HARVARD FOREST
HARVARD UNIVERSITY

2009 SUMMER RESEARCH PROGRAM IN ECOLOGY

The Harvard Forest Summer Student Research program attracts a diverse group of students to receive training in scientific investigations and experience in long-term ecological research. All students worked closely with researchers while many conducted their own independent studies. Students presented major results of their work at the Annual Summer Student Research Symposium

SYMPOSIUM ABSTRACTS
13 AUGUST 2009

17TH ANNUAL HARVARD FOREST SUMMER RESEARCH PROGRAM

13 August 2009

HARVARD FOREST
FISHER MUSEUM

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Photography by Larisa Proulx, Harvard Forest Staff and 2009 Summer Program Participants

INTRODUCTION TO THE HARVARD FOREST

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

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

Administratively, the Harvard Forest is a department of the Faculty of Arts and Sciences (FAS) of Harvard University. Faculty associated with the Forest offer courses through the Department of Organismic and Evolutionary Biology (OEB), the Harvard Kennedy School (HKS), and the Freshman Seminar Program. Close association is also maintained with the Department of Earth and Planetary Sciences (EPS), the School of Public Health (SPH), and the Graduate School of Design (GSD) at Harvard and with the Departments of Biology, Natural Resource Conservation, and Computer Science at the University of Massachusetts, the Ecosystems Center of the Marine Biological Laboratory and the Complex Systems Research Center at the University of New Hampshire.

The staff and visiting faculty of approximately fifty work collaboratively to achieve the research, educational, and management objectives of the Harvard Forest. A management group meets monthly to discuss current activities and to plan future programs. Regular meetings with the HF-LTER science team, weekly research seminars and lab discussions, and an annual ecology symposium provide for an infusion of outside perspectives. The six-member Facilities Crew under take forest management and physical plant activities. Funding for Harvard Forest operations is derived from endowments, whereas major research support comes primarily from federal and state agencies (e.g., National Science Foundation, Department of Energy, Commonwealth of Massachusetts Department of Conservation and Recreation), private foundations, and individuals.

The Harvard Forest Summer Student Research program, coordinated by Edythe Ellin and assisted by Larisa Proulx, 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
2009

17TH ANNUAL HARVARD FOREST SUMMER RESEARCH PROGRAM SYMPOSIUM

13 AUGUST 2009 FISHER MUSEUM 8:45 a.m. – 5:15 p.m.

Aaron Ellison			Welcome

Session I: Conservation and Management (Brian Hall, Moderator)

Danica Doroski	Bates College	Hall & Foster	Factors Driving Species Diversity in Three Vegetation Layers of New England Forest
Michael Lawrence	University of British Columbia – Vancouver	Hall & Foster	Transitional Tree Composition Trends of New England Forests
Bryant Dossman	Bowdoin College	Warren	Urbanization and Nest-Site Preference of Two Cavity Nesting Bird Species: Yellow-Bellied Sapsucker (*Sphyrapicus varius*) and Red Bellied Woodpecker (*Melanerpes carolinus*)
Danielle Bushey	University of Massachusetts	Warren	Urbanization and its Effect on the Feeding Rates in Red-Bellied and Downy Woodpeckers
Cristina Subt	University of Texas at El Paso	Kittredge	Land Owner Decision Monitoring Over Long Term Displays Trends in Acreage Parcelization
Dunbar Carpenter	Harvard University	Thompson	Biomass Energy and a Changing Forest Landscape: Modeling the Effects of Intensified Harvesting of Massachusetts' Forests for Biomass Energy Production
Eliza Ledwell	University of Maryland, Baltimore County	Fitzpatrick	Forecasting Potential Habitat of *Tsuga canadensis* under Climate Change using Bioclimatic Envelope Models

Session II: Hemlock and the Hemlock Woolly Adelgid (Matt Fitzpatrick, Moderator)

Adriana Marroquin	Emerson College	Oswald	Long-term History of Hemlock in Western Massachusetts
Brendan Gallagher	Dickinson College	Orwig, Barker Plotkin & Foster	A 20 Year Study of Vegetation Dynamics in a Virgin Hemlock Forest in Southern New Hampshire
Margaret Wagner	University of Michigan	Orwig, Barker Plotkin & Foster	Mortality, Coarse Woody Debris, and Nutrient Cycling over 20 Years in a Virgin Hemlock-Hardwood Forest in New Hampshire
Tawny Virgilio	Westfield State College	Orwig & Lux	The Use of Mixed-Bead Resins to Determine the Effect of Two Invasive Insects on Throughfall Nitrogen Dynamics Under Eastern Hemlock (*Tsuga canadensis L.*)
Jenna Turner	University of Rhode Island	Fitzpatrick	Stratified Dispersion: Tracking Long-distance Wind and Insect Dispersal Events in the Forest Understory

Session III: Organism, Microcosm, Mesocosm, Megacosm & Metacosm (Clarisse Hart, Moderator)

Jennifer Levye	Harvard University	Wheeler & Holbrook	Sectional Variations in Sap Flow around the Trunk of Red Oak and Red Maple
Samantha Hilerio	Worcester Polytechnical Institute	Hart & Ellison	The Presence of Spiders Reduces Ant Activity in Bogs
Daniella Rodriguez	Arizona State University	Pelini	Under Warmer Conditions, the Advantage of Improved Foraging is Negated by Increased Mortality in *Aphaenogaster rudis*
Jonathan Chandler	Livingstone College	Pelini	The Relationship between Temperature and Ant Interaction at Harvard Forest
Noelia Aponte	University of Puerto Rico	Hill, Vario & Melillo	Response of Nitrate Reductase Enzyme Activity to Soil Warming in Sapling and Canopy Trees
Megan Bartlett	Harvard University	Richardson	Canopy-level Relationships between Leaf Optical Properties, Photosynthetic Productivity, and Nitrogen Content
Corietta Teshera-Sterne	Mount Holyoke College	Boose, Lerner & Osterweil	A Software Engineering Approach to Scientific Data Provenance
Katie Bennett	Ashburnham-Westminster Reg. School District	Hart & Ellison	Nectar production and anthocyanins in *Sarracenia purpurea* and their resulting effect on prey capture

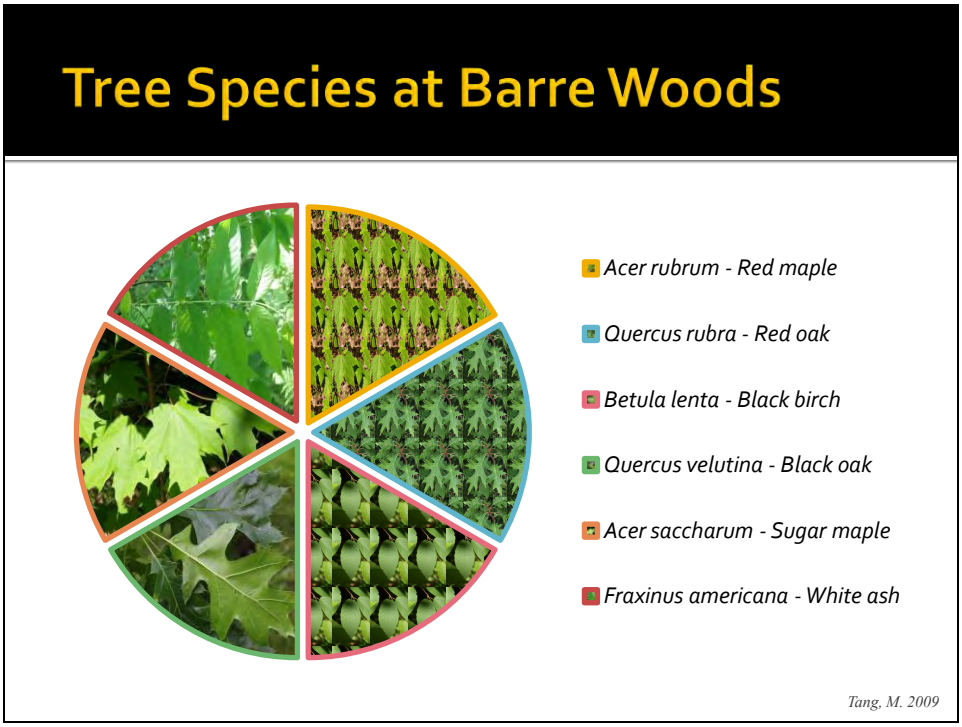
Session IV: Disturbance and Forest Stand Dynamics (Audrey Barker Plotkin, Moderator)

Tamsin Connell	Regis University	Werden & Munger	Changes in Coarse Woody Debris and Fine Woody Debris due to an Ice Storm in Harvard Forest
Alanna Kassarjian	Simmons College	Barker Plotkin	Removing the Eastern Hemlock Influences Overstory Tree Growth
Susan Irizarry	Clemson University	Barker Plotkin	Effects of Experimental Blowdown on *Acer rubrum* Tree Ring Formation and Growth
Jennifer Popham	University of Massachusetts	Faison	Seedling, Sapling & Shrub Composition Influences Browsing Intensity of Ungulates in Massachusetts
Sonia DeYoung	Harvard University	Faison	The Effects of Ungulate Browsing on the Growth of Red Maple and Other Hardwood Species
Sonny Bleicher	Rochester Institute of Technology	Ellison & Ne'eman	Comparing the Effects of Removal of Woody Species and Grazing Along a Rainfall Gradient in Israel
Aaron Ellison			The Tick Talk, and Closing Remarks

Noelia Aponte - University of Puerto Rico

Response of nitrate reductase enzyme activity to soil warming in sapling and canopy trees

Increased net nitrogen mineralization and nitrification with warming has been recorded in an ongoing soil warming experiment at Harvard Forest. This has resulted in an increased amount of nitrogen available to trees in the heated plot. Trees that possess nitrate reductase enzyme activity are capable of absorbing and reducing nitrates. Species with high nitrate reductase enzyme activity could have an advantage in environments with increased nitrate availability. The present study investigated the relative levels of nitrate reductase enzyme activity among the canopy dominant and understory tree species to examine which species are more readily accessing nitrate than others. We also determined the effects of warming on the nitrate reductase activity of the different species in both the understory and overstory. The results of this study will further enhance the understanding of the nitrogen cycle. Leaf tissues of red maple, white ash and oak trees in the overstory and red maple, sugar maple, oak and black birch trees in the understory were assayed for in vivo nitrate reductase enzyme activity. Determination of the nitrate reductase enzyme activity was done via a colorimetric assay and the enzyme activity was quantified based on the $NO^{-}3$concentration found in the leaf tissues. Higher levels of nitrate reductase enzyme activity were measured in the leaves of oaks and black birch trees suggesting that nitrate assimilation was significant in these species. Understory black birch had the overall highest nitrate reductase activity. Warming had varying effects on nitrate reductase activity dependant on species. Black birch increased in nitrate reductase activity with warming, while oak trees decreased in activity.



Megan Bartlett - Harvard University

Leaf and Canopy-level Relationships Between Optical Properties, Photosynthetic Productivity, and Nitrogen Content

Photosynthetic productivity, average foliar nitrogen content, and albedo are significantly positively correlated at the ecosystem level. This project examines the physiological mechanism inducing this ecosystem-level relationship by examining the connections between these parameters at the level of individual leaves, thereby linking physiological and morphological properties to ecosystem processes that impact global carbon, nutrient, and energy cycles. Because heightened nitrogen content enhances photosynthetic capacity, which increases the structural complexity of leaf cell organization, it was hypothesized that higher nitrogen content would induce more cellular light scattering and therefore correlate with light reflectance and transmittance. Nitrogen content, photosynthetic rate, and abaxial and adaxial reflectance and transmittance were measured for single leaves and stacks of 2, 3, 4, 6, 8, and 12 leaves (as simulations of the canopy) for abundant understory and canopy species at Harvard Forest. Abaxial and adaxial comparisons were used to determine the effect of adaxial cuticular waxes and epidermal features on optical properties. A correlation was found between leaf nitrogen content and photosynthetic rate, as hypothesized, but no association was found between nitrogen content and abaxial or adaxial reflectance or transmittance at any stack thickness. No significant differences were found between abaxial and adaxial optical properties, suggesting that in terms of light scattering they are functionally indistinguishable. The canopy-level association between nitrogen content, photosynthetic rate, and albedo therefore does not reflect leaf-level processes, and may instead be caused by nitrogen-induced changes in tree growth or structure, such as increased canopy thickness or a more reflective leaf angle.

Katherine Bennett - J R Briggs Elementary School

Nectar production and anthocyanins in Sarracenia purpurea and their resulting effect on prey capture

The northern pitcher plant, *Sarracenia purpurea*, possesses extrafloral nectaries that secrete nectar to attract potential prey. They also display intricate red and green patterns that have been hypothesized to play a role in attracting insects. However, our previous results show that insects are attracted by the presence of sugar, not coloration. In fact, prey capture decreases slightly as anthocyanins (red pigmentation) increase. Therefore, we hypothesized a correlation between increased anthocyanin production and decreased nectar production. We conducted our experiments at Tom Swamp between July 1 and August 31, 2009. Fifty pitchers with an incremental range of red patterning density were chosen and analyzed for prey capture. Nectar was sampled twice on these plants, using 1-cm2 filter-paper wicks on six locations on the pitcher. Sugars from the wicks were redissolved, extracted, and analyzed colorimetrically. We predict that wicks from pitchers with more red color will yield less sugar than those with more green, therefore suggesting less nectar rewards to potential prey. Further, we conducted a series of prey capture experiments using four sets of 20 pitcher mimics: 50 ml. centrifuge tubes painted to resemble live pitchers, one set all red, one all green, and two sets with alternating red and green stripes. Sugar solution was placed on half of the pitcher mimics, either randomly on the surface, on red veins, or on green inter-vein spaces, to test which mimics would attract more prey. Half of each set of mimics contained an insect drowning agent of strained fluid from live pitcher plants to determine if the fragrance of decomposing prey also plays a role in the attraction of prey. The mimics were set out in the same bog and prey was analyzed to determine joint relationships of color, nectar, and fragrance and prey capture rates.

Danielle Bushey - University of Massachusetts at Amherst

Urbanization and its Effect on the Feeding Rates in Red-Bellied and Downy Woodpeckers

This project compared feeding rates in red-bellied and downy woodpeckers in residential vs. non-residential areas. The energy efficiently spent on feeding young is very important to reproductive success. This success may be hindered by urbanization in areas where there are less trees and more human developments. In this project, residential areas are defined as plots with a number of houses present. Whereas, Non-residential areas are plots with limited human development, instead consisting of large stretches of woodland. I predicted that red-bellied and downy woodpeckers in more non-residential areas would have a shorter time period at the nest and between visits than their respective species, leading to higher feeding rates. The higher tree density and more diverse and numerous arthropod abundance in more residential areas leads to my prediction that woodpeckers have a greater opportunity in finding their food, therefore decreasing the amount of time spent foraging. The feeding rates were taken by observation with binoculars from the ground. Three one hour observations were taken for each nest between the hours of 8 AM and 12 PM. I recorded the times at which either adult arrived and/or departed, the times either stayed at the nest, and the time that it took them to return to the nest. Although the feeding rates did not significantly differ with age, species, or type of plot, there was a significant difference found in the feeding rates when comparing the parental sex of the woodpeckers. There also was no significant difference in the amount of time spent at the nest and between visits between the plots. This research is important in determining whether or not urbanization has damaging effects on woodpecker foraging and reproductive success to ensure that we are not creating detrimental habitat conditions for wildlife.

Dunbar Carpenter - Harvard University

Biomass Energy and a Changing Forest Landscape: Modeling the Effects of Intensified Harvesting of Massachusetts' Forests for Biomass Energy Production

Climate change, residential development, and timber harvesting are likely to be the primary disturbance agents affecting the forests of Massachusetts in the coming decades. One source of uncertainty is the potential rise of a forest biomass energy industry and the ensuing increases in harvesting to meet demand for feedstock. Under Massachusetts' Renewable Portfolio Standard, potential future demand for biomass electricity could be around 165 MW, which would require up to 2 million Mg of woody biomass annually. The purpose of this study is to assess the effect of such increased demand for wood on the forest landscape of western Massachusetts. A spatially explicit forest landscape simulation model (LANDIS-II) was used, incorporating individual species-age cohorts, biomass accumulation and decomposition, disturbances, and other ecosystem process. Three scenarios were developed: a baseline scenario projecting current trends in development and harvesting into the future, and two biomass energy scenarios in which harvesting increases stepwise in intensity and extent. The scenarios were run for 50 years and the species composition, aboveground living biomass, and harvested biomass of the resulting forest landscapes were compared.

Changes in species composition were slight, but present, under the biomass energy scenarios, with white pine and red oak increasing relative to the baseline scenario, and black birch, beech, and hemlock decreasing. Living aboveground biomass increased by 2.0%, from 225 to 229 Mg/ha under the baseline scenario, while decreasing to 207 Mg/ha (-7.9%) and 201 Mg/ha (-10.7%) in the two biomass scenarios. In all three scenarios, most of the change in biomass occurred in the first 20 years and then leveled off. The difference in standing biomass translates to a net carbon sequestration of 1.9Tg over 50 years under current trends, compared to a 7.3 and 9.9Tg of net emissions in the biomass energy scenarios. In spite of this, the amount of biomass feedstock harvested in the biomass future scenarios was only enough to generate 90 and 100 MW of power, well short of potential future demand. These results indicate that demand for biomass energy is likely to greatly increase the importance of harvesting as a disturbance on the forest landscape. Furthermore, pursuing a renewable energy policy that relies heavily on biomass power is likely to come at the cost of a diminished forest carbon sink.

Jonathan Chandler - Livingstone College

Temperature Alters Competitive Interactions in Ants at Harvard Forest

Ants make up a considerable amount of the biomass in terrestrial communities. They provide ecosystem services such as soil turnover, decomposition and seed dispersal. However, ant composition and activity may be altered by climate change and interactions population dynamics strongly influenced by temperature. This study examines the effects of temperature on interspecific competitive interactions among ants at Harvard Forest. I conducted my research in the Harvard Forest near the warm ant chambers. Using surveys using standard baiting (index cards and tuna) techniques in forest plots. I recorded the temperature, abundance and composition of ants present and behavioral interactions (aggression, submission, neutrality) at the baits hourly during each sampling period. I found that the most abundance species was the least aggressive; however, the least abundance ant species was slightly more aggressive. I found that more interactions occur in cooler temperatures and there were no interactions in the warmest temperatures. These findings suggest that interspecific interactions among ants may be altered under climate change, altering the diversity of and ecosystem services provided by ants.

Tamsin Connell - Regis University

Changes in coarse woody debris and fine woody debris due to an ice storm in Harvard Forest

Long term atmosphere-biosphere CO_2 exchange and ground-based biometry measurements at the Harvard Forest have shown systematically increasing C sequestration over the past 20 years. The mechanism behind this increase in C sequestration has not been fully explained but could be due partially to a recovery from a past disturbance. In December of 2008 an ice storm passed through the New England area causing damage to forests including the Prospect Hill tract of the Harvard Forest in Petersham, Massachusetts. We quantified the amount of CWD (coarse woody debris) and FWD (fine woody debris) down at the HFEMS (Harvard Forest Environmental Monitoring Site) as a consequence of this ice storm and determined which tree species were most affected. In order to do this, we conducted CWD and FWD surveys in 33 plots that fall in the footprint of the eddy-flux tower. We found that CWD downed in the ice storm (0.57 MgC/ha) was approximately equal to the CWD added to the pool (0.64 MgC/ha) since the 2006 survey. Additionally, FWD (0.41 MgC/ha) and CWD (0.57 MgC/ha) constitute similar portions of the downed biomass from the ice storm. We concluded from this result that when quantifying ice storm damage, FWD as well as CWD surveys are necessary to obtain representative results. On a species-specific level, it was determined that red maple *(Acer rubrum)* made up the majority of the surveyed ice storm FWD (0.25 MgC/ha) and in terms of downed FWD sustained significantly ($p < 0.05$) higher damage than any other species. Species-specific CWD was found to be extremely variable among the plots, and thus we were unable to determine with confidence which species sustained the most damage in terms of ice storm CWD. Future research using the eddy-flux technique and biometry methods could determine if C sequestration at the Harvard Forest is affected in upcoming years due to the ice storm damage sustained by the forest in December of 2008.

Sonia DeYoung - Harvard College (Harvard University)

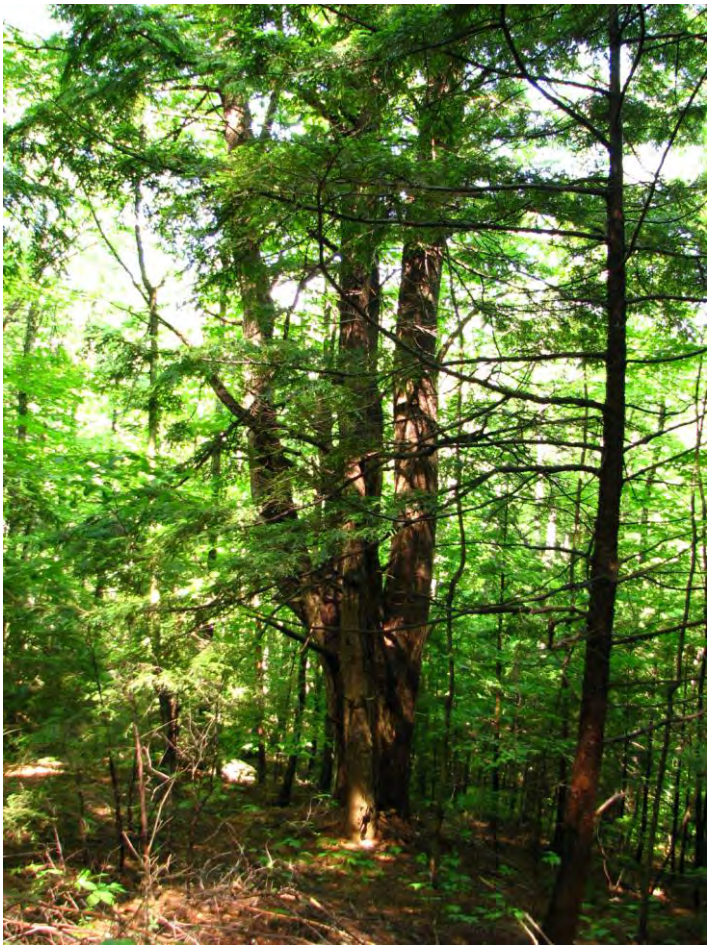
The Effects of Ungulate Browsing on the Growth of Red Maple and Other Hardwoods

With the re-colonization of moose and the rise of deer in southern New England, red maple and other hardwoods face the challenge of increased browsing pressure. We examined the effects of browsing on the height of red maple, birch, and oak seedlings and saplings, and on the abundance of red maple, in twenty-five recently harvested sites in the Quabbin and Ware River Watersheds in Massachusetts. Sites were chosen randomly, stratifying by age of harvest, forest type (oak-pine), harvest type, and proximity to major roads. We compared browsed status (browsed/un-browsed) with stem height in three harvest age classes (2001-2002, 2004-2005, and 2007) for each of the three taxa. Then using the overall browsing intensity of each site along with other site characteristics as predictor variables, we analyzed the effects of browsing on red maple stem densities in five height classes. No significant relationship between height and browsed status appeared for any of the 2007 sites or for oaks in any age class. Browsed red maples of the 2001-2002 and 2004-2005 age classes were significantly taller than un-browsed maples, and browsed birches taller than un-browsed birches in the 2004-2005 class. This difference may be because browsing accessibility increases with height, or potentially because of compensatory growth under browsing pressure. Stem densities for red maple were not significantly decreased by browsing, but rather in lower height classes by percent fern cover. These results may suggest that red maple is relatively resilient under browsing pressure in regenerating oak-pine-maple stands of southern New England, and other factors instead may limit its growth and abundance. Given this resilience, growing deer and moose populations are unlikely to slow the rise of red maple that has occurred in eastern North America in the last century.

Danica Doroski - Bates College

Factors Driving Species Diversity in Three Vegetation Layers of New England Forest

Species diversity and richness is an important gauge of the ecological health of a natural community and is often a driving factor in land conservation projects. Several environmental and historical factors were analyzed to determine which factors have the greatest influence on species richness and diversity in four New England forests. Factors expected to influence species richness and diversity include; slope, aspect, topographic position, overstory composition and both recent and historic disturbances. We set up 20 x 20m plots in Martha's Vineyard, MA; Groton, VT, Petersham, MA and Strafford NH. Within each plot we recorded all the herbaceous species present, counted all of the overstory and understory trees/shrubs and recorded evidence of natural or anthropogenic disturbances. The influences of environmental factors were analyzed separately for overstory trees, understory trees/shrubs, and herb layer species. The influences of each factor were varied within the three strata; latitude and disturbance (both recent and historic) are related to vegetation diversity and richness in all three strata. Historic disturbances showed a positive correlation to diversity and richness while recent disturbance negatively influenced diversity and richness. Long term monitoring of this disturbance-diversity relationship could help us apply better land management techniques to maintain species richness and diversity in the New England forest.



Bryant Dossman - Bowdoin College

Urbanization and Nest-Site Preference of Two Cavity Nesting Bird Species: Yellow-Bellied Sapsucker *(Sphyrapicus varius)* and Red Bellied Woodpecker *(Melanerpes carolinus)*

Populations of cavity nesting bird species, like the Yellow-bellied Sapsucker and Red-bellied Woodpecker, tend to be highly affected by urbanization through the increased removal of snags and deadwood in more urban environments. In order to provide adequate tree care guidelines, we undertook an investigation into the nest-site preferences of these birds to ensure that proper removal of deadwood from urban environments can be done in an efficient manner in which not to negatively impact these woodpecker populations. Five nest trees were identified for each species and plots were set up with a 25-meter radius around the nest tree. An additional five plots were set up, where possible nest trees were selected and plots of the same size were set up around the possible nest tree. With in these plots arthropod abundance was measured by use of arboreal pitfall traps. Vegetation sampling within these plots consisted of identification of each tree to species and measurement of percent dead and tree diameter (dbh). Total percent canopy cover and ground cover in the plots were also measured. It was determined that there were significant differences between nest-sites of these two species. At the plot level analysis, arthropod abundance, percent dead wood, and tree size structure were significantly different between the two species. We also determined that at the landscape level, both urbanization and elevation had a significant influence on distinguishing the nest-sites between the two species. These differences lead me to suspect that competition over nesting habitat is unlikely because they do not seem to share a common resource. However, due to a strong inverse correlation more research is needed in order to distinguish the effects of urbanization from elevation in order to determine the effect those landscape level characteristics have on woodpecker population dynamics and nest-site preferences. I would also suggest that due to these findings that tree care practice guidelines be updated to accommodate the nesting habitat differences between these two species in Western Massachusetts.

Brendan Gallagher - Dickinson College

A twenty year study of vegetation dynamics in a virgin hemlock forest in Sothern New Hampshire

The Pisgah tract, a Harvard Forest property located in Southern New Hampshire, provides a rare opportunity to study virgin forest dynamics. The focus of this study was to study forest succession after a major disturbance, the hurricane of 1938. The tract was first studied by R. T. Fisher in the early 1900's. The hurricane of 1938 destroyed most of the old growth trees that initially attracted Fisher, principally *Tsuga canadensis* and *Pinus strobus,* however, the land was never salvaged or cleared. A vegetation analysis was initially conducted in 1989 and repeated again in 2009 along two transects designed to show variation along a topographic gradient. The two transects combined contained fifty-seven ten by ten meter plots. All stems greater than 2.5 cm dbh were mapped and measured along with the coarse downed wood and stumps. An inventory of all understory vegetation was also taken. Trends since 1989 suggest an increase in overall basal area and a decrease in density. This is indicative of a forest in the ~~"s~~tem exclusion phase" of forest stand development. Both transects had minimal ingrowth, and ingrowth trees were principally *T.canadensis*. In both 1989 and 2009 the forest was dominated by *T. canadensis*, *Acer rubrum, Fagus grandifolia*, & *Betula spp*. Understory vegetation showed twenty-four species in the understory. Highest levels of diversity and coverage were found on the east facing ridge and at the bottom of the transect. The ridge had recently been disturbed by the ice storm in the winter of 2008 and this area had the largest amounts of canopy openness. The bottom of the transect had richer soils and fewer stems which also lead to peaks in diversity and percent coverage.

Samantha Hilerio - Worcester Polytechnical Institute

The Presence of Spiders Reduces Ant Activity in Bogs

Little is known about how top predators in bogs interact. Our experiment investigated the effect of spiders and pitcher plants, two top predators in New England bogs, on the activity level and capture rate of ants, a common prey item. We hypothesized that the presence of either predator would decrease the activity level of ants, and further, that web-weaving spiders and hunting spiders would affect the ants differently. We created experimental bog settings in 10-gallon (51cm x 20 cm) terrariums each holding sphagnum moss, a medium-sized pitcher plant *(Sarracenia purpurea),* and an ant nest *(Tapinoma sessile)* extracted from a local bog. Tanks were assigned one of four spider addition treatments: one hunting spider, one web-weaving spider, one hunting spider plus one web-weaving spider, or three hunting spiders. Half the tanks were also assigned a pitcher plant manipulation: a mesh plug that prevented the plants from catching prey. Two pitfall traps measured ant activity in each tank. We extracted prey from the pitfall traps and all unplugged pitcher plants every 24 hours during six 4-day observation periods. Results showed that the presence of spiders decreased ant capture by pitfall traps ($p=0.02$). In single spider additions, the type of spider added (hunting versus web-weaving) did not affect ant abundance. However, in both pitfall traps and pitcher plants, the abundance of spiders added (1 versus 3) influenced the mean number of ants caught ($p<0.05$). The feeding status of pitcher plants (plugged versus unplugged) did not affect pitfall trap capture of ants. The strong influence of spiders and the comparatively low influence of pitcher plants on ants in this system raises the need for further investigation of spiders as a keystone predator in bogs.

Susan Irizarry - Clemson University

Resilience of *Acer rubrum* growth after sustaining damage caused by an experimental blow-down

The growth of *Acer rubrum* damaged in an experimental blow down was examined using annual dendrochronological data to determine if the damage had a noticeable effect on tree growth. The experimental blowdown, designed to mimic severe hurricane damage, was initiated in October of 1990 at the Harvard Forest in Petersham, MA. Using preexisting data sets from this LTER experiment, I determined which *A. rubrum* were damaged and still living 19 years after the manipulation. I selected trees from four damage classes: bent (n=15), uproot (n=6), snap (n=6), and standing (undamaged, n=15), plus an additional set of trees (n=15) from the adjacent control plot. Each of the trees was cored at breast height (if possible) and annual ring width measured. The raw data was highly variable. I expected that the damaged trees would show decreased growth after the manipulation, with bent trees showing the least drastic decrease and snapped trees declining the most. However, I found that many of the damaged trees actually exhibited an increase in growth during the ten years after the blowdown, relative to the ten years prior to the manipulation. Snapped trees showed the strongest trend with 67% of the trees exhibiting a ≥ 50% increase in growth. Bent and uprooted trees showed similar, but weaker growth trends. I expected the standing trees to increase in growth in response to greater growing space after the manipulation; however, only 47% showed an increase of ≥ 50% in growth and 13% showed ≥ 50% decrease in growth. This study represents an unusual opportunity to test dendrochronology methods used to screen for disturbance, and to examine how damage affects growth of *A. rubrum*. The results demonstrate the resilience of *A. rubrum* to damage and can be applied to studying recovery of hardwood stands after large-scale windstorms.

Alanna Kassarjian - Simmons College

Removing the Eastern Hemlock Influences Overstory Tree Growth

The hemlock removal experiment at Harvard Forest contrasts differences in forest response to the removal of *Tsuga canadensis* due to the hemlock woolly adelgid and by pre-emptive salvage logging. Treatments include girdled plots to simulate damage caused by the adelgid, logged plots simulating a commercial logging operation, hemlock control plots, and hardwood control plots. This sub-study aims to better understand the effect the treatments have on the growth of overstory trees remaining in the plots through the use of diameter measurements and tree coring. Expected outcomes included variation in tree growth by species and plot treatment and that each species would show the most growth in the logged plot. In the Valley block of plots, diameter at breast height was measured for each living tree in 2004 and 2009. Growth of *Acer rubrum, Quercus rubra, Betula lenta,* and *Pinus strobus* was examined among treatments. For *B.lenta*, and *P.strobus*, tree cores were sampled from ten trees in each plot to determine the annual growth by species. *A.Rubrum* and *B. lenta* showed an increase in growth in the logged and girdled plots after hemlock removal whereas *P.strobus* and *Q.rubra* showed little response to the treatments. The tree core samples showed similar increase in ring growth in the logged and girdled plots for *B.lenta*, while *P.strobus* showed the highest rate of growth in the girdled plot. Overstory vegetation fills a fundamental role in forest structure and greatly contributes to forest regeneration. Through better understanding of overstory tree growth after hemlock removal, we can better forecast stand development after a disturbance.

Michael Lawrence - University of British Columbia - Vancouver

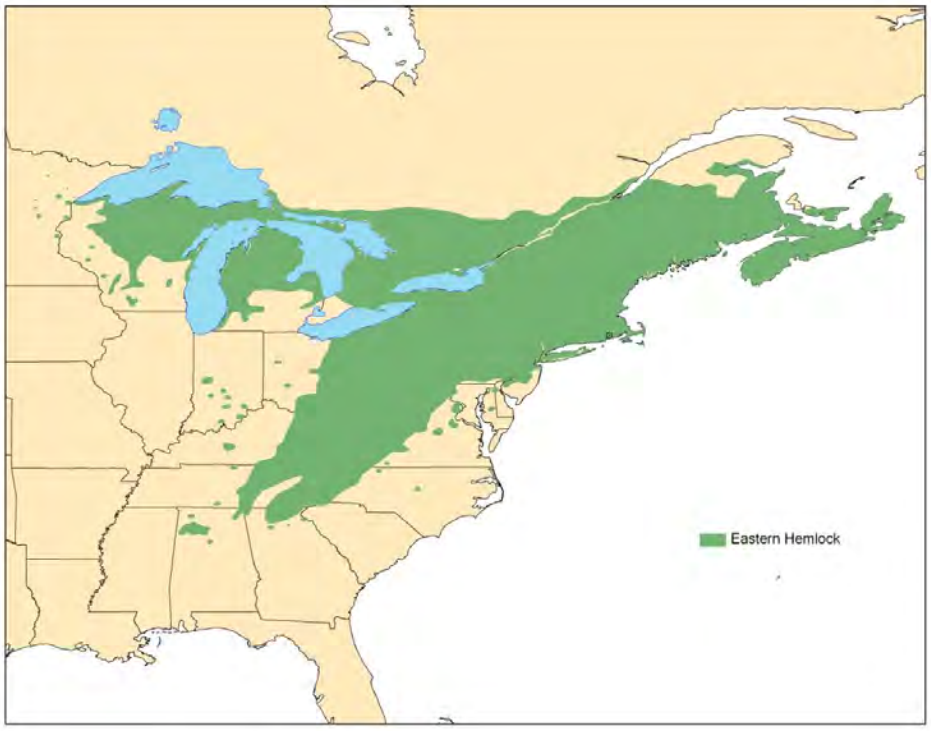
Regional and Historical Variation of Tree Composition in New England Forests

Differences between forest plant communities are the result of complex interactions among a multitude of environmental variables and disturbance. The environmental and disturbance factors determine successional changes in forest structure and composition. In this analysis, plot level data collected in the summer of 2009 is used to compare the overstory composition of forests in four New England locations (Martha's Vineyard (MA), Petersham (MA), Strafford (NH), Levi Pond (VT)). Next, Horn's model of forest succession is used to predict the future composition of these forests. The present and projected forests are then compared to early European settlement forests (according to witness-tree data) to showcase transitional trends in the overstory vegetation over the past 500 years. New England offers a prime example to study reforestation after major landscape alteration, and delineating the patterns of change in these forests will help to understand the long term ecological impacts of such intensive management on temperate forests.

Eliza Ledwell - University of Maryland, Baltimore County

Forecasting potential habitat of *Tsuga canadensis* under climate change using bioclimatic envelope models.

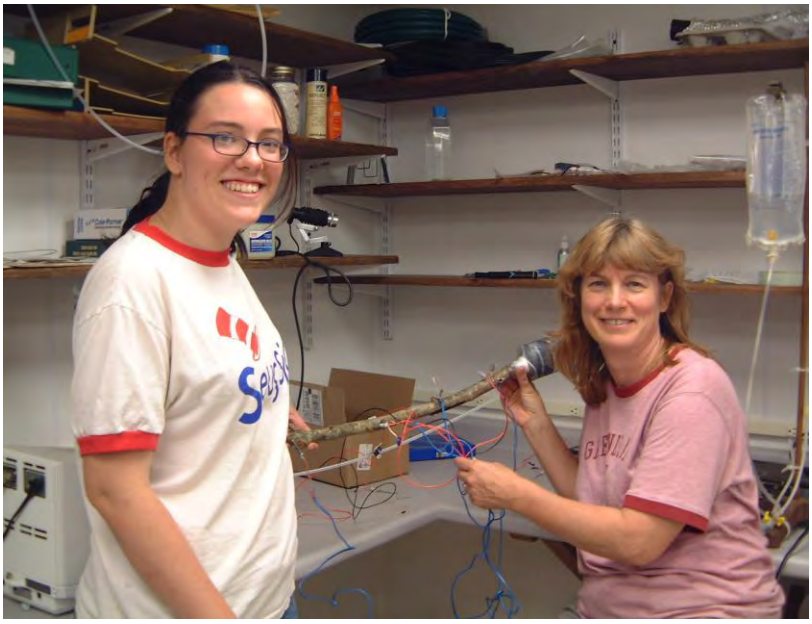
Recent climate change has already caused changes in the geographic distributions of species and range shifts are expected to be a dominant response of species to projected changes in climate during the next century. A common approach to forecasting such changes in distribution is the application of bioclimatic models. These models are attractive because they require only two, relatively easy to obtain inputs: (1) information on the distribution of the species and (2) environmental predictor variables. Despite their relative ease of parameterization, bioclimatic models do not incorporate biotic factors also known to influence species distributions, such as dispersal ability, interactions with other species, and evolutionary change and therefore their forecasts are often considered unreliable. Further, studies rarely quantify uncertainty in model forecasts. Here we employed a variety of models to assess the potential influence of climate change on the distribution of eastern hemlock *(Tsuga canadensis).* We addressed two key questions: (1) How well do models developed under current climate predict mid-Holocene distributions and vice versa and (2) How do forecasts differ between different climate change projections? Our results showed that climate is a good predictor of hemlock distribution both at present and in the past, suggesting the bioclimatic envelopes may serve as a reasonable first approximation to the response of hemlock to climatic change. Forecasts developed from both current and past distributions of hemlock agree that its climatic range will shift in north-eastern direction in the future given no dispersal limitations. By evaluating the reliability of the species distribution models and quantifying the uncertainty associated with future range shifts, we hope to assist policy makers in making decisions about conservation plans.



Jennifer Levye - Harvard University

Implications of Sectoral Variation in Red Oaks and Red Maples on Sap Flow Measurements

Radial variation or sectoriality of sap flow and nutrient distribution in trees has been observed in many contexts. Trees can partition the distribution of nutrients based on the areas of the stem requiring resources. Our aim in this study was to determine if this partitioning of sap flow was present in forest trees focusing on the implications of sectoriality for sap flow measurement methods. We used Granier's style thermal dissipation probes in red maple and red oaks on the Prospect Hill tract at Harvard Forest to look for patterns in variation of sap flow around the trunk. By inserting either two or three probes in the trunks of trees, we collected sap flow velocity data from April to July, then focused analysis on high-flow days in the late spring and summer. Red oak species seemed to show patterns of variation among the sensors; maples did not show significant variation among probes. The amount of variation found in red oaks could have implications for sap flow measurements since using too few probes per tree could result in significant underestimation or overestimation of total sap flow. Further research is needed to understand the extent of the variation in oaks, and to determine whether variation could be detected in red maples if more sensors were used.



Adriana Marroquin - Emerson College

Long-term dynamics of hemlock in western Massachusetts

Lake-sediment records provide a long-term perspective on the relationship between climate change and ecosystems. With this study we intend to create a record of the history of the vegetation surrounding Guilder Pond in Berkshire County, Massachusetts. Comparison of pollen assemblages before and after European settlement allows us to better understand the recent dynamics of the supposedly old hemlock stand that surrounds the pond and the effects of any human disturbance. We used data from two sites in Berkshire County—Guilder Pond and Benson Pond—as historically this area had the highest hemlock abundance in the Northeast. To date we have measured the organic content of the Guilder Pond sediments and have counted pollen for the upper 120 cm of the core. The organic content data for Guilder Pond correlated with that of Benson Pond, suggesting similar reactions to regional climate changes; a series of peaks in organic content for both ponds imply shallow waters, which in turn suggest periods of drought. The pattern of hemlock in the surface core also correlated with the middle-Holocene increase in hemlock abundance seen in Benson Pond's pollen record, which dates to ~4000 yr BP. A drop in hemlock pollen in the uppermost samples, and an increase of ragweed pollen at the same level, correspond to European settlement and suggest that the Guilder Pond area experienced some logging. Future research with tree-ring samples and a more detailed pollen record for the uppermost 50 cm will help provide a better understanding of the current hemlock stand and the possibility that it is not a pristine old-growth forest, but instead has been subject to human disturbance

Jennifer Popham – University of Massachusetts

Seedling, Sapling and Shrub Composition Influences Browse Intensity of Ungulates in Massachusetts

Forest ungulates, such as deer and moose, select areas in which to feed based on particular site and landscape characteristics. Therefore, the extent to which ungulates impact the regeneration of forest patches that have experienced disturbances such as logging, may be strongly linked to both site and landscape conditions. To determine how habitat features influence deer and moose foraging in southern New England, browsing intensity (proportion of stems browsed per site) was analyzed in relation to five predictor variables including harvest age, harvest size, proximity to development, local temperature, and percent of deciduous seedlings and saplings. Study sites were located in the Quabbin Reservoir Watershed and Ware River Watershed forests in the Worcester-Monadnock Plateau ecological subsection. We randomly selected 34 recently harvested stands, stratifying by (1) age of harvest, (2) forest type (oak-pine), (3) harvest type, and (4) proximity to major roads. To maximize the variation in the relative intensity of ungulate activity, we also used data from five radio-collared moose roaming the study area to select at least one site per harvest age known to be heavily used by moose.

Although four of the predictor variables proved to be insignificant, we did find a positive correlation between browsing intensity and the relative percentage of deciduous seedlings and saplings growing within a plot. Overall, sites with a greater amount of deciduous stems were intensively browsed compared to sites with a higher conifer composition. We also found that 74% of the sites had at least half their stems browsed, which demonstrates the important impact ungulates can have on young forests. The high levels of browse intensity found at sites close to roads and development suggests that moose and deer may not be deterred by human presence.

Daniella Rodriguez - Arizona State University

Under Warmer Conditions, the Advantage of Improved Foraging is Negated by Increased Mortality in *Apheanogaster rudis*

Ants are an important part of our ecosystem although people may not realize this because we think of them as pests. We rely on ants for ecosystem services such as decomposition, soil turnover, and seed dispersal. Ant activities that facilitate these services- survival and foraging- are strongly correlated with temperature, making them sensitive to climate change. Recent studies on insects have linked climate change to increased range shifts, extinctions and changes of ecosystem processes. To understand how increasing temperatures may affect ants, I performed a greenhouse experiment with *Aphaenogaster rudis*, a common species at Harvard Forest. I placed field-collected *A. rudis* nests under infrared lamps with temperatures at ambient, +2°C, +4°C or +8°C. I measured survival and conducted feeding trials in multiple colonies in each temperature treatment for three weeks. I gave *A. rudis* colonies 20 seeds daily and recorded time to discovery and foraging rate. I found that increases in temperature do affect survival and foraging activity in *A. rudis*. My results show that food was found faster in warmer temperatures; however, there was also higher mortality in warmest conditions. Therefore, the ecosystem services provided by ants may be positively affected under climate change if temperatures do not exceed increases of 4°C, but this could be reversed at higher temperatures.

Cristina Subt - University of Texas at El Paso

Land Owner Decision Monitoring Over Long Term Displays Trends in Acreage Parcelization

The purpose of this project was to develop an effective way to characterize and monitor land owner decision-making over an extended period of time. We created a random sample of 100 points, all found on privately owned forest land in the North Quabbin area. We studied patterns or trends in the types of decisions land owners typically make about their land (e.g., changing ownership, acreage, and price), by using the Registry of Deeds for transaction and spatial data, and tracking the ownership of land over time. We also determined type of ownership (e.g., single owner, joint/spousal, family or business) and the extent to which people own adjacent parcels. Through these methods we found that most owners own multiple adjacent parcels, and about 2/3 of these owners are multiple people. The rate of decision-making for businesses is considerably slower than it is for other types of landowners. In the aspect of harvesting decisions, the decision to harvest has some correlation to parcel size, but appears to be unrelated to the sale-of-land decisions. These results provide an indication of the rate and kind of decisions owners are making, and the consequences of this decision making on the landscape. Unlike other projects, where the research provides insight to the decisions landowners make about their land only for single snippets of time, this project looks at decisions over long periods of time, so it is possible to gain an idea of how often these decisions are made.

Corietta Teshera-Sterne - Mount Holyoke College

A Software Engineering Approach to Scientific Data Provenance

Advanced technology has enabled scientists to design elaborate experiments, collecting ecological data from extensive, sophisticated sensor networks. In turn, these experiments produce far larger, more complex datasets than previously encountered. The requirements of funding agencies and collaborations with remote scientists lead ecological data producers such as Harvard Forest to make datasets publicly available over the Internet. In order to be useful to data consumers, scientific datasets need to be reliable and reproducible. Both require that the process used to produce the data be transparent: consumers need access to data provenance, accurate information about the datasets and how they were produced. Collecting this information and presenting it in a useful way is a complex research problem that can benefit from approaches originally developed for software engineering. Computer scientists at the University of Massachusetts, Amherst have developed Little-Jil, a graphical programming language capable of organizing tools used to collect, analyze, and manage scientific data. An example is a proposed network of sensors at Harvard Forest measuring stream flow, precipitation, and other hydrological data with the goal of gaining a more complete understanding of the water budget of small forested watersheds. Research conducted this summer has resulted in Little-Jil processes for automated processing and quality control on data collected from these sensors, as well as capturing information about the process itself as it runs. As this project moves forward, this metadata will be stored in a way that will permit any individual data value to be traced backward through the process to its origin. The resulting software will allow data consumers full knowledge of scientific datasets.

Jenna Turner - University of Rhode Island

Stratified Dispersion: Tracking Long-distance Wind and Insect Dispersal Events in the Forest Understory

Understanding the dispersal mechanisms of invasive species is the key to predicting the speed and potential of their spread. Most propagules disperse short distances. However, secondary dispersal mechanisms can transport propagules great distances and such events are the primary determinants of spread rates. The hemlock woolly adelgid *(Adelges tsugae)*, is rapidly infesting and killing eastern hemlock populations across the Northeastern United States. *A. tsugae* is a passively-dispersed organism known to be dispersed by multiple short- and long-distance vectors, namely wind, birds, deer, and humans. However, it is nearly impossible to determine the source population of dispersing *A. tsugae* and therefore to understand its true dispersal dynamics. To circumvent the problems associated with observing dispersal of *A. tsugae*, we instead tracked dispersal of fluorescent powders which, also consisting of small, passively-dispersed particles, should serve as a proxy to *A. tsugae* dispersal. By dusting individual hemlocks with different colored powders, we were able to define ―source" populations, control propagule pressure by manipulating the amount of powder applied to each tree, and to determine with confidence its dispersal through the forest understory. We tracked movement of the fluorescent particles using sticky cards located from 10 to 400 m away from the source trees. The amount of powder captured was quantified by photographing cards under a black light and by counting the number of fluorescing pixels using image analysis software. We captured powder at a distance of 400 meters, with many of the longest dispersal events being associated with transport of powder by insects. This suggests that wind alone may not explain the movement of *A. tsugae* between trees within forests and that a secondary dispersal mechanism such as insects may facilitate longer-distance dispersal events. Future work could consider whether insects are truly capable of dispersing *A. tsugae*.

Tawny Virgilio - Westfield State College

The Use of Mixed-Bead Resins to Determine the Effect of Two Invasive Insects on Throughfall Nitrogen Dynamics Under Eastern Hemlock *(Tsuga canadensis)*

Herbivores are important components of many ecosystems due to their ability to influence nutrient cycling and primary production. There are several mechanisms by which herbivores can influence ecosystem function, such as through the deposition of frass, cadavers, and a change in the quality and quantity of leaf litter. Insect herbivory may increase the rates of nutrient leaching from the damaged leaves and can therefore change throughfall (the nutrient content of precipitation as it passes through plant canopies). This can also happen by the dissolution of frass from foliage. An increase in foliar microbes due to this input of frass, cadavers, and body coverings might too have an impact on throughfall and nutrient cycling. This study utilized a new technique to examine how two invasive insects, feeding on the same host, influence throughfall nitrogen content. We examined eastern hemlock *(Tsuga canadensis)* saplings infested with hemlock woolly adelgid (HWA; *Adelges tsugae*), elongate hemlock scale (EHS; *Fiorinia externa*), both invasive pests, or neither pest in a field experiment at the University of Rhode Island. Mixed-bead resin bags were placed underneath hemlocks with each of these pest treatments for 30 days and examined for ammonium and nitrate content. Results suggest that NH_4 capture under treatment trees did not differ significantly from ambient precipitation levels (~ 88 µg NH_4/g resin) captured on resin bags suspended above ground at the site, suggesting that insects did not lead to significant inputs of NH_4 as predicted. Resin bags under treatment trees did capture significantly higher amounts ($P < 0.005$) of NO_3 (73-88 µg NO_3/g resin) than ambient levels in precipitation (~8 µg NO_3/g resin), but there was no significant difference among infestation treatment. Several potential factors could have contributed to the lack of herbivore related inputs observed in this project including: very wet summer months which may have leached out nutrients previous to our study, very low EHS population densities, and resin bag size which may have limited nutrient capture.

Maggie Wagner - University of Michigan

Mortality, coarse woody debris, and nutrient cycling over 20 years in a virgin *Tsuga canadensis* forest in New Hampshire

Coarse woody debris (CWD) studies are common in Europe and western North America, but are somewhat neglected in the eastern United States. CWD has been shown to provide important plant and animal habitat and contribute to both terrestrial and aquatic nutrient cycles. We surveyed 57 ten-by-ten meter plots in the Harvard tract of the Pisgah State Park in southwestern New Hampshire, one of the few parcels of primary forest remaining in New England. The surveys were conducted in 1989 and 2009. In each plot, we measured and mapped every tree (all stems ≥ 2.5 cm diameter at breast height) and every piece of CWD (all stumps, snags, and downed wood with an average diameter ≥ 10 cm). In 2009 we also analyzed the C and N contents of soil samples from beneath and adjacent to a variety of coarse woody debris. Censuses showed that all major tree species declined between surveys, with eastern hemlock *(Tsuga canadensis)* suffering mortality at half the rate of the hardwoods (*Acer rubrum, Fagus grandifolia*, and *Betula spp*.). Mortality rates did not appear to differ among substrates (soil vs. rock vs. tip-ups). Total CWD decreased from 354.6 m^3/ha to 215.5 m^3/ha. CWD input over 20 years was 8.4 m^3/ha and was outpaced by volume loss due to the decay of debris added by the major hurricane of 1938. The basal area of snags increased slightly from 2.64 m^2/ha to 2.78 m^2/ha. Under CWD, soil C:N was higher ($p = 0.0042$) and soil N was lower ($p = 0.0238$) than they were 1 m away from debris. These results suggest that CWD is an important structural component of primary New England forests, and its effects on nutrient cycling should be investigated further.

2009 STUDENT SEMINARS AND PROGRAMS

June	3	David Foster, HF Director – Reading the New England Landscape (Field Walk)
	5	Jonathan Thompson/Matt Fitzpatrick, Ethics Lunch – Experiment Design
	9	Serita Frey, Sustaining the Wood-wide Web in a Changing World
	12	Chris Preheim, Museum/Library Tour Harvard Natural History Museum, Harvard Museum of Comparative Zoology & Harvard University Herbaria
	16	Aaron Ellison, Harvard Forest – Pitcher Plants
	18	David Kittredge, University of Massachusetts – "Woodland owner behavior & change in the forest"
	19	Paige Warren, PEL- Woodpecker habitat, research reporting, and private landowners
	22	Ethics Day; Kristina Stinson
	23	Bill Sobczak, College of the Holy Cross – Streams and the global carbon cycle
July	9	Graduate School Panel, Israel DelToro, Shannon Pelini, Jim Wheeler
	10	David Kittredge, University of Massachusetts PEL- Science and the Media
	14	Kristina Stinson, Harvard Forest – "Microbial Responses to Plant Invasion: Fungi, Forests and the Future"
	16	Career Day
	17	Kristina Stinson/Audrey Barker Plotkin- Harvard Forest, PEL- Collaboration & Authorship- whose idea was this anyway?
	21	Paige Warren, University of Massachusetts – "From Bottom to Top: Human Impacts on Urban Biodiversity and Species Interactions"
	23	N. Michele Holbrook, Harvard University – Whole Tree Physiology
	24	Emery Boose/ Lee Osterweil PEL- Data management, archiving, public domain
	28	Dave Orwig, Harvard Forest – Scientific presentation workshop
	30	Clarisse Hart, Harvard Forest – Abstract Writing Workshop

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National Science Foundation

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

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

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

US Department of Energy

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

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

3. Department of Energy and Univ. of North Carolina - Impacts of elevated temperature on ant species, communities and ecological roles at two temperate forests in eastern North America (DE_FG02-08ER64510)

USDA Forest Service, Land Owner Decision Monitoring Over Long Term (09-DG-11242305-071)

University of Massachusetts Amherst - Family Forest Research Center

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PERSONNEL AT THE HARVARD FOREST - 2009

Audrey Barker Plotkin	Site and Research Coordinator
Michael Babineau	Summer Maintenance Crew
Mackenzie Bennett	High School Research Intern
Stephen Blackmer	Bullard Fellow
Emery Boose	Information & Computer System Manager
Jeannette Bowlen	Accountant
Chelsea Carr	High School Research Intern
Laurie Chiasson	Financial Assistant/Receptionist
Elizabeth Colburn	Aquatic Ecologist
Sheila Connor	Archivist
Elaine Doughty	Research Assistant
Israel Del Toro	Graduate Student
Xioajun Du	Bullard Fellow
Edythe Ellin	Director of Administration
Aaron Ellison	Senior Ecologist
Matthew Fitzpatrick	Post Doctoral Fellow
Ava Foster	High School Research Intern
David Foster	Director
Serita Frey	Bullard Fellow
Carlos Garcia Nunez	Bullard Fellow
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Julian Hadley	Ecophysiologist
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Linda Hampson	Staff Assistant
Clarisse Hart	Outreach and Development Manager
David Kittredge	Forest Policy Analyst
Oscar Lacwasan	Maintenance Technician
Noah Lavine	High School Research Intern
James Levitt	Director, Program on Conservation Innovation
Heidi Lux	Research Assistant
Ron May	Maintenance Technician
Glenn Motzkin	Plant Ecologist
Liza Nicoll	Research Assistant
Nathan Nkongolo	High School Research Intern
Nsalambi Nkongolo	Bullard Fellow
John O'Keefe	Museum Coordinator
David Orwig	Forest Ecologist
Wyatt Oswald	Paeloecology Lab Coordinator
Julie Pallant	System and Web Administrator
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Shannon Pelini	Post Doctoral Fellow
Doralinda Puente	Summer Assistant Cook
Larisa Proulx	Summer Resident Advisor
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Relena Ribbons	Intern
Lisa Richardson	Accounting Assistant
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Sabrina Smith	Summer Maintenance Crew
Pamela Snow	Environmental Educator
William Sobczak	Bullard Fellow
Kristina Stinson	Staff Scientist Population Ecologist
Travis Stolgitis	Maintenance Technician
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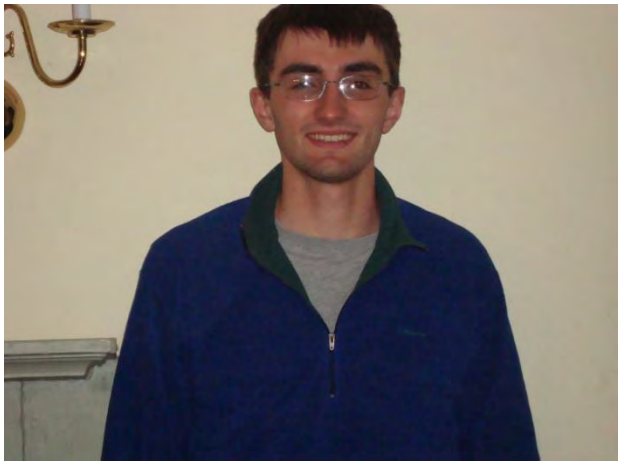

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Jennifer Popham

Jennifer Levye

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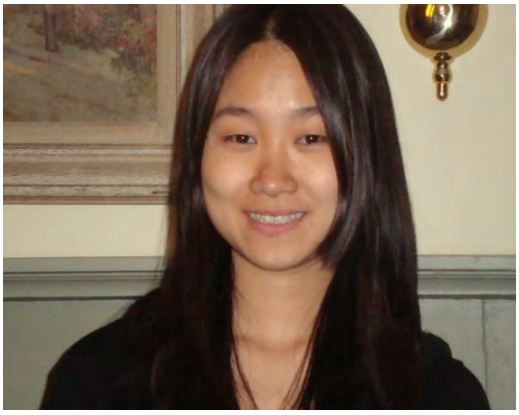
Maggie Wagner



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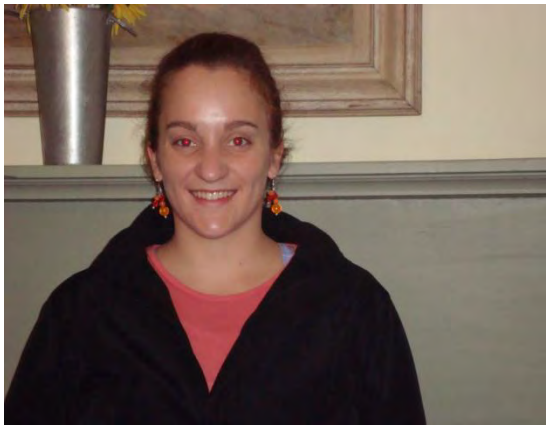

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