HARVARD FOREST
Summer Student Research Assistants

Abstracts from the 1st Annual
Harvard Forest Summer Student Symposium
10 August 1993
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SUMMER STUDENT RESEARCH SYMPOSIUM
Tuesday, August 10, 1993, Fisher Museum

Schedule of Speakers

9:00 A.M.  Introduction and Welcome  Rich Bowden

Trace Gases

9:15  Influence of Precipitation on Trace Gas Fluxes at Harvard Forest  Gina Rullo
9:30  Trace Gas Fluxes from an Agricultural System  Germaine García
9:45  Ecosystem CO₂ Exchange of Temperate Forests  Robert Ditzion
10:00  Effects of Soil Factors on Trace Gas Fluxes  Nedžad Ajanović

10:15  BREAK

Soils

10:45  Abiotic N immobilization in Chronic N Soils  Shannon Scott
11:00  Hydrologic Nitrate Output at the DIRT Plots  Phoebe Goodwin

Wildlife

11:15  Influence of Land-use History and Habitat on Bird distribution at the Harvard Forest  Dan Cooper
11:30  Environmental Effects of Temperature and Vegetation on Microsite Butterfly Populations  Martha Shumann
11:45  Macrosite Correlation Between Vegetation and Butterfly Diversity  Jennifer Thaler

12:00 NOON  LUNCH

Forest Vegetation

1:15 P.M.  A Tale of Two Research Projects: The Germination of a Seedling/Understory Experiment and the Highs and Lows of Photosynthetic Measurement  Meghan Clancy-Hepburn
1:30  Kalmia Sucks, and Other Observations from Vegetation Sampling  Doug Holland, Becky Sauser & Carol Collier
1:45  Genetic Diversity in Taxus canadensis: Electrophoresis and Yew  Becca Tatum
Land Use

2:00 Land-use and Vegetation Patterns on the Montague Sand Plain
Jonathan Harrod

2:15 Ecological Analysis of New Massachusetts Audubon Property in Preparation for a Management and Recreation Plan
Wenda Luff

2:30 BREAK

Vegetation Disturbance

3:00 Wind Direction and treefall in the 1938 Hurricane
Joel Carlson

3:15 Forest Regeneration In a Simulated Blow-down: Vegetation Survey of Uprooted Tree Microenvironments
Wendy Cass & Wendy Smith

3:30 Dealing with Stress: Indicators from Red Maples
Saara DeWalt

3:45 Winter Storm Damage in a Red Maple-Red Oak Stand
Jennifer Reed & Chris Chamberlin

4:00 DISCUSSION OF SUMMER PROGRAM

5:00 PICNIC
Effects of Soil Factors on Trace Gas Fluxes

Nedzad Ajanovic

This study was conducted to measure greenhouse gas fluxes of CO₂, N₂O and CH₄ from intact soil cores (IC) with varied additions of N, C and H₂O. Eighteen ICs were extracted from Bousson experimental hardwood forest located in Northwestern PA. Six different IC treatments, each with three replicates, were added to the soil cores. These treatments included: 1) ambient moisture soil, 2) low addition of H₂O to soil, 3) high addition of H₂O to soil, 4) low addition of H₂O + low addition of N to soils, 5) low addition of H₂O + high addition of N to soils and 6) high addition of H₂O + high additions of N & C. For low additions of H₂O, we added 30 ml H₂O/core. For high additions of H₂O, we added 45 ml H₂O/core. To create low & high N soil environments, we added 50 kg N/ha and 150 kg N/ha equivalents to the ICs. Finally, in order to obtain a high C soil environment, we added 200 kg C/ha equivalent to the ICs. Methane uptake decreased in very dry and moist soils during both the initial incubation as well as during the incubation that was done a week later. Additions of N decreased methane uptake as well. Carbon dioxide emissions at both incubations were not effected by the moisture increases. Additions of N contributed to higher fluxes of NO₂. These results are reflective of trace gas flux rates obtained in other temperate forests, including the Harvard Forest.

Wind Direction and Treefall in the 1938 Hurricane

J. Carlson

Hurricanes play an important and complex role in the natural disturbance regimes of New England's temperate forests. This study's intention is to create a more complete understanding of the wind orientation at different locations during the 1938 Hurricane in central New England. The results will be used as a field check of the wind directions produced by a computer model of the 1938 Hurricane that has been created at the Harvard Forest.

Each site visited is plotted by UTM zone and grid coordinates. All orientation readings are done in magnetic azimuth, for this reason declination is recorded. The aspect and slope of each individual site is recorded, and the diagonal distances and bearings are recorded to calculate the area of the sample site. On each sample site data are collected for each tree that could be identified as a remnant from the 1938 Hurricane, and is still attached to a mound. Basal diameter is measured to the nearest centimeter just above the root collar. Whether the remains of the tree is a bole or a stump is noted, and whether it is a hardwood, softwood or unknown. The orientation of the bole or stump is recorded to the nearest degree magnetic. The treefall orientations after being entered into a data-base are then converted to wind direction by appropriately adding or subtracting 180 degrees.

Tree type and basal diameter, and site slope, aspect, distance to storm track, and location to minor and major topography, will be looked at
individually and in combination. Trends and patterns that these variables may have on treefall orientation will be noted and analyzed for significance and applied appropriately to the wind orientation at local and regional levels.

Forest Regeneration in a Simulated Blowdown: Vegetation Survey of Uprooted Tree Microenvironments

Wendy Cass and Wendy Smith

In September 1990 as part of the Harvard Forest LTER, 232 trees were pulled down in the Tom Swamp I tract to simulate hurricane damage to a red oak-red maple forest. This study assesses the development of understory plant communities in response to wind disturbance. Four microenvironments associated with tree uproots (pit, root plate, mound, mount top) were sampled annually. Three additional microenvironments, two on intact ground near the uproot (fern and open), and one outside the blowdown were also sampled. Circular plots (0.1 m²) were used to estimate substrate, degree of shading, and percent cover of all plant species within each microenvironment.

Preliminary results indicate that the physical characteristics of the microenvironments may influence plant community composition. The high light-low moisture conditions of the mound support many herbaceous species, sedges, and mosses. Leaf litter and deposition of eroded material inhibit seedling establishment in the pit. Unstable soil on the vertical mound top and root plate environments hinders vegetation colonization. The fern and open sites had similar conditions and were dominated by hay-scented fern (Dennstaedtia punctilobula), and wild sarsparilla (Aralia nudicaulis). These small scale vegetation patterns may reflect the role of microenvironments in shaping forest composition.

A Tale of Two Research Projects: The Germination of a Seedling/Understory Experiment, and the Highs and Lows of Photosynthetic Measurement

Meghan Clancy-Hepburn

Lisa George and I searched for sites to conduct research on seedling/understory interactions by running 30-55 m transects in a range of sites, then sampling the vegetation and seedlings there to collect the initial data about correlations and presence/absence of species. I was also involved in decisions about the logistics and statistical power of various proposed experimental designs, and worked to carry out the various treatments for the chosen sites. The development of a research project, in this case, provided a real window onto the design process and awakened me to the initial tasks so crucial to any experiment. With Susan Bassow, I climbed far into the canopy
to measure seedlings and mature trees at different light and CO₂ levels, and then compared those values to measurements made at Harvard University's glass house. This job involved working on an experiment already in progress, providing me with insight into the guts of research: measurement, observation, and most importantly, maintenance.

Birds and Land-use at the Harvard Forest

Daniel Cooper

The effectiveness of using historical land-use information to predict patterns of avian distribution across a landscape was tested at the Harvard Forest in north-central Massachusetts. During the summer of 1993, sixty-eight points were selected to provide even coverage of the 900-acre property, and fixed-radius point counts were conducted at each point three times during the field season. The points were identified in terms of what had been the dominant surrounding land-use, either pasture, cultivation, or woodlot, using digitized images of the property. Vegetation surveys provided the number and size of tree species at each point, as well as other habitat information. Because land-use categories were found to be correlated with several modern habitat variables (e.g. Woodlot/Eastern Hemlock, large average tree diameter), land history information should be a useful tool in predicting bird distribution.

Dealing With Stress: Indicators From Understory Red Maples

Saara DeWalt

As a complement to the long-term damage and response assessment of trees in the Tom Swamp blowdown simulation grid, we are examining the early response of understory red maples (Acer rubrum) to bending damage. We will compare elongation of older shoots, total spout growth, and amount of leaf damage due to disease or herbivory between bent and standing trees to determine whether there are differences that may indicate stress. We hope to isolate the effect of light intensity from the stress of bending by measuring the amount of light reaching the branches and sprouts we sample. Herbivory and disease of sprouts and of high and middle branches are being characterized by the percent of leaf area damaged. Initial observations suggest that gypsy moths, ocellate gall midges, and eriophyid gall mites are the main herbivores affecting the red maple trees. Future studies may compare bent versus standing trees for other indicators of tree stress including starch content in roots, twigs, and sprouts and leaf water potential.
Carbon Storage at Harvard Forest: A Comparison of Eddy-flux, Allometric and Chamber Based Observations

Robert Ditzion

Dr. Steven Wofsy's lab has used eddy correlation over the last 4 years to determine that a portion of the Harvard Forest Prospect Hill Tract absorbs 3 to 4 tonnes of carbon per hectare annually, more than has been previously allotted to temperate forests in global carbon exchange models. Eddy correlation is a micro-meteorologically based technique that averages the exchange of CO₂ between the forest and the atmosphere over an area approximately 100 to 500 meters upward of an experimental tower (the footprint). Shifts in wind direction cause the tower to sample different footprints, and we have observed that the forest to the northwest of the tower is respiring more, and storing less CO₂ than that to the southwest. Other researchers at Harvard Forest have noted that this pattern is consistent with differences in land-use history.

Our goal for the summer is to both affirm and further explore the eddy-flux observations using traditional ecological methods. We are currently investigating a total of 40 plots divided between the southwest and northwest footprints using three main techniques. Firstly, since soil respiration makes up a large portion of total ecosystem respiration, we are measuring soil carbon dioxide fluxes using portable chambers, monitored with an infra-red gas analyzer. Secondly, we have produced a survey of the trees in each plot. This provides information on forest type and allows us to calculate standing biomass from diameter at breast height using published regressions. Lastly, we are coring a sample portion of the trees in each sector. These cores are used not only to determine stand age, but also to analyze annual diameter growth, and hence, when related to biomass regressions, above-ground net production. Preliminary results indicate little difference in biomass between the northwest and southwest sectors but a significantly lower basal area in the southwest. Our biomass estimates are consistent with available temperate forest data. We hope that our work will allow for further understanding of forest growth and carbon dioxide exchange as well as for a more complete assessment of the role of temperate forests in the global carbon cycle.

Trace Gas Fluxes From An Agricultural System

Germaine Garcia

Greenhouse gas fluxes at an agricultural site and a temperate forest are being compared. The objective is to determine the effect of agricultural land use on the exchange of atmospheric carbon dioxide, nitrous oxide, and methane.

Flux measurements were taken from a 51 year-old dairy farm in Petersham, Massachusetts. Sites were established within a hayfield and a cornfield. The hayfield received no fertilizer or water, while the cornfield was treated with
224 Kg/ha/yr of nitrogen fertilizer in the form of ammoniated cornstarter and urea. Gas exchange between the earth's surface and the atmosphere was measured four times during the summer.

Mean carbon dioxide emissions were highest in the hayfield (275 mg C/m²/hr), followed by the cornfield (220 mg C/m²/hr), and the forest (165 mg C/m²/hr). Nitrous oxide emissions were extremely high in the fertilized cornfield (45 µg N/m²/hr), and near zero in the hayfield and in the forest. Nitrous oxide emissions from the cornfield declined 4-fold in the month following fertilization. Methane uptake existed in all three sites, but the most consumption was within the forest. These results indicate human land-use practices play an important role in the emissions of trace gases.

Hydrologic Nitrate Output at the DIRT Plots

Phoebe Goodwin

Soil solution chemistry can be useful in determining the fertility, or nutrient availability of forest soils. Nitrate concentrations in soil solutions were measured, using both tension and zero tension lysimeters in plots in a long-term litter manipulation study at the Harvard Forest. Nitrate concentration measurements were analyzed in order to determine treatment effects on plot fertility.

Plots which contained no roots, and plots which contained no roots and no above-ground litter, gave mean concentration values for June 1993 as 2.57 ppm and 0.444 ppm respectively. These nitrate concentrations were the greatest of all the plots and were statistically the same. Mean nitrate concentrations were higher in the zero tension lysimeter samples (0.463 - 13.377 ppm) than in the tension lysimeter samples (0.002 - 2.568 ppm). Increased nitrate concentrations in soil water can be attributed to the absence of root uptake in these plots.

Land-use and Vegetation Patterns on the Montague Sand Plain

Jonathan Harrod

The Montague sand plain, in the town of Montague, MA, is a sandy delta deposit formed by melting glaciers. Despite its flatness and uniform soils, the plain supports a complex vegetation mosaic. Forest types include stands dominated by pitch pine, white pine, scarlet oak, and aspen. The plain also features shrublands dominated by scrub oak and open patches of little bluestem grass. Boundaries between vegetation types often correspond with property lines, suggesting that historical land-use has largely determined modern vegetation patterns.
Our team selected plot sites using property maps and aerial photos. In each 20 x 20 m plot, we measured all trees ≥ 2.5 cm dbh and estimated abundance of understory species. We also recorded evidence of fire and logging and dug soil pits to see if the site had been plowed.

Preliminary analyses show strong correlations between land-use and vegetation. Grassy patches and pitch pine and aspen-dominated forests occur predominantly on plowed sites. Oak forests and scrub-oak shrub lands are found primarily on unplowed sites. The distribution of understory species has also been strongly influenced by land-use. Further analyses may shed light on the processes which have led to the observed pattern.

Kalmia Sucks, and Other Observations From Vegetation Sampling

Doug Holland, Carol Collier, and Rebecca Sauser

We are conducting a regional vegetation survey of 36 towns in north central Massachusetts. We are examining the relationship between land-use history, environmental factors, and current vegetation across a cultural and environmental gradient from the Connecticut River Valley to the central uplands. The results of this survey will also be used with historic vegetation and land-use data to examine post-settlement vegetation change, and may contribute to our understanding of the relationship between bird and butterfly distributions and vegetation.

The number of plots surveyed in each town were determined by the area of each town in 1830. The plot locations were randomly selected at the intersections of Universal Transverse Mercator (UTM) lines on United States Geological Service (USGS) topographical maps, and are located in the field using landmarks (roads, powerlines and houses) and a compass. Once located, a 20 x 20 m plot is laid out and all plant species present are recorded and given a cover class value. Environmental data such as slope, aspect, % rocks, hurricane damage and recent management, also are recorded. By the end of the summer 360 plots will have been surveyed and the analysis of the relationship between land-use history environmental factors, and current vegetation will begin.

Ecological Analysis of New Massachusetts Audubon Property in Preparation for a Management and Recreation Plan

Wenda Luff

An ecological survey was conducted on 32.8 ha Massachusetts Audubon property in Hampden, Massachusetts. Plant species composition was recorded on
a 50 x 100 m sample grid, uniformly surveyed across the property. Evidence of past land-use was recorded when encountered along transects and verified by searching property records. Tree basal area of 107 ft² acre varied considerably. *Acer rubrum*, *Quercus alba*, *Q. velutina*, *Betula lenta* and *Tsuga canadensis* were the most frequently encountered species. An average of thirty understory plant species were recorded at each point. Breeding birds were enumerated during three surveys conducted in June. Thirty-six species nested on the property with the most abundant species being the American Crow, black-capped Chickadee, Veery, and Ovenbird. Small mammals will be live-trapped in each plant community during September. All the data will be incorporated into a Geographical Information System to be used by the Massachusetts Audubon Society to prepare a conservation plan for the area.

Assessment of Winter Storm Damage

*Jennifer Reed and Kris Chamberlin*

A survey of recent winter storm damage was conducted in five long term tree mapped sites, the Tom Swamp Detritus, Removal, and Trenching site (DIRT - 1.3 ha), and the overstory deadening manipulation sites (.25 ha each). This study contributes to Harvard Forest’s long-term research goals by observing the effect of natural disturbance on the New England landscape. Storm damage may influence stem density and species composition by naturally thinning a stand and creating light gaps. On December 11 and 12, 1992, a particularly fierce storm deposited 15 inches of snow in Petersham, MA. The snow was 1.21 inches water and wind measurements in nearby Worcester, MA were in excess of 50 mph.

We categorized the amount and type of damage by species, size, location, and prior condition of the 2097 and 782 trees in the DIRT and overstory deadening sites, respectively. Damage included snap, major snap, crown snap, uproot, lean, bend, or root break. Preliminary results show that 15.02% of the tagged trees over 5 cm dbh in the DIRT plot and 3.0% of the tagged trees over 5 cm dbh in the overstory deadening plots were damaged. Damage was not uniformly distributed within the stands. Smaller trees (5.0 - 15.0 cm dbh) were more likely to be damaged. Certain species sustained more damage than others species - *Acer rubrum* had a higher damage frequency in most size classes in both the overstory deadening and DIRT plots than other species at those sites (Figures 1 and 2). Other studies have also documented the low resistance of *Acer rubrum* to ice and snow damage (Fowells, 1965). These surveys suggest winter storms may influence regeneration and maturation of *Acer rubrum* populations.
Effects of Precipitation on Trace Gas Fluxes at the Harvard Forest

Gina Rullo

Greenhouse gases such as CH$_4$, CO$_2$ and N$_2$O are increasing in the earth's atmosphere. Fluxes of these gases are known to have a relationship with soil moisture. Methane (CH$_4$), CO$_2$ and N$_2$O fluxes between chronically nitrogen fertilized (150 kg N/ha/yr), red-pine plantation soils and the atmosphere were measured at the Harvard Forest following a simulated 10 cm precipitation event in June, 1993. Methane uptake into the normally consumptive soils decreased sharply with the precipitation addition. Methane uptake ranged from .007 mg CH$_4$-C/m$^2$-hr at the time of wetting to .07 mg CH$_4$-C/m$^2$-hr 72 hours into the experiment. Mean CO$_2$ effluxes pulsed briefly after the onset of water where levels reached 418 mg C/m$^2$-hr, then remained near control levels for the rest of the experiment. Nitrous oxide fluxes were lowest after the treatment with water (.249 µg N/m$^2$-hr), but rose to higher levels (12.1 µg N/m$^2$-hr) as soil moisture decreased. At the start of the precipitation addition, there is an inverse relationship between soil moisture, and both CH$_4$ uptake and N$_2$O flux, as well as a direct relationship between soil moisture and CO$_2$ effluxes. Investigation of the nature and duration of wetting responses and their relationship to gas flux changes will be helpful in predicting trace gas flux measurements in areas of varying precipitation.

Abiotic N Immobilization in Forest Floor Material at Chronic N Plots

Shannon Scott

For five years two forest stands at the Harvard Forest have been receiving chronic nitrogen additions in the form of ammonium nitrate. Of the 50 and 150 kg N/ha added annually to the treatment plots, nearly 100% was retained by the forest system during the first three years of treatment. Some nitrogen is now beginning to be found in lysimeter water from the high N plots. One large sink for the added nitrogen is believed to be soil organic matter. Nitrogen immobilization, the process by which inorganic nitrogen is converted to organic nitrogen, could be responsible for tying up a large amount of nitrogen in the forest floor. Although considered to be largely mediated by the soil microbial population, nitrogen immobilization may also occur by an abiotic mechanism in soil organic matter. Forest floor material from the pine and hardwood stands were sterilized using propylene oxide, after which they were spiked with $^{15}$N-labelled ammonium sulfate. Sterility was checked by plating samples and checking for CO$_2$ production at the beginning and end of the incubation. KCl extracts will be analyzed for ammonium and nitrate; the $^{15}$N content of the extracts will be measured following diffusion analysis. Net $^{15}$NH$_4$ immobilization will be determined by both the change in organic $^{15}$N content and the change in KCl-extractable $^{15}$NH$_4$ during the incubation.
Environmental Effects of Temperature and Vegetation on Microsite Butterfly Populations

Martha Shumann

Butterfly populations are sensitive to the differential habitats created by land-use practices. The objective of this project was to correlate within site variation of vegetation and temperature with butterfly distribution. The location and dynamics of butterfly populations on a microsite level were observed and recorded throughout the summer. The local environment was constructed by collecting vegetation and temperature data. Ringlets (Coenonympha tullia) were studied in detail. They were phenotypically scored, marked, released, and recaptured. These data were used to see if phenotypic variation was specific to temperature or location. The species diversity data collected from the two fields suggest a correlation with vegetation, temperature, and habitat selection. The data this year will be used to establish a data base documenting butterfly populations as they respond to habitat disturbance.

Genetics of Canada Yew

Becca Tatum

Izyme analysis is being used to determine genetic diversity within and among populations of Canada Yew (Taxus canadensis Marsh) in Central Massachusetts. Attempts have been made to locate promising isozyme loci to determine both the extent of any within-population variation and the scope of variation among populations. Canada yew is a monoecious, clonally-reproducing species; therefore, high within-population variation is not expected. These results will help to determine whether genetic differences correspond to differences in yew population size, age, habitat, and location, and whether the apparent lack of inbreeding depression in Canada yew is a consequence of low genetic diversity.

Macrosite Correlation Between Vegetation and Butterfly Diversity

Jennifer Thaler

The amount of open grassy habitat is decreasing in New England as agricultural fields are abandoned and forests regrow. This loss of butterfly habitat could have a dramatic affect on butterfly diversity. Butterfly diversity was observed in several fields to determine whether there was a relationship between butterfly and vegetation diversity. Butterfly diversity
was monitored throughout the summer in nine fields of different successional stages. Vegetation in the fields was also identified. Phenotypic variation in one species, the ringlet (*Coenonympha tullia*), was measured in each field to determine whether individual populations constituted metapopulations created when the open landscape was fragmented.
1993 Harvard Forest Summer Student Activities

Seminars

June 7 Dr. Richard Bowden, Allegheny College

Trace gas fluxes, by a male soil scientist, after dinner (or, effects of natural and human disturbances on trace gas fluxes in temperate and tropical forests).

June 21 Dr. David Foster, Harvard Forest

Vegetation and land use history of New England forests

June 28 Dr. Richard Lent, Harvard Forest

Vegetation and birds: Effects of human disturbance on avian ecology and distribution

July 5 No seminar (field trip this week to the Hubbard Brook LTER)

July 12 Dr. Mark Castro, The Ecosystems Center

Greenhouse gas fluxes: Extrapolation of Harvard Forest experiments to New England forests

July 19 TBA Chris Catricala, The Ecosystems Center

July 26 Dr. Ann Lewis, University of Massachusetts

Growing trees and Stay-Free Ultra Plus

August 2 Dr. Emery Boose, Harvard Forest

A tale of two hurricanes

August 9 Dr. Julian Hadley, Harvard Forest Bullard Fellow

Effects of sunlight, temperature, and air pollution on high elevation red spruce

August 16 Dr. Taber Allison, Harvard Forest

Sex in the prairie: How grasses reproduce
Dinner Discussion Schedule

June 10      Dr. Richard Bowden, Allegheny College
            Ms. Ann Lezberg, Harvard Forest
            How to find a job

June 22      Dr. Richard Boone, Dr. Taber Allison; Harvard Forest
            Initiating research: Deciding on your question

July 29      Dr. Richard Bowden, Allegheny College
            Research presentation workshop: Successfully informing your audience

August 12    Dr. Richard Boone, Dr. Taber Allison; Harvard Forest
            Applying to graduate schools

Field Trips

June 14      Field trip to the Perkins Dairy Farm, Petersham, MA

June 26      Field trip to Old Sturbridge Village (Working replica of 1830’s New England farm and village)

July 6-14     Field trip to the annual Hubbard Brook Cooperators Meeting
            Trip included attendance at annual meetings, afternoon hike in White Mountains, and visits to research sites
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Charles C. Spooner
Russell D. Stafford
Lynne Stopen
P. Barry Tomlinson
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Summer Cook
Soil Ecologist
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Woods Crew (part-time)
Laboratory Assistant (part-time)
Forest Manager
Research Assistant
Librarian/Secretary
Director of the Harvard Forest
PhD Candidate, OEB
MFS Candidate
Bullard Fellow
Summer Cook
Woods Crew
Woods Crew (part-time)
Custodian
Data Manager/Ecologist
Research Assistant
Research Assistant
Charles Bullard Fellow
Graphic Artist (part-time)
Research Assistant
Museum Coordinator
MBL Research Assistant
GIS Assistant
UNH Research Assistant
Woods Crew
MFS Candidate
Woods Crew (part-time)
E. C. Jeffrey Professor of Biology
Woods Crew
Students get down and dirty

By Ann G. Forrester
Correspondent

PETERBOROUGH - The trails and byways of Harvard Forest are busy with more than hikers and researchers this summer. About 50 students from colleges in the Northeastern U.S. are participating in a research education program.

The program aims to teach them the responsibilities of scientific research. Their studies all are part of ongoing, grant-funded research into the effects of natural and human-caused disturbances on forests.

Some collect leaf litter in the Pinchot Project, some study the boughs at 10 a.m. watching birds, some analyze at a computer screen trying to turn their observations into text, and some sort houseflies. All implement into cheap versions of costly scientific devices.

Germaine Garcia, who will be a sophomore at Connecticut College in the fall, is comparing air collected from a pasture to the Pinchot Farm site with air collected in the forest. She wants to know if there is a difference in the carbon dioxide, methane, and nitrous oxide given off in the two places because that will tell her something about the potential of different environments to add to the "greenhouse effect."

Her nickname, given to the other students, is "Snake." While the campus of Garcia's native New Haven doesn't give her a second thought, the possibility of moose hidden in the leaf litter or forest underbrush in Petersham don't give her a second thought.

Gina Rullo, on her way to a senior year at Allegheny College in Pennsylvania, used a gas analyzer to tell Garcia and others what exactly it is in the air they collected. Rich Byard and Garcia work with Rick Bowden, Ph.D., an environmental sciences professor at Allegheny College.

"I'm trying to decide between research and research," Rullo says with a smile. Rullo spent a semester at Duke University studying marine biology. She thinks that subject is her favorite, but wants to spend a summer in the forest for comparison.

"One thing I've learned is that science in general can get tedious," she says. She injects a syringe of air, held together with a rubber band, into a narrow bore tube on the syringe. "It can take a whole day to get one graph. Now I see why researchers need people like us. I found out that even an evening major can spend a lot more time in the lab than outdoors.

The beaded syringe is one example of having to make the most out of what's handy. Sharon Scott, going into her junior year at Harvard, and Phoebe Goodwin, soon to be a senior at Connecticut College, found themselves in the woodshop during the first few weeks of their internships.

They built shelves to hold the pressure cookers that sterilize soils and then carrying cases to haul instruments, the students filled sturdy glass bottles with tubes that