) respiration (23.5 µg C m-2 day-1) greatly exceeds primary production (6.9 µg C m-2 day-1); and 6) dissolved organic matter (590 g C day-1) dominates organic matter export. In order to produce an annual stream organic matter budget similar seasonal budgets must be constructed for the fall, winter and spring seasons.

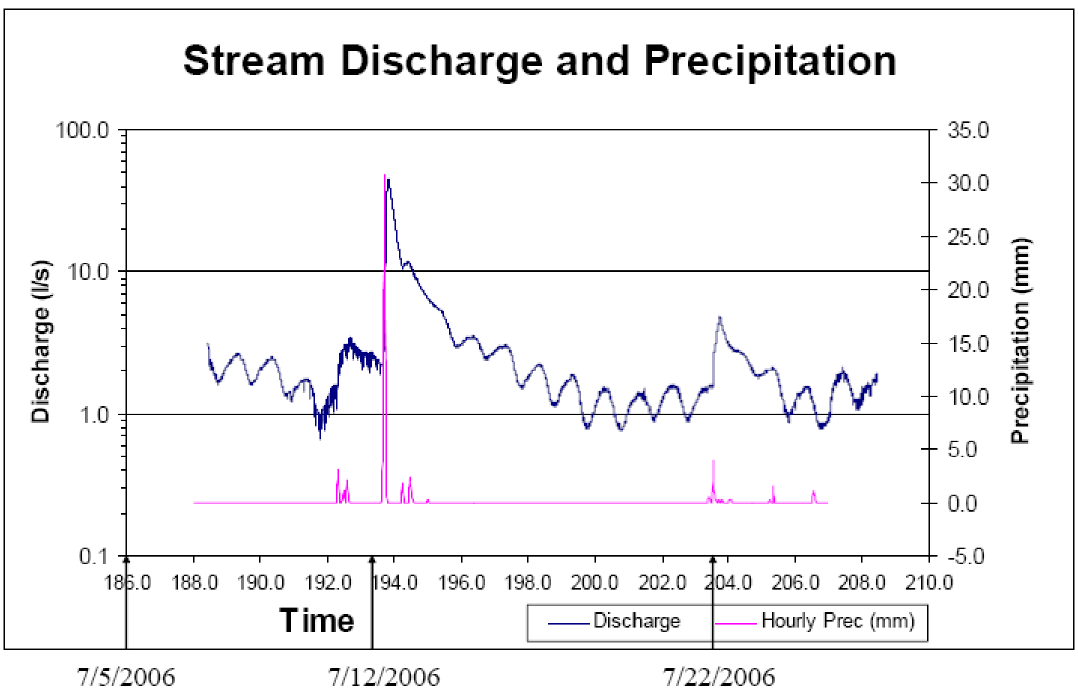


Figure 1. Marked diurnal variations and rapid responses of stream discharge to storm events.

Investigating the Interactions between Garlic Mustard and Ectomycorrhizal Fungi

Rachel Stahr

Garlic mustard, *Alliaria petiolata* is an invasive plant commonly found in forest understories in North America. Previous research has shown that GM inhibits arbuscular mycorrhizal fungi, root symbionts of herbaceous plants and some trees. In this study, we examine the interactions between ectomycorrhizal fungi (ECM), symbionts of conifers and other trees, and GM in the field and greenhouse. In the field, soil cores were taken from three different forests in areas with and without GM. At two of the forests, there was significantly lower ECM root tip biomass found in cores taken from areas with GM. Soils cores were also taken in and around GM patches to observe differences in root tip abundance with different GM densities, and we are currently analyzing these cores. To determine if GM affects ECM root tip establishment on tree seedlings, we experimentally invaded soils with GM, the native herb *Impatiens capensis*, as well as with no plant in the greenhouse. Pine, *Pinus strobus* seedlings were planted in the soils and root tips from the seedlings will be counted in several months. To compare GM with native mustards, a pine seedling and either *Arabis canadensis*, GM, or nothing will be grown in clear chambers to view the interactions between the mustard and the ECM. In the laboratory, the effects of root exudates of GM and native mustards will be assessed by growing fungi on different agars containing exudates from different mustards. Our preliminary results show that GM may inhibit the abundance of ECM, but the strength and implications of these effects are currently unknown. These experiments are beginning to elucidate the impacts of GM on ECM and may aid to understand the broader impacts of GM on forest ecosystems.

Chronic Nitrogen Additions Affect Aboveground Sporocarp Diversity in Hardwood Stand

Chelsea Vario

Studies in Europe and Alaska have shown that elevated levels of nitrogen deposition affect diverse fungal communities, which play an important role in the forest ecosystem by recycling organic matter and supporting symbiotic relationships with trees. In the Northeastern U.S., forests experience the highest levels of nitrogen deposition in the country; however, little is known about the consequences of such nitrogen additions with respect to fungal communities. This study utilized nine subplots within the long-term Chronic Nitrogen Addition Study at Harvard Forest in Petersham, MA to monitor the growth of aboveground fruiting bodies during the summer of 2006. The abundance of ectomycchorizal sporocarps was expected to decrease with increased nitrogen saturation of the soil. At the experimental site, two 30 x 30 m plots have been amended with low and high levels of nitrogen since 1986, and an adjacent control plot serves as reference to a healthy forest. The low nitrogen treatment receives 5 g N m-2yr-1 in the form of NH4NO3 (ammonium nitrate) and the high nitrogen treatment receives 15 g N m-2yr-1. Three 5 x 5 m subplots in each treatment were randomly selected for this sporocarp study. Once a week for six weeks, every mushroom on each subplot was collected for identification. Statistical analysis showed a significant decrease in the number of ectomycchorizal sporocarps across the nitrogen gradient. These findings support the hypothesis that trees growing in nitrogen saturated soil need not utilize a symbiotic relationship with belowground ectomycchorizal fungi. Saprotrophic species also showed sensitivity to nitrogen saturation, such as *Marasmius capillaris* whose abundance significantly decreased with increasing nitrogen. These results confirm the vulnerability of fungal communities under conditions of elevated nitrogen deposition.

Garlic Mustard Population Demographics Differ among Forest Habitats at the Harvard Forest LTER.

Jessica Megan Woltz

Invasive species can severely affect ecosystems by displacing natives, disrupting trophic interactions, and altering natural processes such as nutrient cycles. Garlic mustard (*Alliaria petiolata*), an invasive biennial plant that ranges over much of the Northeastern and Midwestern US, is known to invade a vast range of habitat types. This experiment investigated garlic mustard population dynamics in forest edge, intermediate, and understory habitats at the Harvard Forest LTER. We predicted that only the edge populations would be self-sustaining. We monitored garlic mustard populations in three study sites, each consisting of contiguous forest edge, intermediate and understory habitats that had been invaded with garlic mustard prior to our study. Twice per summer from 2003 to 2006, we counted all garlic mustard individuals within 10 1 m2 quadrats placed in each habitat within each site. This census data was used to construct population matrices for each full garlic mustard life cycle in each habitat, for a total of 9 matrices. Using MatLab computer software, we calculated population growth rates (λ) and sensitivity values for each matrix. Sensitivity values measure how much a change in a given matrix element will affect λ. The edge populations were increasing over all three time periods, while the intermediate populations were decreasing over all three time periods. The understory populations, which were initially increasing, decreased over the last time period. These results indicate that only the edge populations are self-sustaining, and may in fact be supplying individuals to the other populations. Also, in all 9 matrices, the transition from rosette to adult had the greatest sensitivity, indicating that changes to this transition would have the greatest impact on λ. Our results suggest that management efforts should be focused on populations in edge habitats and on reducing over-winter survival of rosettes to achieve maximum management efficacy.

2006 STUDENT SUMMER PROGRAM
SEMINARS AND WORKSHOPS

June 5th	Seminar 1. Land-use History	David Foster
June 7th	Seminar 2. Plant Identification	Glenn Motzkin & John O'Keefe
June 16th	Harvard University Field Trip	Kathleen Donohue
June 19th	Seminar 3. Carbon Cycling	Steven Wofsy
June 21st	Seminar 4. Old Growth Forests	Tony D'Amato
June 26th	Student Mid Summer Presentations	REUs
June 28th	Student Mid Summer Presentations	REUs
July 10th & 11th	Institute of Ecosystems Studies in Millbrook, NY	
July 17th	Quabbin Field Trip	John Burk
July 19th	Seminar 5. Graduate School Panel	Jess Butler, Tony D'Amato, David Kittredge & Wyatt Oswald
July 24th	Seminar 6. Ethics	John Drake
July 25th	Seminar 7. Ethics Panel	Elizabeth Farnsworth, John Drake & Jerrold Meyer
July 27th	Seminar 8. Scientific Presentation	David Orwig
August 2nd	Seminar 9. Writing an Abstract	Kristina Stinson
August 17th	Summer Research Symposium	REUs

PERSONNEL AT THE HARVARD FOREST - 2006

Audrey Barker Plotkin	Site and Research Coordinator
Hormoz BassiriRad	Bullard Fellow
James Bever	Bullard Fellow
Emery Boose	Information & Computer System Manager
Jeannette Bowlen	Accountant
John Burk	Research Assistant
Posy Busby	Master Student
Jessica Butler	Research Assistant
Laurie Chiasson	Financial Assistant/Receptionist
Elizabeth Colburn	Aquatic Ecologist
Eowyn Connolly-Brown	Research Intern
Sheila Connor	Archivist
Brian DeGasperis	Master Student
Elaine Doughty	Research Assistant
Edythe Ellin	Director of Administration
Aaron Ellison	Senior Ecologist
Ed Faison	Master Student
Elizabeth Farnsworth	Bullard Fellow
Adrien Finzi	Bullard Fellow
Christian Foster	Research Intern
David Foster	Director
Sheri Fritz	Bullard Fellow
Lucas Griffith	Maintenance Technician
Julian Hadley	Ecophysiologist
Brian Hall	Research Assistant
Linda Hampson	Staff Assistant
Amber Jarvenpaa	Summer Assistant Cook
Demetrios Karagatzides	Post-doctoral Fellow
David Kittredge	Forest Policy Analyst
Paul Kuzeja	Maintenance Technician
Oscar Lacwasan	Maintenance Technician
James Levitt	Director, Program on Conservation Innovation
Heidi Lux	Research Assistant
Brooks Mathewson	Master Student
John McDonald	Bullard Fellow
Robert McDonald	Post-doctoral Fellow
Jacqueline Mohan	Post-doctoral Fellow
Glenn Motzkin	Plant Ecologist
John O'Keefe	Museum Coordinator
David Orwig	Forest Ecologist
Wyatt Oswald	Paeloecology Lab Coordinator
Julie Pallant	System and Web Administrator
Scott Pearson	Bullard Fellow
Michael Scott	Maintenance Technician
Richard Schulhof	Research Assistant
Judy Shaw	Building Services Assistant
Sabrina Smith	Administrative Intern
Pamela Snow	Environmental Educator
Kristina Stinson	Population Ecologist
Travis Stolgitis	Maintenance Technician
P. Barry Tomlinson	E.C. Jeffrey Professor of Biology, *Emeritus*
Judith Warnement	Librarian
John Wisnewski	Maintenance Technician
Tim Zima	Summer Cook

Harvard University Affiliates

John Budney	Div. Engineering & Applied Sciences
Dan Curran	Div. Engineering & Applied Sciences
Peter del Tredici	Arnold Arboretum
Kathleen Donohue	Organismic & Evolutionary Biology
Richard T.T. Forman	Graduate School of Design
Charles H.W. Foster	JFK School of Government
N. Michelle Holbrook	Organismic & Evolutionary Biology
Kathryn McKain	Div. Engineering & Applied Sciences
Paul Moorcroft	Organismic & Evolutionary Biology
William Munger	Div. Engineering & Applied Sciences
Steven Wofsy	Div. Engineering & Applied Sciences
Maciej Zwienicki	Arnold Arboretum

The Institute of Ecosystem Studies

A FORUM ON OPPORTUNITIES IN ECOLOGY

Tuesday, July 11, 2006
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
- Museums
- Activism
- Urban Planning
- Conservation

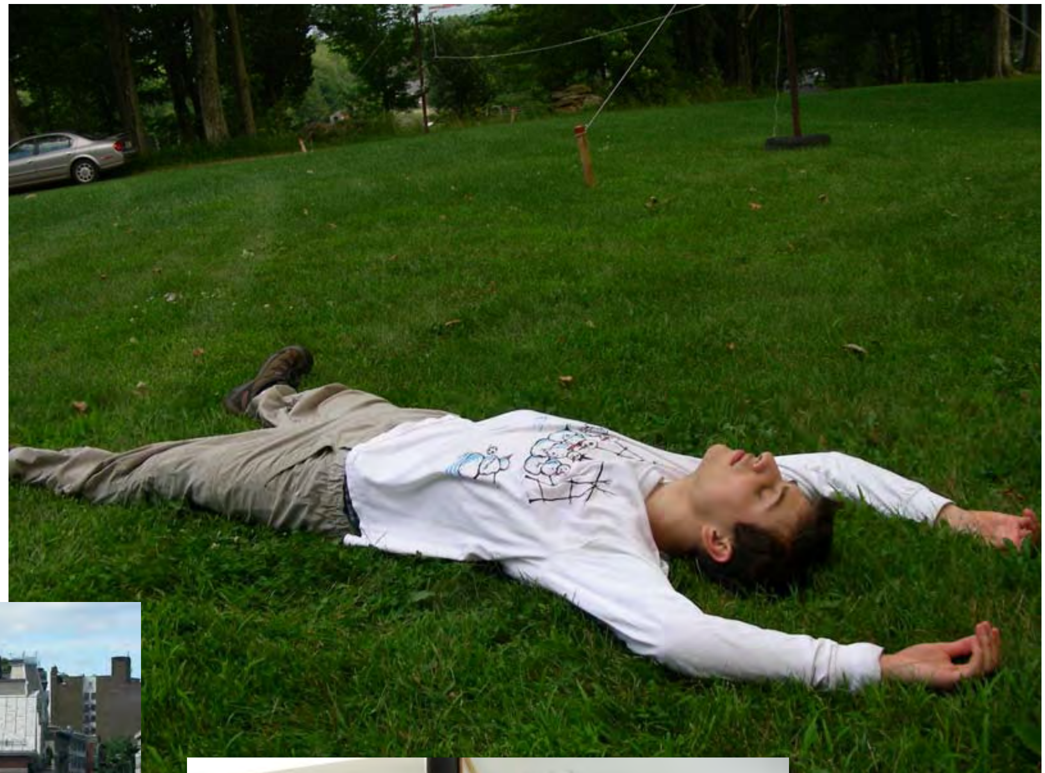
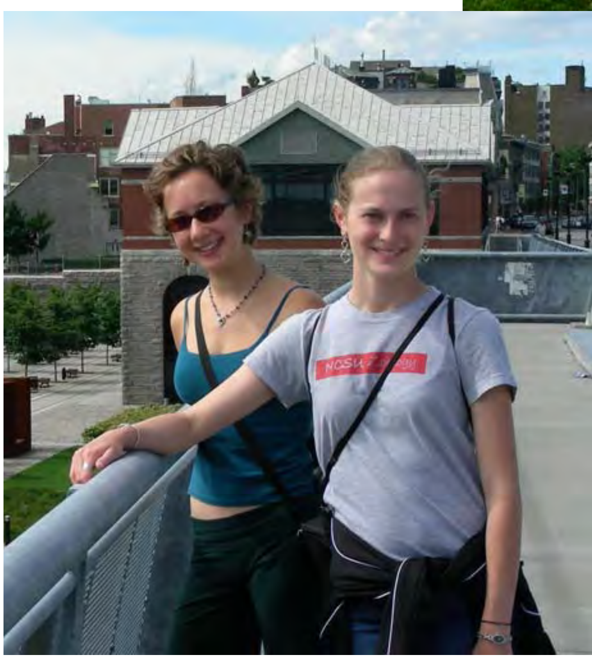
In the morning session (9:30 a.m. - 12:30 p.m.), speakers representing each field will discuss the rewards and motivations involved in their work.

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, REU Program Coordinator at* (845) 677-7600 x326. 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
www.ecostudies.org/reu.html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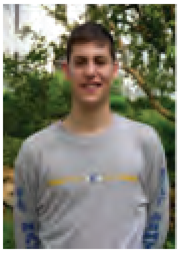
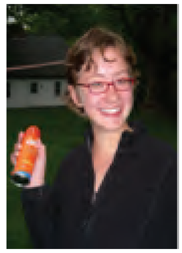
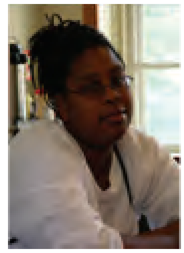


Alex Arguello

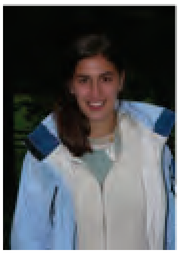
Alex Ireland



Alison Grantham

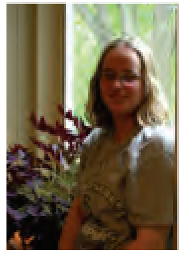


Brynne Simmons



Chelsea Vario

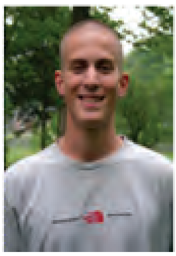
Christy Rollinson



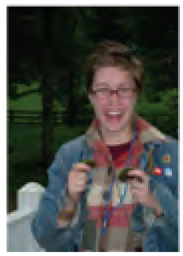
Frances O'Donnell

Justin Frisino

Kaya Schmandt



Kevin Burls



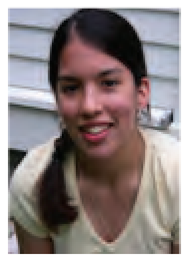
Laura Briscoe

Lori Simpers

Megan Woltz

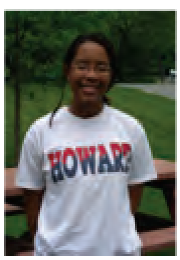
Rachel Osborn

Rachel Stahr



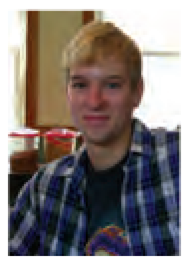
Rebecca Orozco

Safina Singh

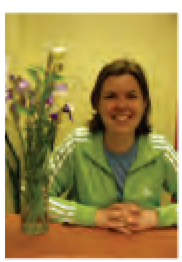


Stephanie Day

Stephanie Searle



Timothy Rowell



Hilary Crowell