HARVARD FOREST
Summer Student Research Assistants

Abstracts from the 4th Annual
Harvard Forest Summer Student Symposium
9 August 1996

FOURTH ANNUAL HARVARD FOREST SUMMER STUDENT SYMPOSIUM

9 AUGUST 1996

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INTRODUCTION TO THE HARVARD FOREST

Since its establishment in 1907 the Harvard Forest has served as a base for research and education in forest biology. Through the years researchers at the Forest have focussed on silviculture and forest management, soils and the development of forest site concepts, the biology of temperate and tropical trees, forest ecology and economics and ecosystem dynamics. Today, this legacy of research and education continues as faculty, staff, and students seek to understand historical and modern changes in the forests of central New England resulting from human and natural disturbance processes. This activity is epitomized by the Harvard Forest Long Term Ecological Research (HF LTER) program, which was established in 1988 through funding by the National Science Foundation (NSF).

Physically, the Harvard Forest is comprised of approximately 3000 acres of land in Petersham, Massachusetts that include mixed hardwood and conifer forests, ponds, extensive spruce and maple swamps, and diverse plantations. Additional land holdings include the 25-acre Pisgah Forest in southwestern New Hampshire, 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 conifer plantations; 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 laboratory space, computer and greenhouse facilities, and a lecture room and lodging for seminars and conferences. An additional six houses and apartments provide housing for staff, visiting researchers, and students. Extensive records of plant research, long-term data sets, and historical information 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, with the Director reporting to the Dean of FAS. The Harvard Forest administers the Graduate Program in Forestry that awards a Masters degree in Forest Science. Faculty at the Forest offer courses through the Department of Organismic and Evolutionary Biology (OEB), which awards the PhD degree, and through the Freshman Seminar Program. Close association is maintained with the Department of Earth and Planetary Sciences (EPS) and the Graduate School of Design (GSD) at Harvard and with the Department of Forestry and Wildlife Management at the University of Massachusetts, the Ecosystems Center (Marine Biological Laboratory, Woods Hole), and the Complex Systems Research Center at the University of New Hampshire.

The staff of approximately 50 work collaboratively to achieve the research, educational and management objectives of the Harvard Forest. A sub-group of researchers meet monthly to discuss current activities and to plan future programs. Regular meetings with the HF LTER science team and with the Harvard Forest Advisory Committee provide for an infusion of outside perspectives. Forest management and physical plant activities are undertaken by our three-member Woods Crew and directed by the Forest Manager. The Coordinator of the Fisher Museum oversees many of our educational and outreach programs.

Funding for the base operation and staff at the Harvard Forest is derived from endowments, whereas research activities are supported with grants primarily from the federal government. Major research support comes from the National Science Foundation, Department of Energy (National Institute for Global Environmental Change), the U.S. Department of Agriculture, and the Andrew W. Mellon Foundation. Our summer Program for Student Research is supported by the National Science Foundation, the Northeastern Consortium for Undergraduate Science Education (Pew Charitable Trust), the A. W. Mellon Foundation, and the R. T. Fisher Fund of Harvard Forest.

Summer Research Programs

The Harvard Forest Summer Student research program attracted a diverse group of students to receive hands-on training in scientific investigations, and to gain experience in working on long-term ecological research. The program, coordinated by Chris Kruegler, Administrator at the Harvard Forest, was supported by NSF Research Experience for Undergraduates program, Collaborative Research for Undergraduate Institutions, National Institute for Global Environmental Change, Mellon Foundation, and the Harvard Forest. Students work closely with faculty and scientists, and many conduct their own independent research studies. The program includes weekly seminars from resident and visiting scientists, weekly discussions on issues pertinent to careers in science (e.g. career decisions, diversity in the scientific community, ethics in science), and field trips on soils, land-use history and vegetation of the forest. An annual field trip is made to the Institute of Ecosystem Studies (Millbrook, NY) to participate in a Forum on Jobs in Ecology, which includes discussion of environmental occupations with students and professionals employed in the field. The summer program culminates in the Annual Summer Student Research Symposium, in which students present major finds of their summer work. This year the summer program welcomed the addition of the Collaborative Research for Undergraduate Institutions (CRUI) program with nine students and three faculty from Mount Union College, Allegheny College and Gustavus Adolphus College.

FOURTH ANNUAL HARVARD FOREST SUMMER STUDENT SYMPOSIUM

9 August 1996

HARVARD FOREST - FISHER MUSEUM

8:30 A.M.	Introduction and Photographic Review	David Foster
8:45	"Central Massachusetts vegetation study: an introduction to climate, landform, vegetation, and disturbance patterns in central New England"	Dana MacDonald
9:00	"Central Massachusetts vegetation study: a comparison of overstory vegetation trends with specific focus on the towns of Berlin, Leyden, and Pelham"	Alexandria Wolf
9:15	"Evaluation of hemlock mortality and understory vegetation responses following hemlock woolly adelgid outbreaks in south central Connecticut"	Chris Lawinski
9:30	"Vegetation composition and structural characteristics of an old-growth hardwood forest on Wachusett Mountain, Massachusetts"	Kevin Dodds
9:45	"Paleoecology: Comparison of modern pollen rain and local vegetation of small ponds in central Massachusetts"	Christopher Wurster
10:00	"Spatial variations in C:N ratios of lake surficial sediments from Lake Pleasant, Massachusetts"	Sujay Kaushal
10:15	**Coffee Break**	
10:30	"Interannual variation of CO_2 flux from the soil warming experiment at Harvard Forest"	Derek Pelletier
10:45	"The effects of soil warming on root and microbial respiration: The TRUTH experiment"	Katariina Tuovinen
11:00	"Soil conditions and carbon dioxide flux at Harvard Forest"	Lauren Interess
11:15	"Variability of soil pH among three past land-use areas in a New England temperate forest"	Karli Clark
11:30	"The influence of three land-use legacies on available phosphorus in a New England temperate forest"	Shana Stewart
11:45	"Variations in total phosphorus according to land-use history on Prospect Hill and Pierce farm sites"	Laurel Schaider
12:00 Noon	"Spatial heterogeneity of soil characteristics in pit-and-mound complexes across three land-use legacies"	Scott Heath

12:15 P.M.	**Lunch**	
1:15	"The influence of rock walls on habitat selection of *Peromyscus* spp. in central Massachusetts"	Kevin Puls
1:30	"Regional patterns of hurricane damage in Puerto Rico"	Laura Hoffman
1:45	"Effect of a simulated hurricane on small mammal populations"	Kristin McCarthy
2:00	"Regional and local-scale variation in butterfly diversity: spatial analysis and field experiment"	Catherine-Astrid Mendenhall
2:15	"Initial investigation of successional transectories in response to three land-use histories"	Mark Norris
2:30	"Spatial heterogeneity and species richness of forest vegetation across three land-use legacies in central New England"	Jessica Rigelman
2:45	**Break**	
3:00	"Assessment of growth of standing trees by species and size class six years following a simulated hurricane"	Mike Leneway
3:15	"Vertical soil organic matter and root distribution in Red Maple *(Acer rubrum)* and Red Oak *(Quercus rubra)* seedlings in three land-use types in central Massachusetts"	Vicki Hunker
3:30	"The photosynthetic relationship to reproduction and to biomass in the herbaceous species*Medeola virginiana* and *Trientalis borealis* in three land-use types"	Melissa Kibler
3:45	"Changes in drought response with ontogeny in *Quercus rubra*: do juveniles cope with stress differently than adults?"	Sara Chun
4:00	"Foliar carbon exchange of eastern hemlock saplings at Harvard Forest"	Gregg Saunders
4:15	"Sub-canopy air flow: accounting for missing carbon dioxide in eddy covariance measurements during stable atmospheric conditions"	Chad Nielsen
4:45	Summer Evaluation	
5:30	Picnic	

Changes in Drought Response with Ontogeny in *Quercus rubra*: Do Juveniles Cope With Stress Differently Than Adults?

Sara Lai Ming Chun

Quercus rubra (red oak) plays a significant role in the carbon balance in the eastern United States and it is a very important species economically, yet it has recently had difficulty regenerating. We were motivated by these factors to understand the changes that occur in the species' physiological response to stress as it progresses from regeneration to its adult phase. Specifically, the two major questions we ask in this study are:

1. How do seedlings, saplings, and mature trees respond to drought in terms of gas exchange and water status?

2. Do differences in response arise from environmental differences (i.e. differences in light, water, and nutrient availability) or from developmental differences?

To address the first question, we measured gas exchange and predawn and midday water potential in seedlings, saplings, and mature trees during the drought summer of 1995 and the relatively wet summer of 1996 in three stands along Prospect Hill Road at the Harvard Forest. Preliminary results indicate that photosynthetic rates in seedlings were depressed by 73% throughout the 1995 drought summer relative to 1996. Photosynthetic rates of mature trees were only reduced by 25%. Saplings showed an intermediate response of 40% reduction. Mature trees were able to increase their water use efficiency (defined here as photosynthesis (A)/conductance (g)) by 40% during July of the 1995 drought relative to July of the 1996 wet year. Seedlings demonstrated no significant change in water use efficiency for July. Seedling predawn leaf water potential became an order of magnitude more negative as the drought progressed in the summer of 1995, whereas mature trees became only slightly more negative throughout the season.

These data suggest that different sized individuals respond very differently to drought stress. Mature trees appear to close their stomata slightly during drought thus decreasing water loss significantly while sacrificing a much smaller percentage of carbon gain. Seedlings, which have lower access to water, must close their stomata almost completely for most of the day to prevent water loss. Thus, they appear to photosynthesize only enough to maintain respiration.

To determine the importance of changes in environmental conditions with size in explaining differences in drought response, we established a field experiment to ascertain if seedlings grown under mature tree conditions, i.e. access to full sun and continuous water, would behave more like mature trees or like understory seedlings in terms of leaf physiology and anatomy. Our preliminary data show that although seedlings exposed to mature tree conditions have somewhat higher in situ gas exchange rates than understory seedlings, their maximum photosynthetic rates are only marginally higher. This indicates that environmental conditions are less important than developmental stage in determining the physiological behavior of *Q. rubra*.

Variability of Soil pH Among Three Past Land Use Areas in a New England Temperate Forest

Karli J. Clark

Past land use disturbance by humans greatly impacts current forest ecosystem processes. Severe disturbances to the soil, such as those caused by plowing, alter soil chemistry, disrupt the microbial community, and mix soil horizons.

This alteration may influence soil pH, which in turn, influences nutrient availability and can thus affect vegetation, composition and productivity. The purpose of this study was to determine the spatial heterogeneity of soil pH within and among three different land use legacies: plowed, pastured and woodlot.

From each of six 30 x 50 meter plots, (2 woodlot, 2 pasture, 2 plowed), 27 soil samples each of forest floor (ff) and mineral soil (ms) were collected every five meters along rows that were 10 meters apart. Soil pH was determined by placing fresh soil into either water or 0.01 M CaCl2 (FF 1:3 soil:water; MS: 1:1 soil:solution), and allowing it to sit for 30 minutes prior to reading pH. Plowed sites exhibited a very narrow range of pH, 3.5 - 3.75 for FF and 4 - 4.5 for MS, while the soil from the woodlot site had a range twice as wide, 2.5 - 3.5 for FF and 3 - 4.25 for MS. (See Figs. 1, 2). The reduced range in plowed sites is probably due to homogenization caused by plowing. The soil in the woodlot site was relatively undisturbed, so values were more variable and had a wider range. The pH range of pastured sites, which had an intermediate level of disturbance, also had intermediate pH range.

Soil pH values for woodlot sites were consistently lower than pH values of pastured sites, and plowed sites had the highest pH readings. Plowing disturbs the microbial community and the soil organic matter content, which probably attributes to the higher pH reading. Woodlot sites were not disturbed, therefore the pH is lower. (See Tables 1 and 2)

To examine fine scale spatial heterogeneity of soil pH, samples were taken from each site at 25 cm, 50 cm, 100 cm, 200 cm, and 400 cm away the from the original collection point. The pH gradient was only slightly more pronounced in plowed sites than in woodlot sites.

Overall, the plowed sites had a narrower pH range than pastured or woodlot sites and less variability in pH overall, Pastured sites have an intermediate range, and the pH was mildly variable across a gradient. The woodlot sites have the widest range of pH, and were only slightly more variable on a smaller scale.

Photosynthesis, Nutrient Distribution, and Biomass Allocation of *Acer rubrum* and *Quercus rubra* Seedlings in Three Land-use Legacies in Central Massachusetts

Jennifer K. Dean

The effect of land use history on forested regions of central Massachusetts has been a subject of intense study in recent years. Differences have been found in soil profiles and nutrient content between plowed (vegetation removal and soil mixing disturbance), pastured (vegetation removal only) and woodlot (little to no disturbance) sites. However, less is known about the influence of land use on the physiology of the plants in these sites. Plants are known to invest more photosynthate into stem and leaf growth in nutrient rich soil while, when nutrients are scarce, they expend more energy into developing roots that penetrate deeper into the soil. The purpose of this study is to determine the effect of different soil disturbance regimes on diurnal and potential photosynthesis, nutrient distribution, and biomass allocation of *Acer rubrum* and *Quercus rubra* seedlings. These species were chosen for study because of their abundance and the wealth of information available on them.

Fifteen seedlings of each species, ranging from 10 - 20 cm in height, were selected from three sites - plowed, pastured, woodlot. The LI-6200 Portable Photosynthesis System was used to obtain diurnal measurements of leaf-level photosynthesis in the field to develop predictive relationships between assimilation and environmental variables. Light response curves and CO_2 response curves were generated using the LI-6400 Portable Photosynthesis System to examine the photosynthetic potential of the seedlings. Preliminary results of LI-6400 light response curves (n = 6/species/site) show little variation of photosynthesis in seedlings from different land use legacies for either species (Fig. 1). This allows any differences in diurnal assimilation to be attributed to environmental variables and site-specific factors, such as overstory composition, that may result from land use history.. Comparing the two species, *A. rubrum* seedlings reached saturation at about 500 μmol $m^{-2}s^{-1}$ while *Q. rubra* seedlings continue to photosynthesize at higher rates with increasing

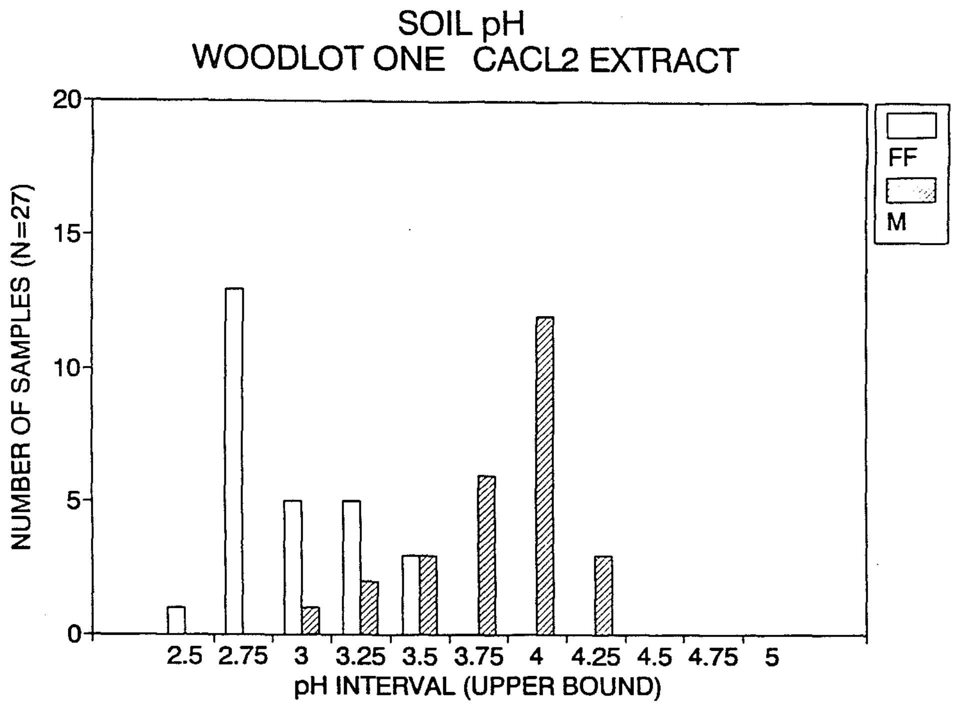


FIGURE 1. The pH range of woodlot one.

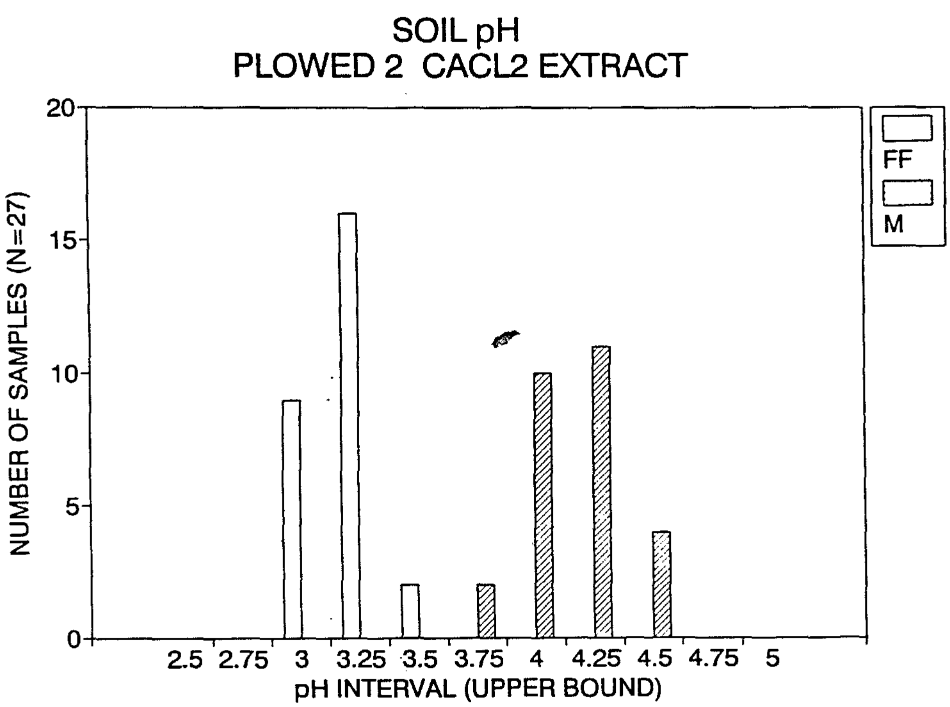


FIGURE 2. The pH range of plowed two.

K. Clark

SOIL pH IN A WATER SOLUTION		
SITE	FOREST FLOOR	MINERAL SOIL
WOODLOT 1	3.75	4.04
WOODLOT 2	3.74	3.89
PASTURE 1	3.66	4.2
PASTURE 2	3.57	4.23
PLOWED 1	3.94	4.59
PLOWED 2	3.93	4.4

TABLE 1. Average pH readings in a solution of water.

SOIL pH IN A CALCIUM CHLORIDE SOLUTION		
SITE	FOREST FLOOR	MINERAL SOIL
WOODLOT 1	2.85	3.69
WOODLO	2.91	3.45
PASTURE 1	2.92	3.92
PASTURE 2	2.77	3.84
PLOWED 1	3.81	4.16
PLOWED	3.05	4.03

TABLE 2. Average pH readings in a solution of calcium chloride.

K. Clark

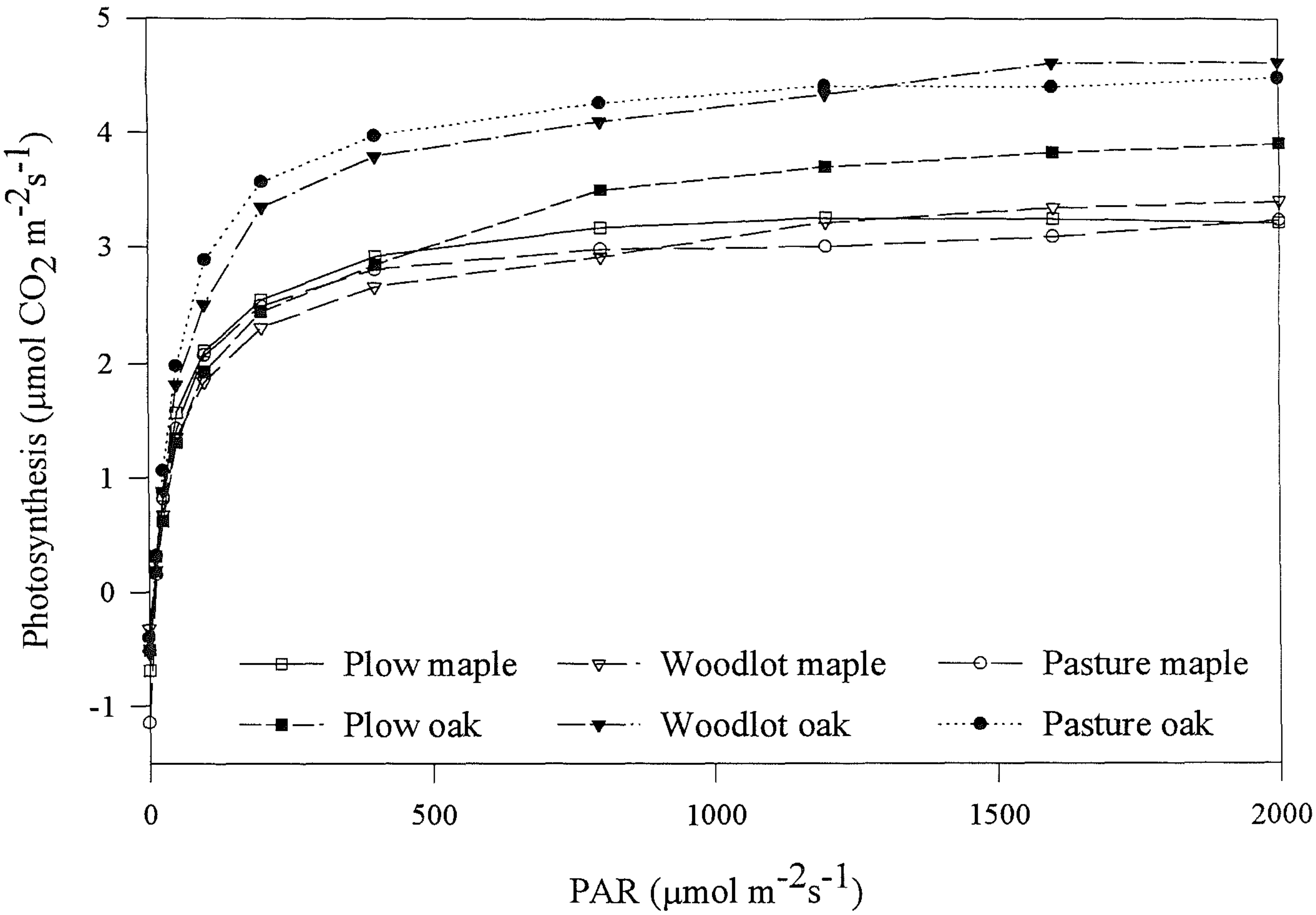


Figure 1. Light response curves for *Quercus rubra* and *Acer rubrum* seedlings from three land use legacies. Generated using the LI-6400 Portable Photosynthesis System, these curves represent the seedlings' photosynthetic potential.

irradiance. This suggests that *Q. rubra* would take better advantage of sunflecks or a less dense overstory than would *A. rubrum*.

Upon completing the collection of photosynthetic measurements, the seedlings are harvested to obtain seedling architecture and biomass allocation data. The plant tissue will also be analyzed using the CHN analyzer to determine the nutrient content of the above- and below-ground tissue. This data will be available for review at a later date.

Composition, Vegetation, and Structural Characteristics of am Old-growth Hardwood forest on Wachusett Mountain, Massachusetts

Kevin J. Dodds

In 1995, approximately 50-100 acres of old-growth forest were discovered on Wachusett Mountain in eastern Massachusetts. These stands represent some of the oldest documented forests east of the Connecticut River in Massachusetts. The presence of these old-growth stands offer a unique opportunity for research on long-term forest disturbance, vegetation dynamics, and presettlement forest structure. To describe the characteristics of the forest stands above Old Indian Trail, five permanent 20x20 m overstory plots were systematically placed along a transect. For all trees (> 8 cm dbh) within the plots, the species, dbh, and canopy class were recorded. All saplings (> 1.5m tall and < 8 cm dbh) were tallied by species. A species list was compiled for all shrubs, herbs, and seedlings encountered in each plot. Cores were taken randomly from 8 trees within each plot for radial growth analysis and age determination. Additional cores were taken from nearby trees outside the plots to gain a better understanding of the age structure and disturbance history of the stand. Volume, basal area, and orientation of coarse woody debris (>10 cm diameter) was also measured in each plot.

The stand was located on the northeast aspect of Wachusett Mountain and was characterized by trees that were widely spaced, uneven-aged, and ranging broadly in size. Dominant tree species included *Fagus grandifolia*, *Quercus rubra*, *Acer rubrum*, and *Acer pensylvanicum*. Sapling layer vegetation was comprised primarily of *A. pensylvanicum*, *Acer spicatum*, *Hamamelis virginiana*, and *F. grandifolia*. The most common understory species were *Aralia nudicaulis*, *Clintonia borealis*, *Dryopteris marginalis*, and *Smilacina racemosa*. The largest trees were *Q. rubra*, ranging from 42.6 to 76.3 cm dbh and from 170 to 322 years old. Following an initial period of oak establishment from 1670 to 1820, overstory recruitment consisted primarily of *B. alleghaniensis* and *F. grandifolia* in the 1800's, and *Acer* spp. in the 1900's (Fig. 1). The most abundant downed CWD was in decay class V and was oriented in a northeastern direction. *Acer pensylvanicum* was the most common snag found in the area and the majority of them were in decay class I. Radial growth analysis will be used to derive a more complete disturbance history of the forest.

Spatial Heterogeneity of Soil Characteristics in Pit-and-Mound Complexes Across Three Land-Use Legacies

Winfield Scott Heath

The tip-up mounds created by falling trees are known to be a significant source of disturbance in the soil of forests. However, there has been little research done on 20 to 80 year old mounds, nor has the effect of historical land uses been investigated. This study examined the impact of middle-aged (approximately 60 years old) pit-and-mound complexes on several soil characteristics, such as pH and organic matter. This disturbance was compared across three different historical land uses types: plowed, pastured, and woodlot.

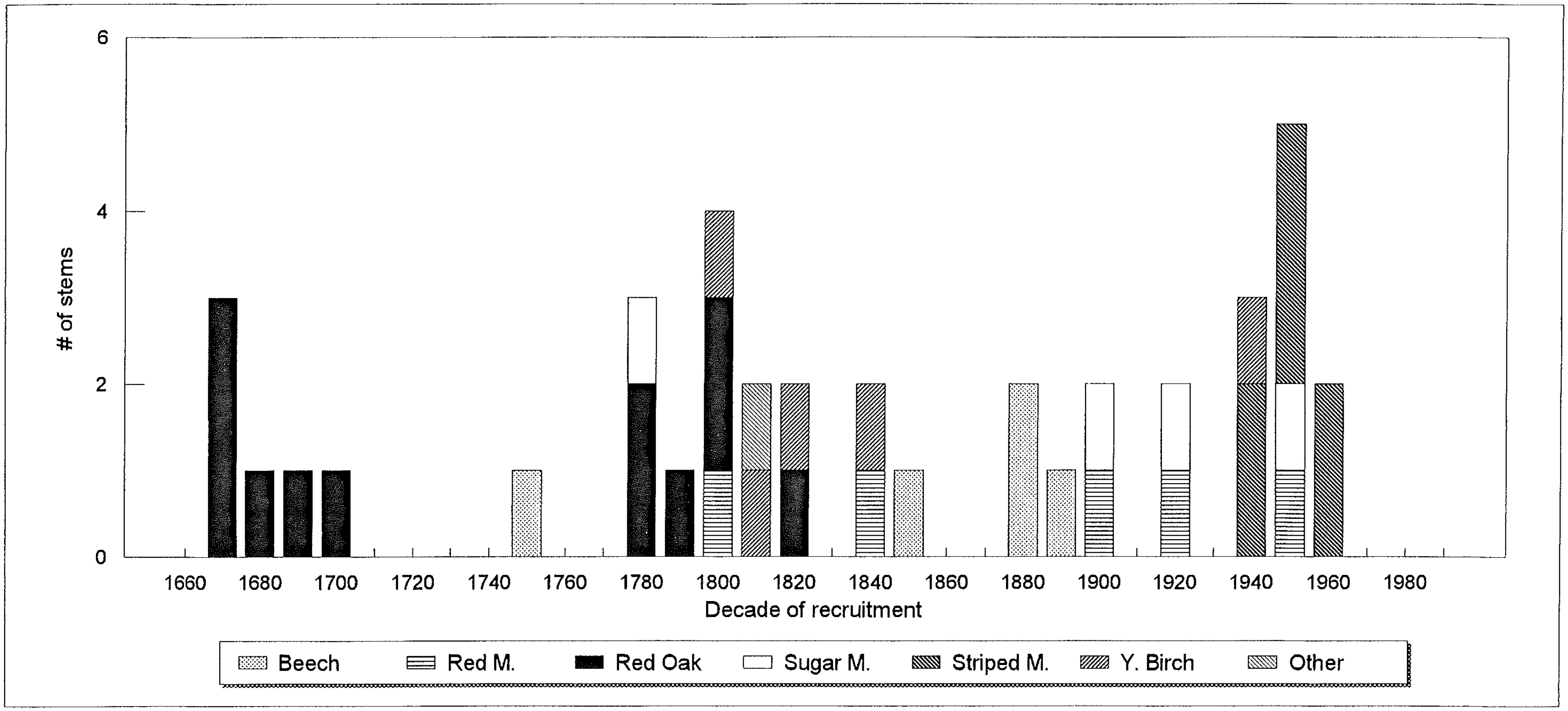


Figure 1. Tree recruitment dates by species for all cored trees within the Old Indian Trail hardwood stand.

In each of the three plots, three pit-and-mound complexes resulting from the 1938 Hurricane were identified. Forest floor and mineral soil samples were taken from three transects that ran across both the pit and mound. This determined variation at specific sites within each complex, such as the bottom of the pit and top of the mound. These samples were analyzed for gravimetric moisture, ph, and organic content by use of loss-on-ignition.

It was hypothesized that soil characteristics would range from most to least varied in the following land-use spectrum: woodlot >pastured >plowed because of the homogenization of the soils carried out in the plowed sites. This means that tip-ups occurring within these sites would have an inversely proportional impact on heterogeneity of the site, with the largest being on the plowed site. Tip-up frequency was greatest in pastured sites followed by plowed and then woodlot. Additional characteristics that may be tested in the future include cation exchange capacity, C:N ratio and phosphorus content.

Regional Patterns of Hurricane Damage in Puerto Rico

Laura Lopez Hoffman

Hurricanes are an important natural disturbance to the forests of Puerto Rico. The spatial impact of the major hurricanes of the last hundred years was analyzed using historical reconstructions of damage from newspaper accounts and also with a meteorological model (HURRECON) that predicts hurricane wind direction, wind speed, and damage. Damage reports were assembled for each municipality and assigned a damage class based on the Fujita scale which is widely used to characterize wind damage in tornadoes. Damage patterns for some hurricanes were consistent with meteorological hypotheses that the damage should be stronger on the right rather than the left side of the storm track and that the storm should lose intensity as it passes over the island. Storms appeared to weaken more if they traversed the entire length of the island (Fig. 1). However, the degree of agreement with these hypothesis varied. Comparison with model predictions suggested that the actual and predicted damage patterns were similar, but that they differ by the magnitude of damage, with the model tending to underestimate damage. Surface conditions were used as an independent check of the model's ability to predict wind speed and wind direction for a specific location. Future work for the project will focus on refining the methods used to assign damage classes so that they become more appropriate for the Puerto Rican landscape and refining the HURRECON input parameters for Puerto Rico.

Vertical Soil Organic Matter and Root Distribution in Red Maple (*Acer rubrum*) and Red Oak (*Quercus rubra*) Seedlings in Three Land-use Types in Central Massachusetts

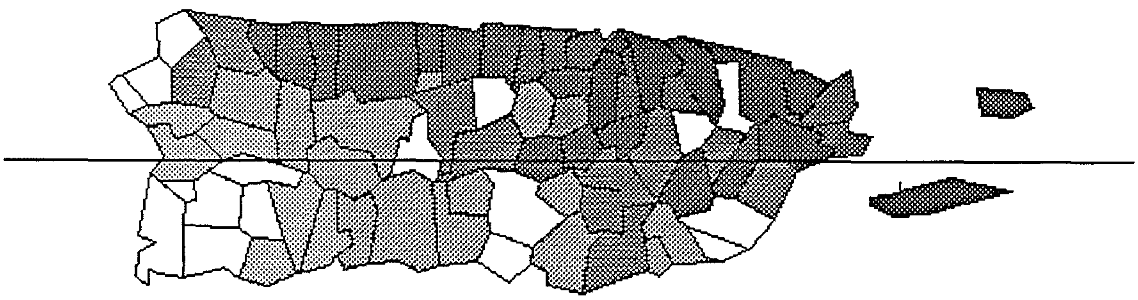
Victoria L. Hunker

Plants invest their energy from photosynthesis into three general areas of growth: leaves, stems, and roots. Overall plant productivity and competitive ability require proper allocation of photosynthate. In general, when soil nutrients are scarce, plants send roots deeper into soil, thus providing less energy for stem and leaf growth. However, in nutrient-rich soil, trees expend proportionally less growth in its roots and expend more energy on leaf and stem growth. Historic agriculturally-related land-use activity across New England has resulted in different soil disturbance regimes, potentially influencing nutrient sources for seedlings. The purpose of this study is to determine the differences in root biomass allocation in red maple and red oak by depth in historically-impacted soil environments.

Three different land use sites were selected (plowed: vegetation removed and forest floor mixed into mineral soil; pastured: vegetation removed and soil not mixed; and woodlot: some vegetation removal, no soil disturbance). Fifteen seedlings (>1 yr.) of each species were randomly chosen at each site from a pool of plants <20 cm. in height and leaves > 2 cm. diameter. Soil organic matter at depth was estimated using four soil cores taken 25cm. from each

1932 San Cipriano II

Actual Damage



Predicted Damage

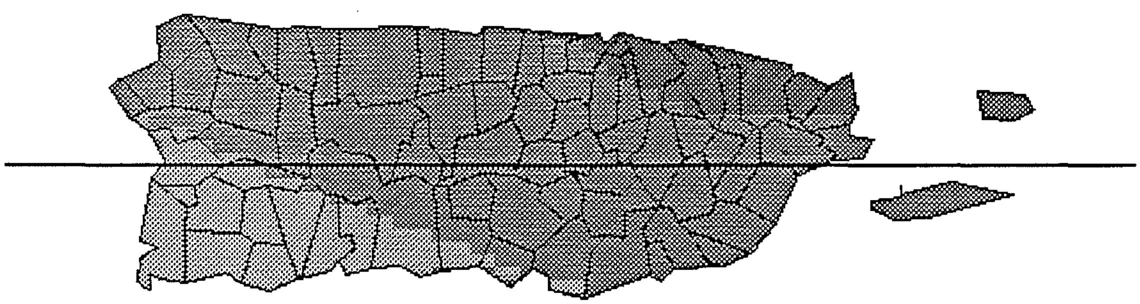
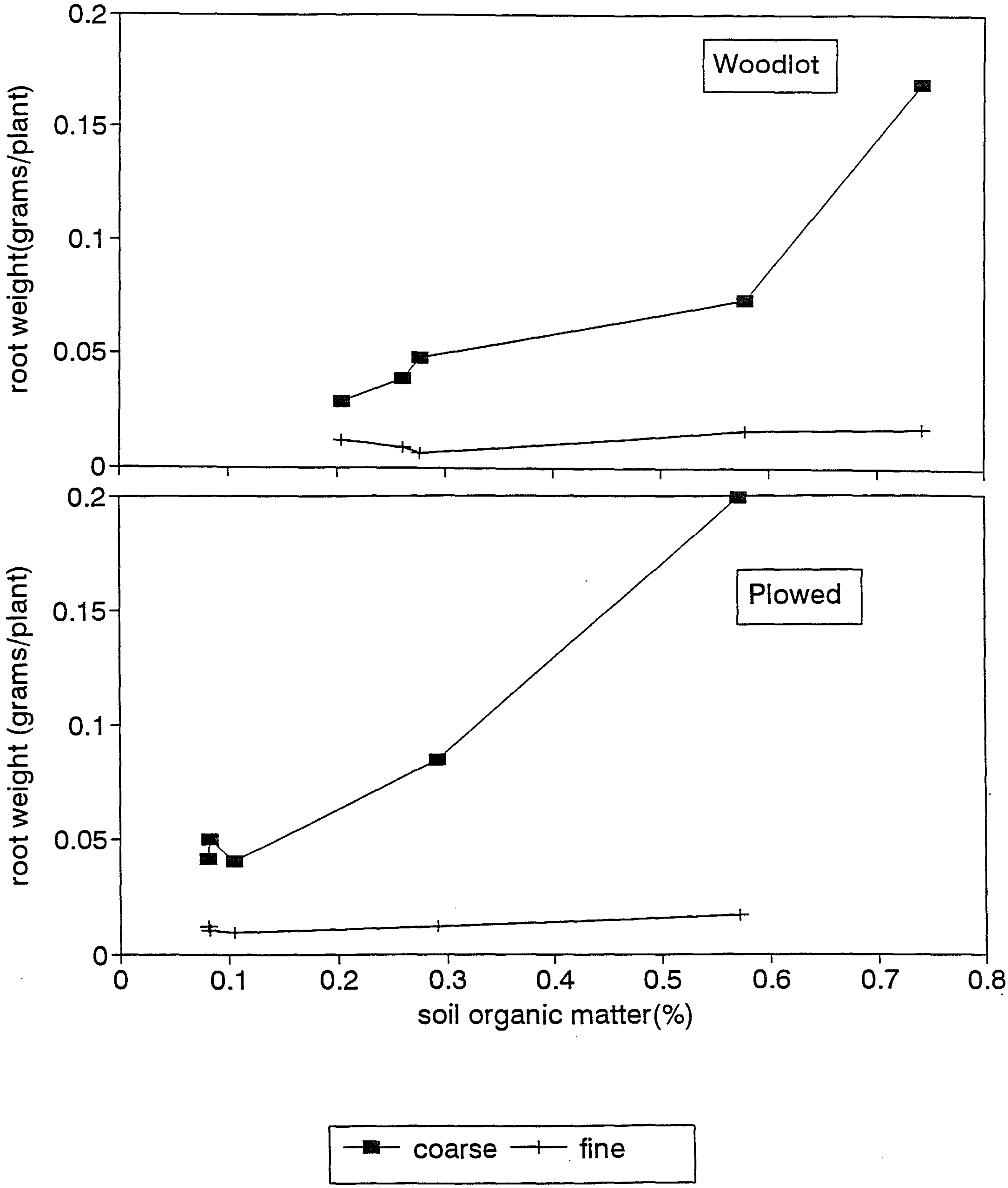


Fig. 1. Actual damage and HURRECON predicted damage for the 1932 San Cipriano II Hurricane in Puerto Rico which passed from east to west across Puerto Rico (storm track shown as a horizontal line). The scale ranges from light grey (no damage) to black (severe damage) (F3 damage on the Fujita scale). White signifies municipalities with no reported data. The Actual Damage figure suggests that there is a gradient of damage intensity from east to west. In addition, damage appears to be more intense on the right side of the storm track.

L. Hoffman

Organic matter vs. fine and coarse root mass in red oak seedlings



V. Hunker

seedling; soil was divided into 2 cm. vertical increments, and organic matter was determined using loss on ignition. The root systems were washed with water, and coarse and fine root mass at 2 cm. increments were determined.

Preliminary results (n = 5/species) show an increase in both coarse and fine root biomass with increasing soil organic matter. For coarse roots in both red maple and red oak, root weight increased from approximately .02g at 8% soil organic matter to .2g at 60% organic matter. Fine roots showed a similar but smaller change, increasing from approximately .01g at 8% organic matter to .02g at 60% organic matter. As soil organic matter increased, fine root mass increased to a greater degree in the woodlot and pastured sites than in the woodlot site (see Figs. 1, 2).

These preliminary results suggest that there are differences between sites in root mass as a function of soil organic matter. Further analyses in the study include root length, as well as carbon and nitrogen content of soil, roots, and aboveground biomass.

Soil Conditions and Carbon Dioxide Flux at Harvard Forest

Lauren Interess

Soil carbon is exchanged with the atmosphere as carbon dioxide through soil respiration, measured as CO_2 flux. Plant roots and soil microbes produce CO_2, which is cycled to the atmosphere at various rates depending on soil and environmental conditions. Soil moisture (drainage), soil and air temperatures, and land-use history are among the factors that can affect CO_2 flux. As part of a study on carbon cycling in the soil, CO_2 efflux has been measured regularly since June 1995 at six sites within a 500 m radius of the Environmental Measurement Station (EMS) at the Harvard Forest. These six sites encompass a variety of drainage classes and historical land uses. Two new sites chosen for their land-use history were added to the sampling regime in June 1996. At each site, soil and air temperatures and CO_2 flux are measured at six chamber bases. Soil moisture is quantified at the six original sites using time domain reflectometry.

CO_2 flux depends on temperature, reaching a peak during the growing season, falling close to zero during the winter months, and rising again as plant and microbe activity recommence with the spring thaw. Soil moisture fluctuations during June and July are accompanied by changes in CO_2 flux (Fig. 1). Fro this period, average soil temperature during sampling was between 14°C and 17°C. Severe rainstorms, as in mid-July, produce high moisture levels that cause sharp decreases in CO_2 flux. When soil moisture drops off, CO_2 fluxes can recover to pre-storm levels. The effects of sustained near-saturation (0.763 cc H_2O/cc soil average fur June-July 1996) are illustrated by the low CO_2 flux at the poorly-drained swamp site (Fig. 2). Soil respiration changes dramatically from season to season due to temperature, but within a season soil moisture is more responsible for differences in soil respiration.

There are some variations in CO_2 flux at different land-use sites (Fig. 2), but these variations are not great enough to confirm disturbance history as a significant factor for present soil respiration. The plowed site's CO_2 flux is comparable to those of the other well-drained sites, indicating that CO_2 processes in the soil have recovered from any soil carbon loss due to cultivation. Soil moisture appears to overshadow the effects of land-use for these sites.

Spatial Variations in C:N Ratios of Surficial Sediments from Lake Pleasant, Massachusetts

Sujay Kaushal

There has been a debate in paleolimnology whether variations in C:N ratios can be used to determine sources of organic matter within lake sediment cores. Allochthonous organic material produced by terrestrial plants contains about 6% crude protein and has a high C:N (molar) ratio of 45:1 to 50:1 whereas autochthonous organic matter produced by

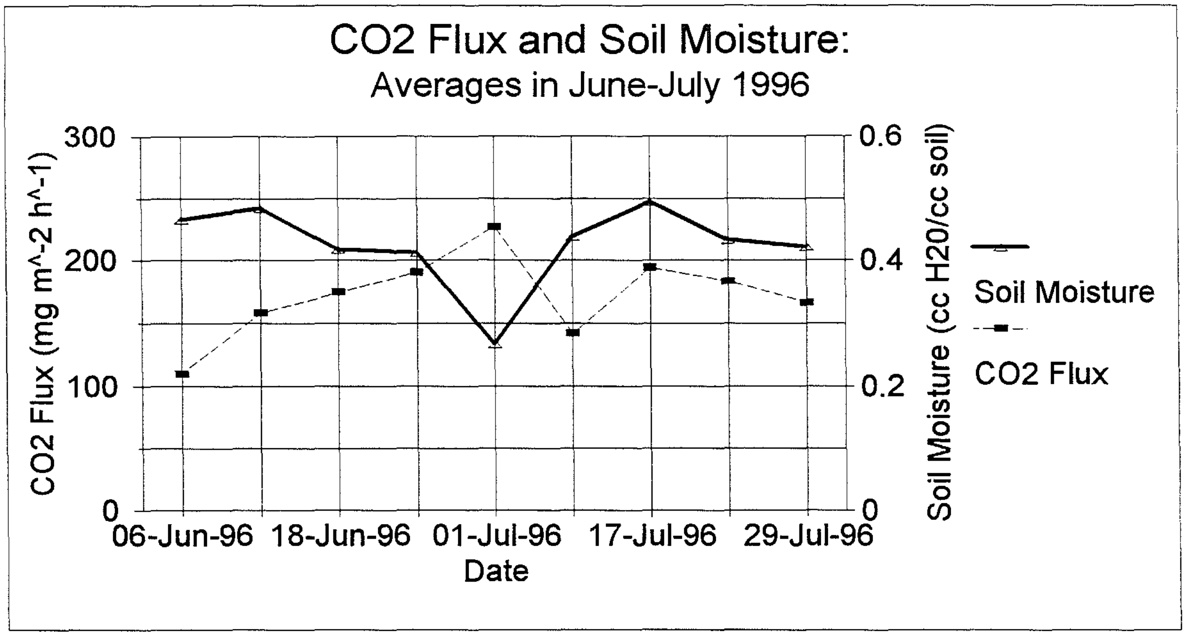


Figure 1. In June and July of 1996, soil respiration tended to decline when soil moisture levels increased. Each point represents an average of values from six sites.

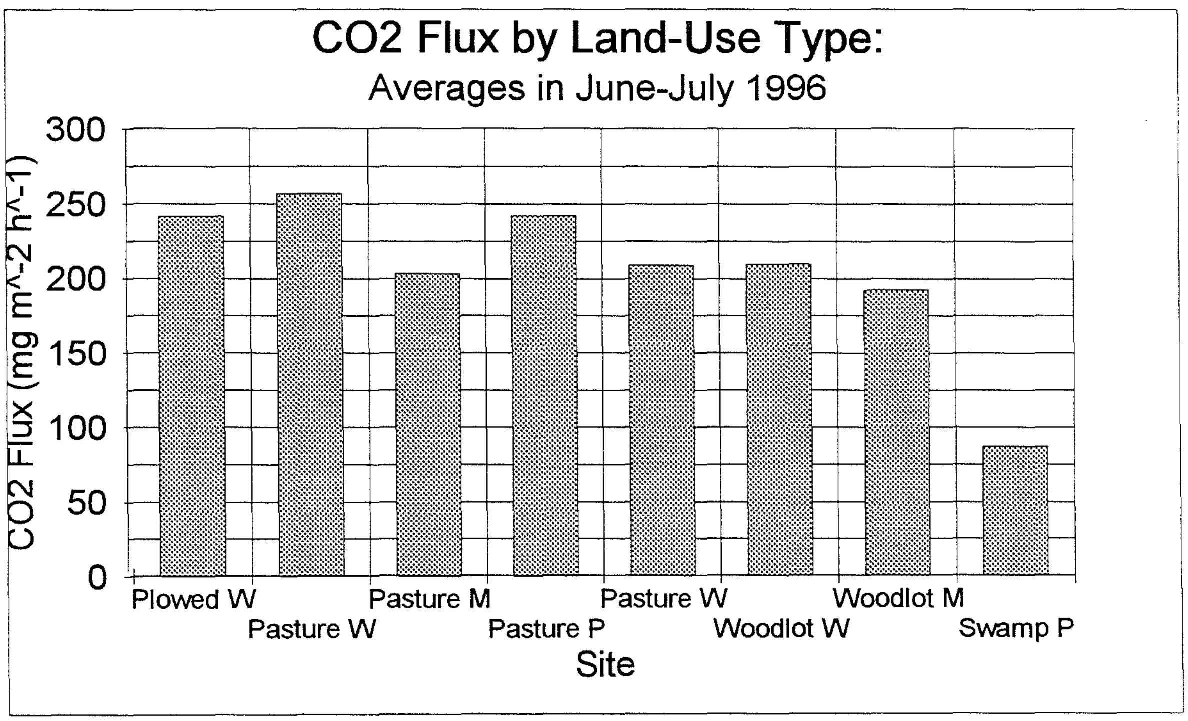


Figure 2. CO2 flux averages for each site in June and July 1996 show some differences according to historical land use. Plowed and pasture sites usually had higher CO2 flux than did woodlots. Differences due to drainage are also evident, as CO2 flux at most well-drained (W) sites was greater than at similar but moderately (M) or poorly (P) drained sites.

decomposition of plankton within the lake contains about 24% crude protein and has a much lower C:N of roughly 12:1.

The goal of this study was to try and interpret a trend of increasing C:N (within the last 200 years) in a sediment core taken from Lake Pleasant, Mass. by examining modern day spatial heterogeneity of C:N of the lake's surficial sediments. My hypothesis is that surficial sediments near major sources of allochthonous organic matter, such as stream mouths or the shoreline, will have a higher C:N than sediments near the middle of the lake, where autochthonous organic matter would predominate. Surface samples were taken along two transects: 1) from the inflowing stream to the outflowing stream, and 2) along the long axis of the lake. C:N were highest for surficial sediments taken near the inflowing stream mouth and for the sediments taken near land indicating high allocthonous inputs in these areas. C:N decreased with distance from the inflowing stream mouth (Fig. 1). The C:N within the lake basin were relatively constant and were low, suggesting the dominance of aquatic inputs of organic matter to sediments in the open lake. These results support the hypothesis that the trend of increasing C:N within the last 200 years in the core taken from the basin of Lake Pleasant may be attributed to high rates of allocthonous inputs to the lake via erosion due to land clearing after European settlement.

The Photosynthetic Relationship to Reproduction and to Biomass in the Herbaceous Species, *Medeola virginiana* and *Trientalis borealis* in Three Land Use Types

Melissa Kibler

The species variation throughout particular areas of the canopy layer of the Harvard Forest in central Massachusetts is thought to be the result of the three major land-use legacies, which includes pastured, plowed and woodlot. It is assumed that the understory layers of the three land-use sites receive varying degrees of sunlight exposure. With light being one of the major limiting factors in the photosynthetic process, it is hypothesized that the photosynthetic rates of the herbs, *Medeola virginiana* and *Trientalis borealis* will differ between sites.

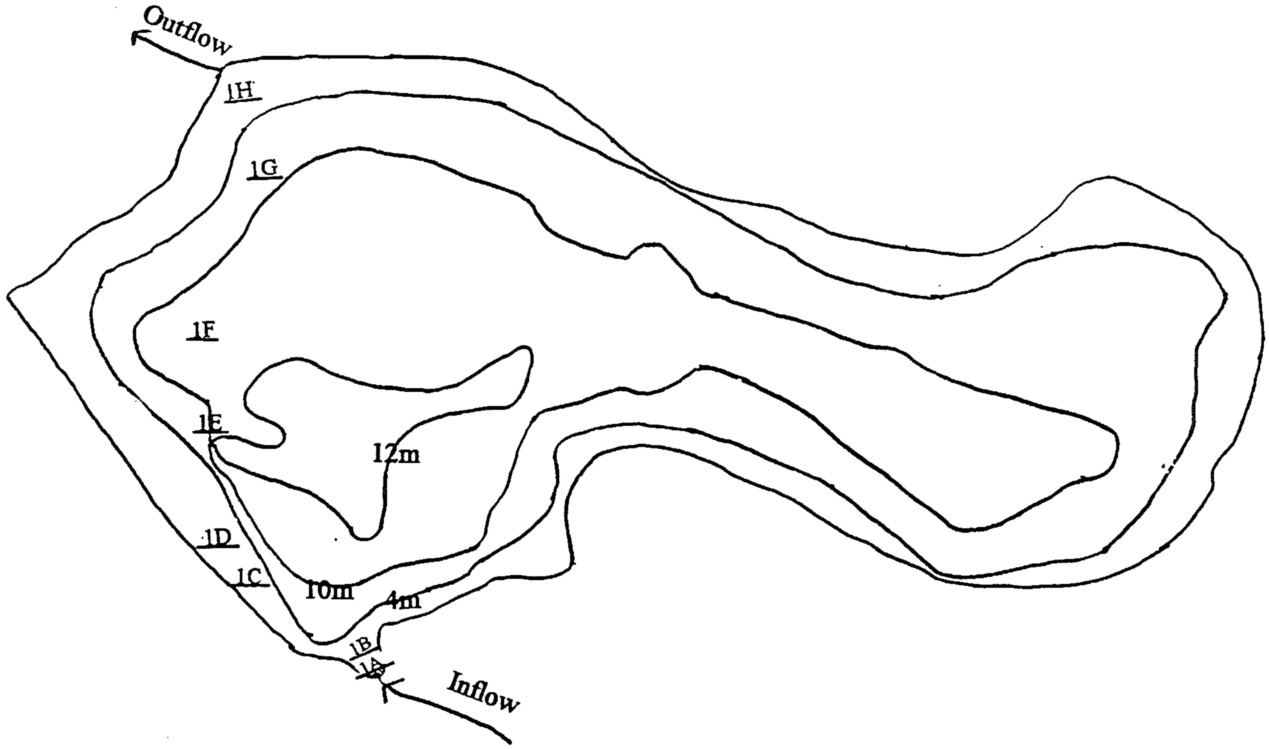
Along with site variation, it is thought that the photosynthetic rate will differ among a range of plant sizes of each species. Because of respiration rates, it is probable that the net photosynthetic rate will decrease with an increase in plant size. Therefore, the larger herbs are expected to photosynthesize at a lower rate than those in smaller size classes.

The photosynthetic capacity of a plant is also known to increase during the reproductive period. When comparing reproductive with nonreproductive herbs, it is plausible that the herbs, which are reproducing, will photosynthesize at a much higher rate in order to comply with the energy demand of the reproduction process.

M. virginiana and *T. borealis* were chosen because of their presence in all three land-use sites. The plants were randomly selected and divided into 6 different size classes and reproducing or non-reproducing groups.

Lab and diurnal photosynthetic measurements were used to determine the amount of energy that the herbs allocate to reproductive activity and to the above- and below-ground biomass of the plant. The LI-COR 6200 was used for field measurements and the LI-COR 6400 was used to measure the potential photosynthetic rate of the plants.

Results thus far show that the photosynthetic rate of the plants appears to be somewhat site specific, especially for the smaller plants, (one large and one small plant was used for both reproducing and non-reproducing). The plants in the woodlot sites generally had lower photosynthetic rates, (see Figs. 1-4). The lower light intensity in the woodlot site is believed to be the cause for the lower photosynthetic rates. The values for the pasture and plow sites are more closely related because of the similar light conditions.



Bathymetric map of Lake Pleasant showing the sites along transect one.

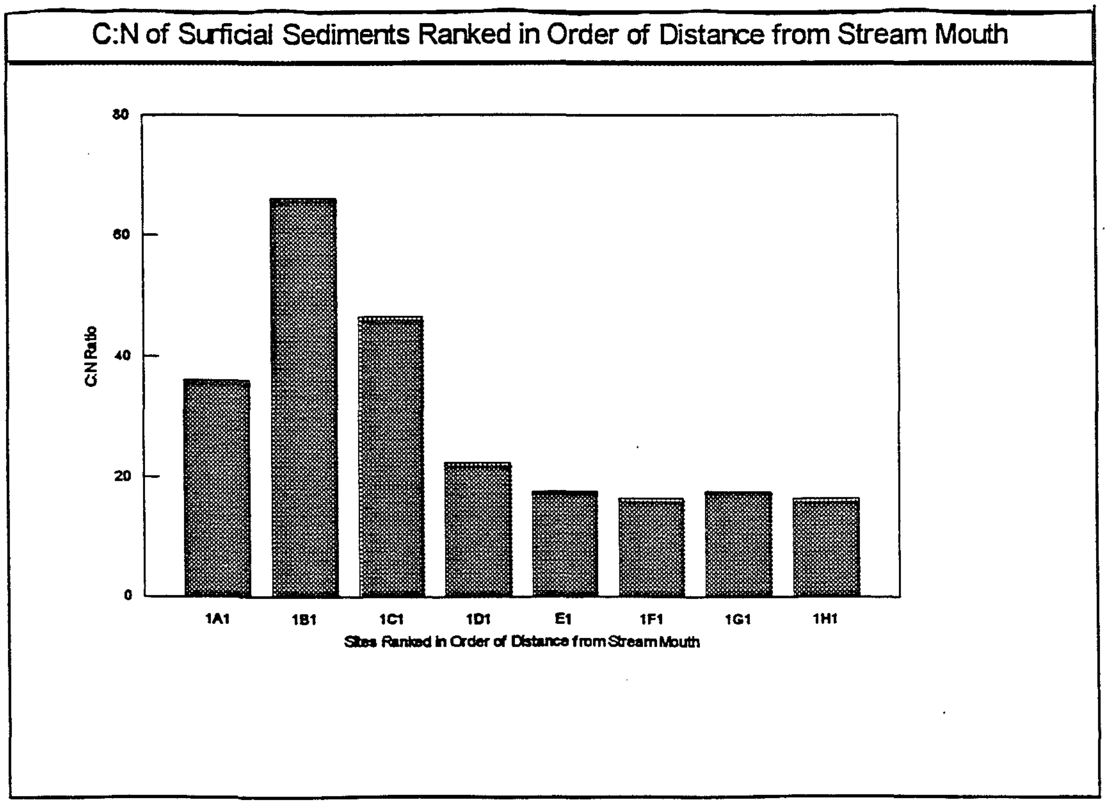


Figure 1. This graph shows the decrease in C:N ratios of surficial sediments along the transect from the inflowing stream mouth to the outflowing stream.

S. Kaushal

Figure 1. M.virginiana (nonreproducing)

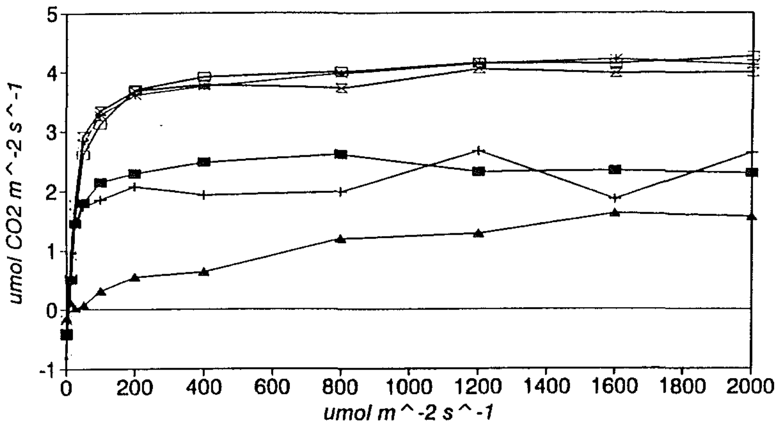


Figure 2. M. virginiana (reproducing)

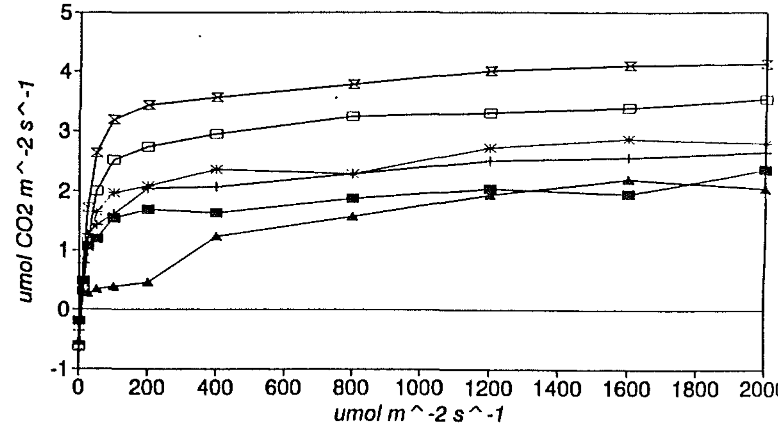


Figure 3. T. borealis (nonreproducing)

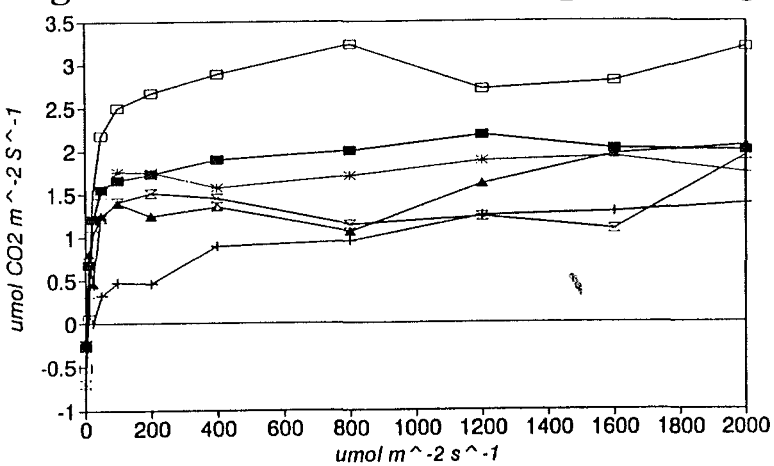
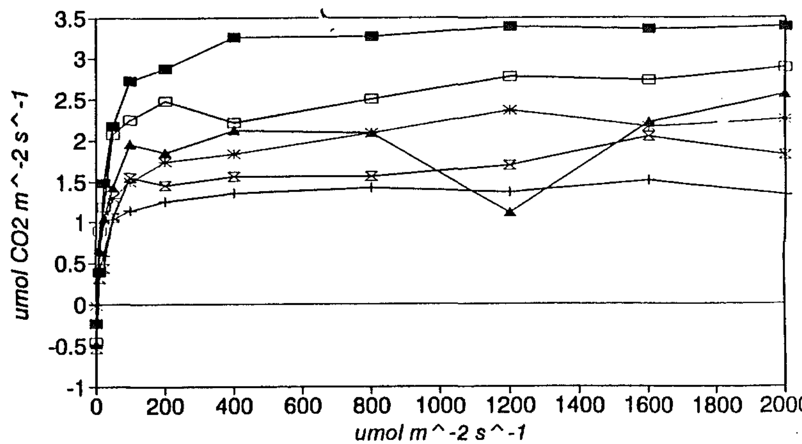
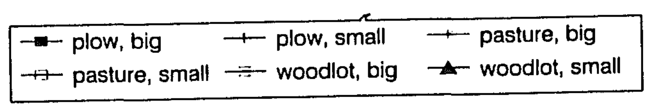


Figure 4. T. borealis (reproducing)





Figures. 1,2,3 and 4.

Light curves for reproducing and non-reproducing herbs, *Medeola virginiana* and *Trientalis borealis* in the plowed, pastured and woodlot sites. Each species is represented by one smaller and larger plant in each site.

No apparent distinction can be made between the photosynthetic rates of the reproducing plants and the non-reproducing plants. In some instances the reproducing plant has a higher rate, yet other plants show higher rates for the non-reproducing plants. Further analysis of the data and microclimate information should determine the cause.

Data for the question of biomass is still being processed and will be analyzed at a later date.

Evaluation of Hemlock Mortality and Understory Vegetation Responses Following Hemlock Woolly Adelgid Outbreaks in South-central Connecticut

Chris Lawinski

Since its introduction in 1985, Hemlock Woolly Adelgid (*Adelges tsugae*), a small, aphid-like insect, has been selectively killing eastern hemlock (*Tsuga canadensis*) trees in south-central Connecticut. The ecological consequences of HWA will be especially dramatic in areas where hemlock is the dominant tree species, due to the unique microenvironment of light, temperature, moisture, and acidity that hemlock creates. When hemlock canopies thin as the trees start to die, the microenvironmental characteristics change, and species that were formally excluded from these habitats, especially black birch (*Betula lenta*), begin to establish. Major questions concerning the death of hemlock, and the subsequent vegetation response, include:

1. How quickly, following initial HWA infestation, has black birch become established across the landscape?

2. How rapidly have hemlock trees died as a result of HWA and does this rate affect the rate of birch recruitment? Is hemlock mortality affected by age, dbh, or canopy class?

3. Is the rate of birch recruitment affected by site or stand characteristics such as hemlock importance value, percent hemlock mortality, or the amount of light reaching the forest floor?

In 1995, 8 hemlock-dominated stands were selected in south-central Connecticut to address these questions. At each site, 5-10, .04 ha permanent plots were established along representative transects. All trees (woody stems >8cm dbh) were recorded by species and dbh, and assigned a canopy class based upon the amount of intercepted light received by the crown. In addition, all saplings (woody stems < 8cm dbh and >1.4 m in height) were tallied by species within each plot. Forest floor light conditions were measured in each stand using 50-100 photosensitive paper sensors. The percentage of dead hemlock trees and saplings at each site was determined during 1995 and 1996.

In 1996, 40 randomly selected trees per stand were cored at breast height for age determinations and radial growth analysis. The annual growth increments of selected cores were measured to the nearest .01 mm. with a Velmex measuring device. In each of 3 stands heavily damaged by HWA, the height of 50 randomly selected black birch seedlings was recorded. Establishment dates were determined for these seedlings by aging cross sections cut at ground level.

Hemlock mortality varied considerably across the study area, ranging from only 5% in a healthy stand to > 95% in two heavily damaged stands (Fig. 1). Between 1995 and 1996, stands experienced only 0-10% additional mortality. By measuring radial growth increments, we estimated the date of adelgid infestation to be between 1989 and 1991. In several stands, understory vegetation responded immediately after hemlock became infested. Average stand age, which ranged from 68-109 years, did not appear to affect hemlock mortality or seedling establishment.

The initial results of this study suggest that hemlock decline resulting from HWA may take longer than was originally expected. In addition, response of understory vegetation to hemlock decline has been surprisingly rapid in some stands. In other stands however, this response has been much more gradual. This points out the need for continued, long-term research into the effects of HWA.

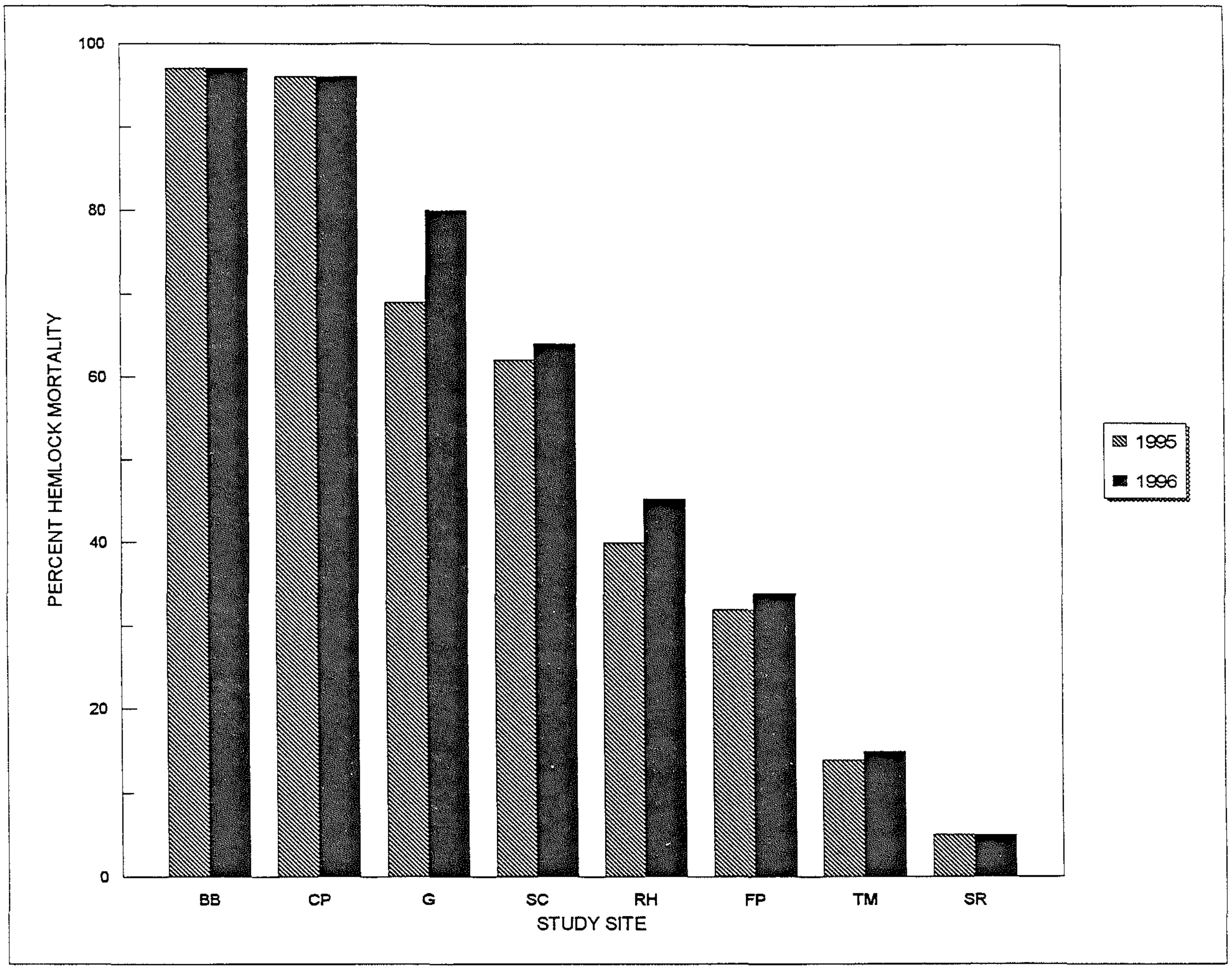


Figure 1. Overstory hemlock mortality of 8 hemlock-dominated stands in south-central Connecticut following HWA infestation.

C. Lawinski

Assessment of Growth of Standing Trees by Species and Size Class Six Years Following a Simulated Hurricane

Michael P. Leneway

In the central New England area, hurricanes have been important in determining forest succession. Wind disturbance creates both small and large forest gaps that both suppressed understory and dominant overstory trees compete to fill. By measuring tree growth, we can assess both long term change in the dominant species in an area, and short term survival of the current dominant species.

In order to study questions about the effects of wind disturbance, a hurricane was simulated in the Tom Swamp tract of the Harvard Forest in 1990. The disturbance was modeled after a hurricane that passed nearby in 1938. The experiment took place in a stand dominated by *Quercus borealis* and *Acer rubrum*. Smaller amounts of *Betula lenta*, *Betula allegheniensis*, *Carya glabra*, *Carya ovata*, *Fraxinus americana*, and *Pinus strobus* are also present. Tree diameters were measured in the 0.8 ha. experiment and the 0.6 ha. control area in 1990 before the experiment and in 1996.

Six years following the disturbance, every single species and almost every single size class, on the average, grew more in the pulldown compared to the control. Overall, *Pinus strobus* averaged the most growth in the pulldown at 3.5 cm compared to 0.4 cm in the control-- almost nine times as much. *Quercus borealis* grew more than any other species in the control with an average increase of 1.9 cm. It also grew an average of 3.0 cm in the pulldown comparing fairly well with the growth of other species in the disturbance. The *Quercus borealis* control figures are not surprising since oaks make up a large percentage of overstory and super-canopy trees in both the control and the pulldown. The larger size classes of every species averaged more growth in the past six years than the smaller size classes respectively. These results are typical of most types of forest disturbance.

Central Massachusetts Vegetation Study: An Introduction to Climate, Landforms, Vegetation, and Disturbance Patterns in Central New England

Dana MacDonald

As part of long-term research conducted at the Harvard Forest on vegetation change within New England, this project continues previous work assessing the present-day forest vegetation of central northern Massachusetts. The primary goal is to produce a random regional sample of forest composition, as well as data on physiography and land use history. Results will ultimately be compared with data on early-settlement forest types interpreted from late 17th and 18th C land surveys and vegetation assemblages derived from pollen analysis of sediments accumulated over the last 2000 years. The study area encompasses 45 towns located within the diverse climatic and physiographic provinces of the Eastern Plateau, Central Uplands, Connecticut Valley Lowland, Pelham Hills, and Western Uplands. Regional differences in climate, elevation, and soil can be great. For example, the warm Connecticut Valley Lowland (60-100 m elevation) is a complex of rich, glacial lake sediments and modern alluvium and contrasts sharply with the cool Central Highlands (300-600 m elevation) composed of relatively acidic, coarse textured till. Forests of the study area can be broadly characterized into three major forests associations. Central Hardwoods of *Quercus* and *Carya* are limited to the Eastern Plateau. Transition Hardwoods of *Acer*, *Fagus*, *Tsuga*, and *Quercus* occur within all physiographic provinces. Northern Hardwoods of *Acer*, *Fagus*, *Tsuga*, and *Betula* are restricted to the Western Uplands. *Pinus strobus*, *Quercus rubra*, and *Acer rubrum* are common dominants in all three forest associations, reflecting a long history of disturbance. Superimposed on these diverse forest ecosystems are complex patterns of forest disturbance including windthrow, fire, and 300 years of clearing, agricultural abandonment, cutting, and reforestation. As physical features and vegetation vary from region to region, even town to town, so does the type and intensity of disturbance. Thus, present-day forest composition reflects not only the wide variation in the climate, landforms, and soil but also overlapping disturbance of both natural and cultural origin.

Effect of a Simulated Hurricane on Small Mammal Populations

Kristin D. McCarthy

In 1990, Harvard Forest initiated a long term research project to determine the effects of a simulated hurricane on a *Quercus rubra - Acer rubrum* dominated forest in Petersham, Massachusetts. Two areas were established, a 0.8 ha experimental area where the hurricane manipulation was performed and a 0.6 ha control (untreated) area. The hurricane study concentrated mainly on vegetation and no effort was made studying the effects of wind disturbance on wildlife. Habitat alterations have been well known to effect the health and composition of mammal populations. The objective of this small mammal study was to determine if a simulated hurricane influenced small mammal populations within the previously established Harvard Forest study area. I tested the hypothesis that there was no difference in white footed mice (*Peromyscus leucopus*) populations between the treated and control areas. Mark recapture was used to obtain population estimates of white footed mice in the two study areas. Trapping period included a total of 7 trapping occasions within a 2 week period. A 90m x 20m trapping grid was established within both the 0.8 ha experimental and 0.6 ha control areas. Three transects were established in each trapping grid and trapped every 10m. Sherman traps were used and baited with peanut butter and rolled oats. Each captured animal was marked with individually coded ear tags for identification. The population estimates of 30 (SE = 8.97) for the treated area and 29 for the control (SE = 7.42) were obtained using the program CAPTURE. The results indicate that there is no difference between the population size of the experimental and control areas (Z = -0.0859, P = 0.5342, power = 0.03). However, low power indicates that this study could only be used as a preliminary study and more research would be needed before any management decisions could be made.

Regional and Local-scale Variation in Butterfly Diversity: Spatial Analysis and Field Experiment

Catherine-Astrid Mendenhall

The amount of animal diversity at the micro- and macro- levels is a major concern in ecological research. In this project we examined butterfly diversity and population ecology at two geographic scales. At the broad scale, we used data from the Massachusetts Audubon Society's Butterfly Atlas. This database allowed us to produce maps of individual species' distributions as well as a map of overall butterfly species richness for the entire state. Butterfly maps will be overlain onto a land-use/land cover map of Massachusetts. This land-use/land cover map was created using USGS land use land cover data in Arc/Info format and was obtained from the EPA web site. This GIS analysis will describe patterns and associations between butterfly diversity and land use across the state.

At a much finer scale, we are examining individual variation (Fig. 1) and survival in a local population of Ringlet butterflies *(Coenonympha tullia)*. Characteristics such as eyespot development, hind and forewing markings, wing length, and body size may affect individual survival rates (Fig. 2). Sex differences in behavior such as predator-avoidance techniques may also affect a Ringlet's life span. These relationships have been quantified with the use of a mark and recapture technique. This scale of observation is important because ecological processes acting on individuals may produce broader ecological patterns.

We will also experimentally manipulate the phenotypes of Ringlets in the field, adding and subtracting eyespots and monitoring survival. Work examining Ringlet diversity will also use the Harvard Forest Insect collection. This collection, containing over 1500 Ringlet specimens, will be examined to determine the relationships among phenotype, wing damage, and age of the butterfly. This work will also provide additional tests of the relationships among phenotype, predator avoidance behavior, and survival.

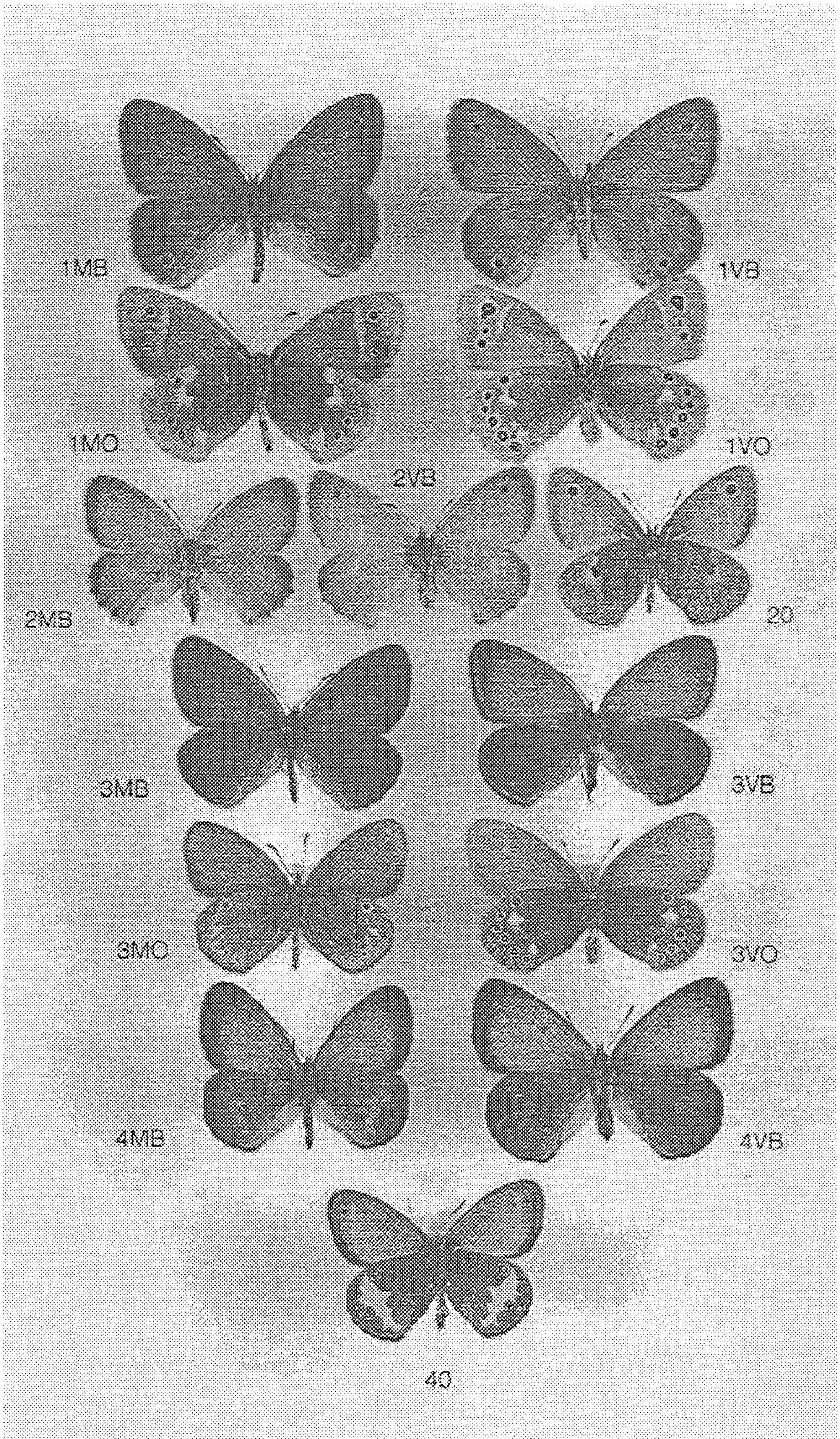


Fig. 1. Individual variation in Ringlet phenotypes

C.-A. Mendenhall

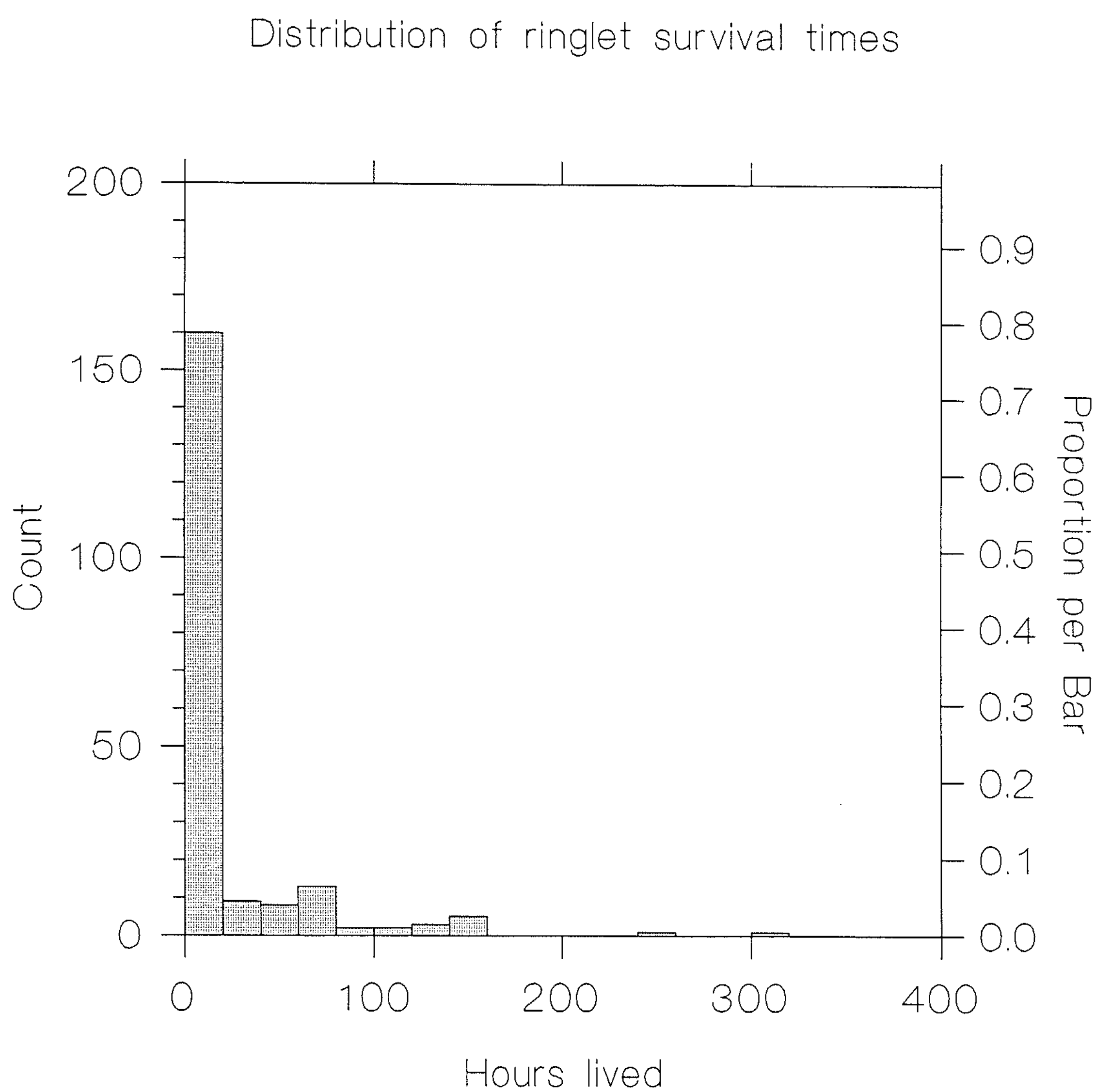


Fig. 2. Distribution of survival times in a sample of marked Ringlets observed in Petersham

C.-A. Mendenhall

Subcanopy Air Flow: Accounting for Missing Carbon Dioxide in Eddy Covariance Measurements During Stable Atmospheric Conditions

Chad D. Nielsen

Net fluxes of CO_2 are measured continuously at Harvard Forest from an instrument tower. The measurements occur above the canopy and consist of uptake by the canopy and emission by the soil and canopy. The data can be misleading if the uptake and emissions are coming from different parts of the forest. One such complication is a disparity between soil chamber and tower estimates of soil CO_2 flux. A hypothesis for this difference is that subcanopy air is disconnected from the canopy and above canopy air to some degree, and that an organized pattern of horizontal air flow may exist near the ground that influences the tower measurements of soil CO_2 flux.

A neutral buoyancy bubble generator enabled the visualization of air flows for assessing randomness below 1.5 m and illuminating coherent patterns. An ultrasonic anemometer with a laptop PC allowed the collection of three-dimensional wind velocity and temperature data in several locations around the tower at four heights per location: 2.4, 1.8, 1.3, and 0.8 m. Topography had a pronounced effect on air movements including the promotion of stable up/down hill flows. Understory vegetation, especially thick ferns, dampened air movement near the ground. The average size of eddies was correlated positively with height above the forest floor (Fig. 1). A vertical convection vent was observed in a sunlit patch below a canopy gap. Stable horizontal flows were observed which carried bubbles nearly 80 m with very little ascent. Horizontal air flow components exceeded the vertical flux contribution to net movement in 26 of 28 data sets with the only exceptions occurring at 0.8 m where horizontal components were substantially dampened. The presence of organized horizontal air flows corroborates the hypothesis that subcanopy air flows may be interfering with the tower flux measurements. Further study of the nocturnal air flows is needed to illustrate the subcanopy air patterns that occur only at night and to confirm the significance of organized horizontal flows.

Investigation of Successional Trajectories in Response to Three Land-use Legacies

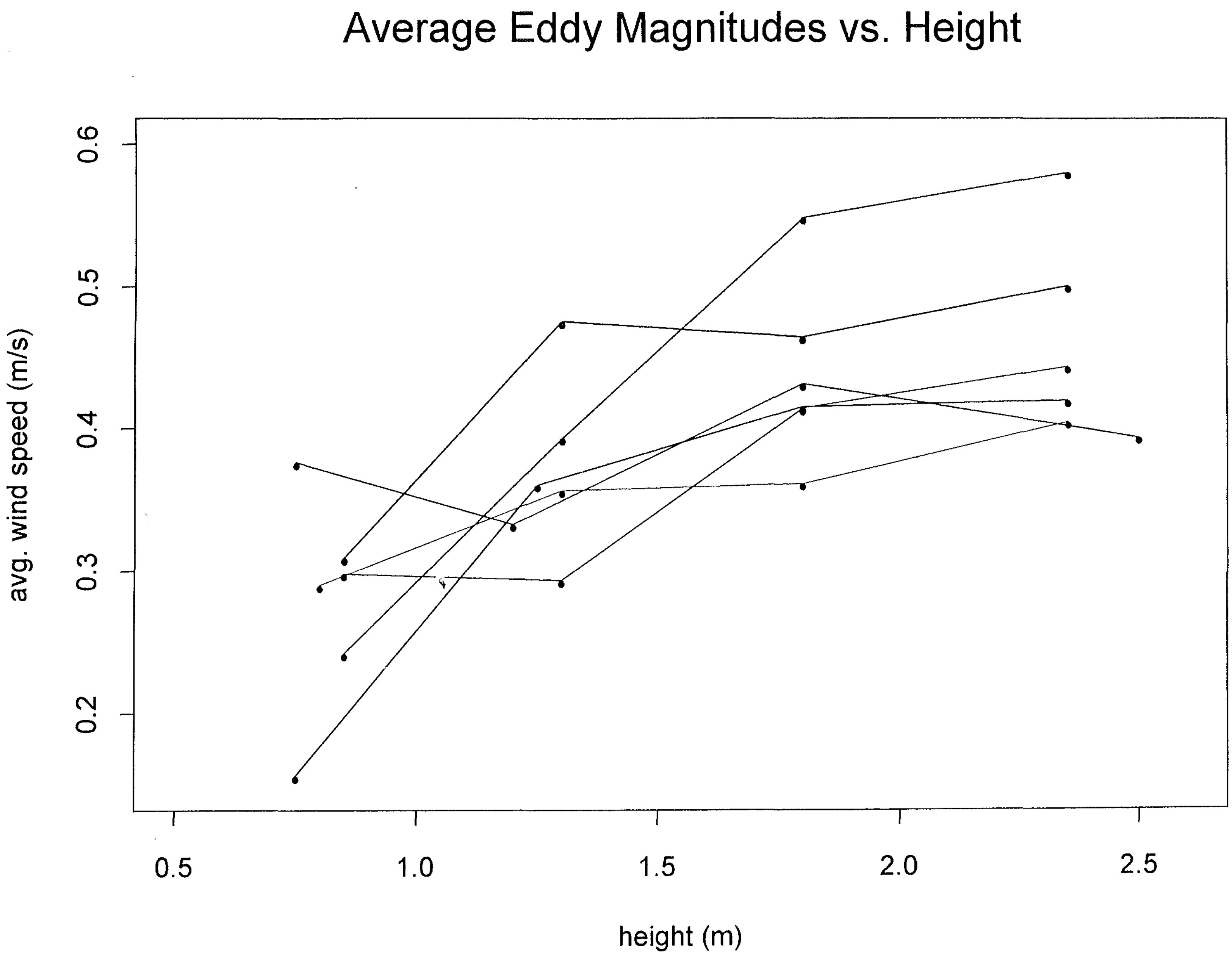
Mark Norris

As a part of the National Science Foundation's Collaborative Research for Undergraduate Institutions (CRUI) project at the Harvard Forest, six sites were established representing three land-use legacies, two each of plowed, pastured, and woodlot. These were three common land-uses during the development period of New England. The project is based on the fact that the different land-uses have disturbed vegetation and soil characteristics to different degrees of severity. This particular investigation's goal is to determine whether or not differences in successional trajectories (the rate of change of forest composition) exist among or within the land-use plots. The purpose of examining this aspect of succession is to determine if differing land-use histories have altered the trajectory of the site's future forest or how the disturbances have affected the recovery of the forests. In other words, will the plowed sites be of the same type of forest or have a similar species composition as the woodlots? Has land-use affected species composition or the successional trajectories and if so, how have these disturbances altered the successional pathway? Is there a predictable pattern of species composition within each site? For example, will the percentage of red maples remain constant or change from seedlings to saplings to the overstory and how does this compare among plots?

To accomplish this task, 30m x 50m sites were permanently staked with species identification and location conducted to 1m x 1m resolution. The data collected for all woody species was done so in five categories including <50cm in height, 50-100cm, >100cm but <2.5cm dbh, 2.5-10cm dbh, and >10cm dbh. The first three categories included the number of each species present per 1m x 1m cell and for the latter two, the trees were mapped on field sheets and the dbh measured.

Fig. 1. Each line represents a different sampling location around the EMS Tower. The average size of eddies is positively correlated with height above the forest floor.

C. Nielsen



These trajectories will be examined by comparing the percentages and abundances of each species in each of the five size classes. Secondly, GIS will be used to analyze the spatial distribution of the tree species to determine to a finer scale, the relationships between seedlings, saplings, and the overstory to better model the future forest composition.

Interannual Variation of CO_2 Flux from the Soil Warming Experiment at Harvard Forest

Derek Pelletier

Since 1991, the Soil Warming experiment at Harvard Forest has measured the differences in CO_2 and other trace gas fluxes from soils warmed 5° C above ambient temperature. The soil respiration data collected at the soil warming experiment are being used in conjunction with the development and validation of climate change models by the Ecosystems Center at the Marine Biological Laboratories. Measurements from the past six years show increased fluxes in heated plots, but examining the data shows variation of CO_2 flux on an annual basis and that the two most important factors dictating changes in soil respiration are soil temperature and precipitation. The purpose of our project is to gain a better understanding of what is responsible for this yearly variation.

Current and past temperature and precipitation data from the ongoing soil warming experiment and the Harvard Forest NOAA station were used to evaluate the interannual variation in CO_2 efflux. Initial data shows a strong correlation of CO_2 flux relative to temperature for 1992 to 1994. The average air temperature and CO_2 effluxes progressively increased over the period 1992 to 1994. In 1995, the warmest year of the experiment, CO_2 fluxes dramatically dropped off in mid to late summer (see Fig. 1). The drop off can be attributed to a dry spell in 1995 that extended back to the fall of 1994. A better understanding of the water balance for Harvard Forest is necessary in order to better quantify the role of precipitation and soil moisture in CO_2 flux. Once this is obtained, it may then be possible to incorporate soil moisture or precipitation into a model of CO_2 flux for the region.

The Influence of Rock Walls on Habitat Selection by *Peromyscus* spp. in Central Massachusetts

Kevin Puls

Rock walls are a familiar sight in much of New England's landscape and have an impact on the fauna and flora that surrounds them. Small mammals may seek to live in the walls for a variety of reasons meaning that the spatial distribution of a species may not be random. The focus of this project is to determine how rock walls have influenced the distribution of individuals of *Peromyscus* spp.. Any impact of a wall on habitat selection may seem insubstantial at first. However, there are hundreds of miles of stone walls scattered about small areas of New England. This results in walls having a potentially large effect on the distribution of small mammals. Though not a focus of this experiment it is interesting to note that a non-random distribution of seed eating mammals may lead to non-random seed dispersal of select species of plant life. This may imply indirect effects of walls on plant community structure.

This study was performed in two second growth mixed hardwood stands the of Prospect Hill Tract of the Harvard Forest from mid-June to late July. Each of two separate sites were studied successively in the same manner. Both sites differed in species diversity and biomass. Each site contained sixty-four 3"x3.5"x9" Sherman live traps arranged in eight rows of eight parallel to the wall at five meter intervals. Each side of the wall had four rows of eight traps spaced 2.5m, 7.5m, 12.5m, and 17.5m from the wall. Traps were baited with sunflower seeds placed in mesh bags to reduce bait theft. Traps were checked every morning for eighteen days. All *Peromyscus* spp. were tagged as individuals using an ear hole punch and weighed at their first capture. Each capture location was recorded for all individuals. *Tamius striatus, Glaucomys volans, Clethrionomys gapperi,* and *Blarina brevicauda* were also captured and their locations recorded. Structural mapping for coarse woody debris, stones and trees greater than 5cm dbh was done both in and 5m beyond the 35m square area.

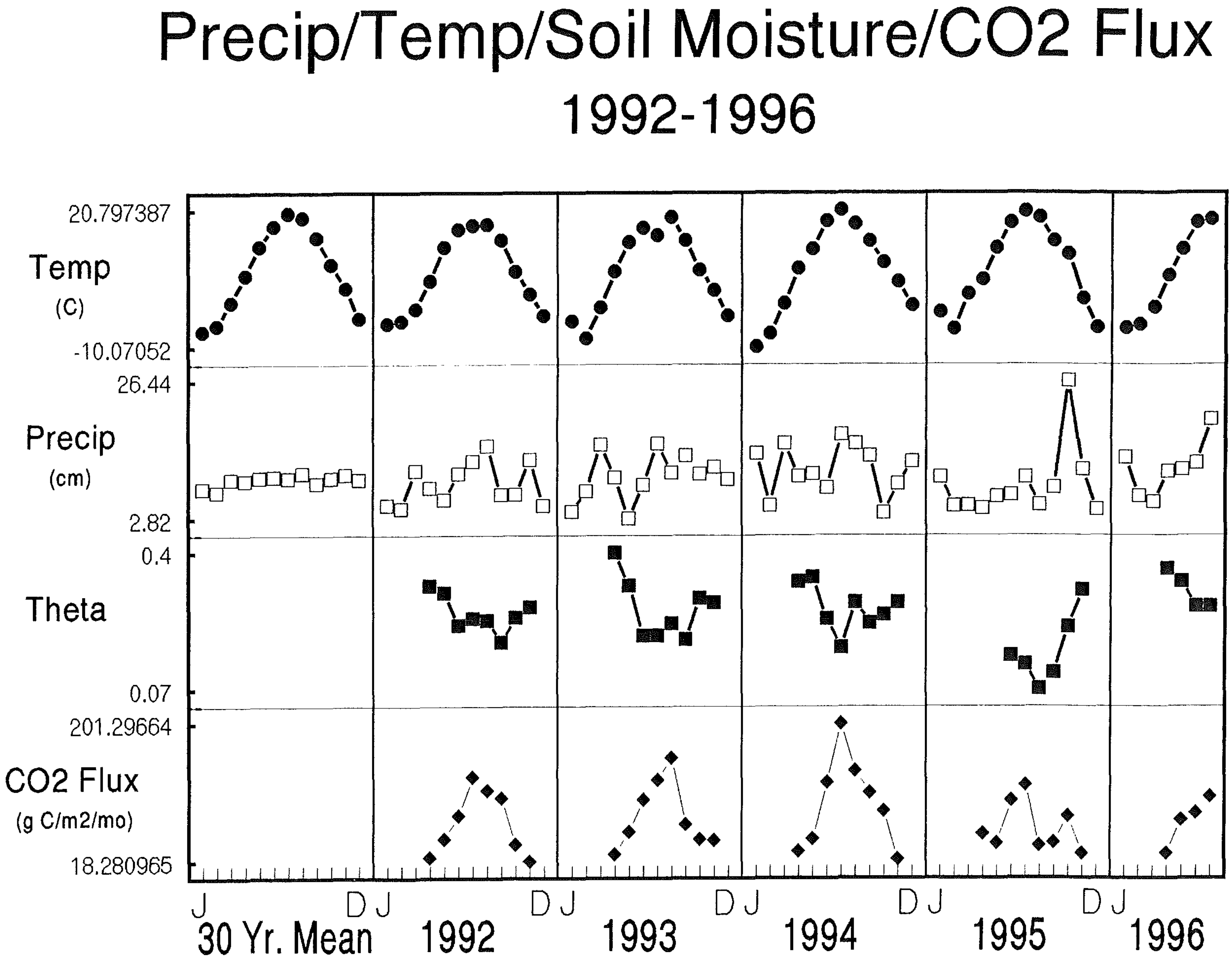


Figure 1: Temp., Precipitation, Soil Moisture, and CO2 Flux variation over five years at Harvard Forest

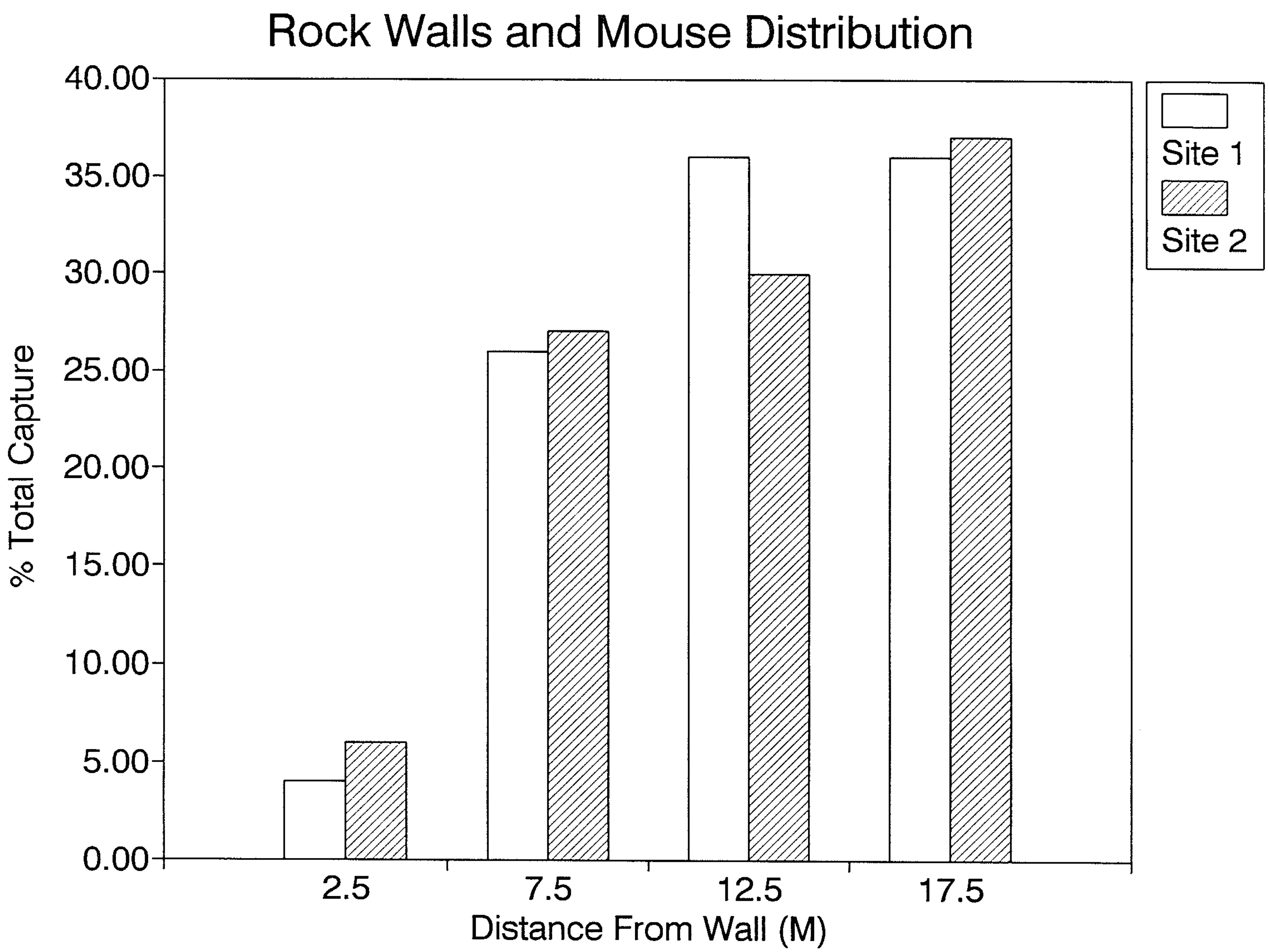


Fig. 1. Percentage of total mouse captures per site. Site 1, 110 total captures; Site 2, 128 total captures.

K. Puls

The results indicate that the walls had an adverse effect on the habitat selection by *Peromyscus* spp.. More mammals were captured in traps further away from the wall. There were 110 total captures at sight one; 4%, 26%, 36%, and 36%of the captures occurred at 2.5m, 7.5m, 12.5m, and 17.5m from the wall respectively. In site two, of 128 captures, 6%, 27%, 30%, and 37% occurred at the same respective distances from the wall (Fig. 1).

This is clearly a work in progress. Full analysis of structure and its role in habitat selection is yet to be completed. Other explanations of this unpredicted pattern may include: competition by more aggressive species of small mammals, predation patterns and food availability.

Spatial Heterogeneity and Species Richness of Forest Vegetation Across Three Land-use Legacies in Central New England

Jessica Rigelman

The present forests of Central New England are a mosaic of community types in spatially variable stages of recovery from former human land use. The three major categories of historical land use are: woodlot, pastured, and plowed fields. These three uses represent a gradient of disturbance to the community composition and ecological processes of the forests. The land uses have differing influences on environmental heterogeneity as seen in the soils, nutrient concentrations, and microclimates. The spatial pattern of plants is an important characteristic of ecological communities, and species diversity is thought to be correlated with higher environmental heterogeneity.

Six 30 x 50m sites, two for each land-use type, were divided into 5 x 5m plots. Within these 5 x 5m plots, a full inventory of species diversity was taken. Tree seedlings abundances and herb presence/absence has been taken to the resolution of 1 x 1m. A checklist of species richness was made on each 5 x 5m plot; an analysis of species composition is being investigated to see whether the sites are unique. GIS maps will be used to show the spatial pattern of species richness across the six sites (Fig. 1).

Preliminary results show that there is not a sizable difference in total species richness across the six sites. However, differences in overall species composition appear to exist. For example, *Cornus canadensis* (Bunchberry) and *Epigea repens* (Trailing Arbutus) are found only in formerly woodlot and pastured fields, whereas *Quercus rubra* (Red Oak), *Acer rubrum* (Red Maple), and *Trientalis borealis* (Starflower) are widely distributed across are three land-use types.

Over the next year, the spatial correlation between the plant populations and microenvironmental patterns will be researched. Tree seedling abundances and herb presence/absence data will be analyzed to see if there is a relationship between the environmental variables (e.g. light, carbon, nitrogen, phosphorus, pH) using both GIS and other statistical tools.

Foliar Carbon Exchange of Eastern Hemlock Saplings at Harvard Forest

Gregg P. Saunders

In the forest understory light can limit growth of tree seedlings and saplings. In order to determine how eastern hemlock (*Tsuga canadensis*) saplings can survive in the dense shade of a mature hemlock canopy, we measured the mean photosynthetically active radiation (PAR) at four locations every ten minutes from June 19 to July 3, 1996 in the understory of a hemlock stand. Dominant trees in this stand were up to 200 years old and 20 to 70 cm diameter at breast height . On sunny days, PAR incident on a horizontal surface on upper canopy foliage during midday is about 1900 μmoles $m^{-2} s^{-1}$ at the latitude of Harvard Forest (43°N). PAR at midday at the tops of saplings in the understory ranged from 15 to 780 μmoles $m^{-2} s^{-1}$ with daily averages ranging from 5 to 54 μmoles $m^{-2} s^{-1}$. Using a high-intensity incandescent light source and a Licor LI-6200 portable photosynthesis system we measured the light response of net photosynthesis (P_N) in 1994 and 1995 foliage (about 60% of all foliage present on saplings in early June) from five randomly selected saplings. P_N, dark respiration and PAR measurements were used to predict the net carbon balance of hemlock sapling foliage.

PAR at the four locations was 50 μmoles $m^{-2} s^{-1}$ or less 90 percent of the daylight hours (Fig. 1). Light curves performed on both 1994 and 1995 foliage showed that the lowest average PAR level at which there was net carbon gain was around 10 μmoles $m^{-2} s^{-1}$ and P_N became light saturated at around 300 μmoles $m^{-2} s^{-1}$ (Fig. 2A). We predicted that the average sapling would have had a net carbon loss on three of the fourteen days studied (Fig. 2B). At the darkest of the four sites sampled, the greatest average net carbon loss from 1994 and 1995 foliage in 24 hours (29.37 mmoles $m^{-2} s^{-1}$) was greater than the highest average net carbon gain in twenty four hours (18.73 mmoles $m^{-2} s^{-1}$). Based on this study, hemlock saplings depend heavily on sunny days and sun flecks to maintain positive carbon balance.

Variations in Total Phosphorus According to Land Use History on Prospect Hill and Pierce Farm Sites

Laurel Schaider

Phosphorus is an essential element for many biogeochemical processes. In order to study the effects of agriculture on total phosphorus concentrations in forest soils, total P was measured from woodlots, which were never extensively cleared, and from abandoned farmed and pastured plots that have become hardwood and conifer stands. Mineral soil samples (0-15cm) were collected from 12 sites throughout Prospect Hill. In addition, samples from horizons down to 90cm were collected at three locations with similar soils on the Pierce Farm property: two plowed sites, one abandoned in the 1880s and the other in the early 1900s, and a nearby woodlot. Soil samples were digested with a hydrogen peroxide-sulfuric acid solution to extract total phosphorus and then analyzed using a Lachat autosampler spectrophotometer.

Comparing sites throughout Prospect Hill, preliminary data indicates that total P in hardwood stands varies according to land usage: plowed > pastured > woodlot. However, similar conifer stands do not clearly exhibit this trend. Depth profiles from the sites near Pierce Farm show that the woodlot site has lower P concentrations than the sites used for agriculture, even to depths of 90cm (Fig. 1), suggesting that over time disturbance can affect more than the surface horizons. Total P content integrated over all horizons to 90cm increases by approximately 6000 kg/ha from the woodlot site to the plowed sites (Fig. 2). Carbon to phosphorus and nitrogen to phosphorus ratios were both higher on the woodlot site than on the two plowed sites. Further analysis will clarify whether this difference is attributable to relatively higher phosphorus additions from manuring or to differential responses of soil nutrients to disturbance.

The Influence of Three Land-use Legacies on Available Phosphorus in a New England Temperate Forest

Shana E. Stewart

There is an increased realization that past agricultural activities (forest removal, plowing, planting) have created different degrees of soil disturbance. These land-use legacies can influence soil nutrient patterns and processes, thus impacting long-term forest productivity. One such nutrient, phosphorus, although influenced strongly by soil disturbance

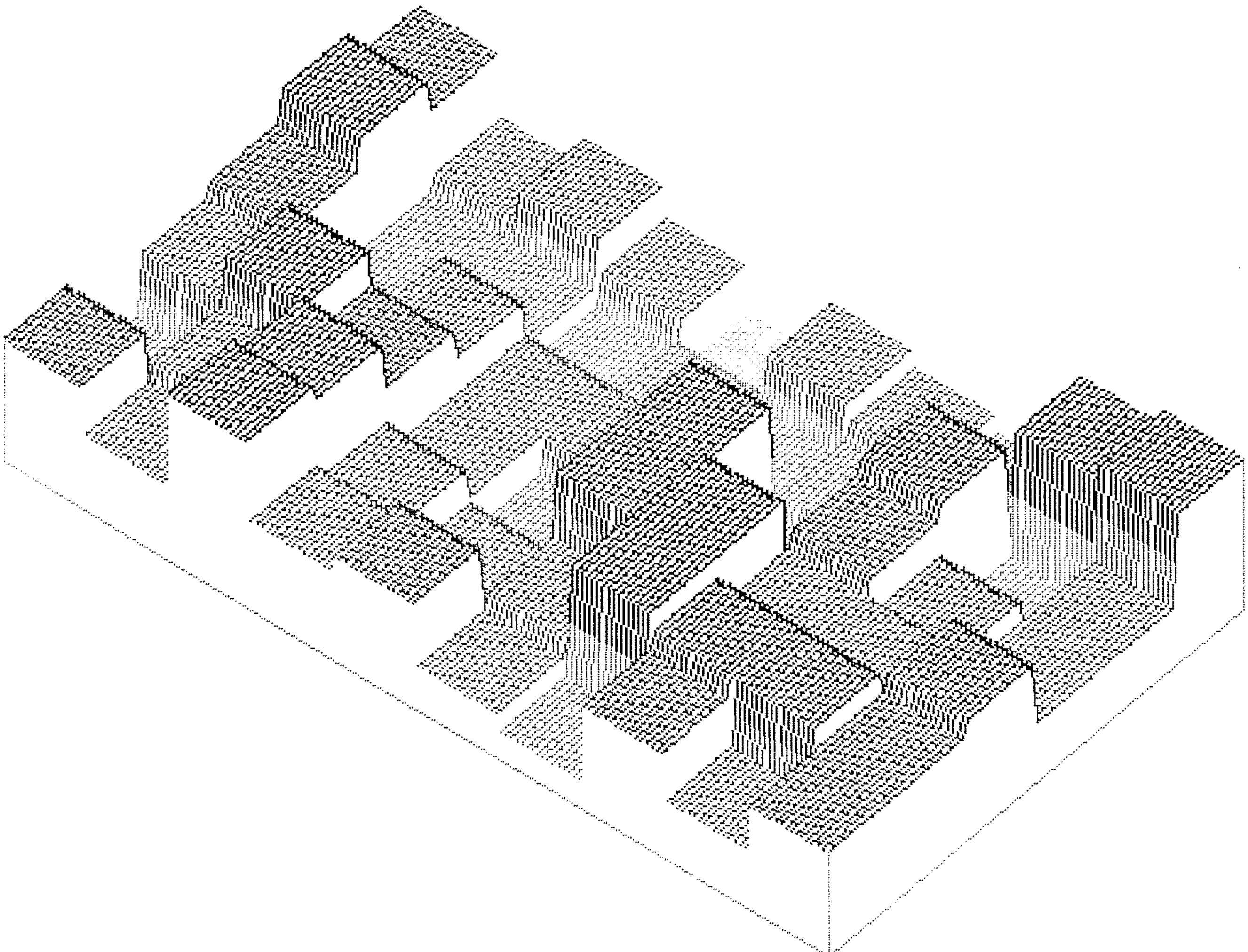


Figure 1: Species richness for each 5 x 5m plot in Plowed 2. Dark grey (25 species) represents highest diversity, whereas light grey (14 species) represents low diversity.

J. Rigelman

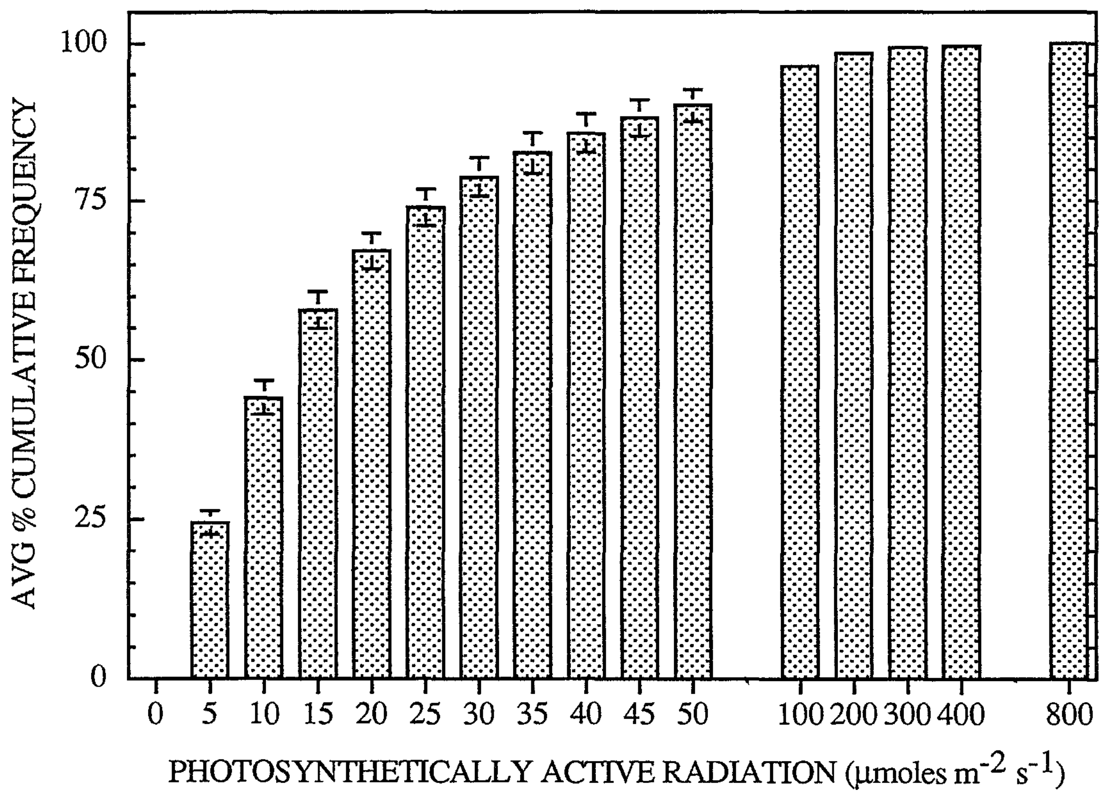


Figure 1. Average percent cumulative frequency of photosynthetically active radiation at four locations in a hemlock understory, measured June 19 through July 3, 1996

G. Saunders

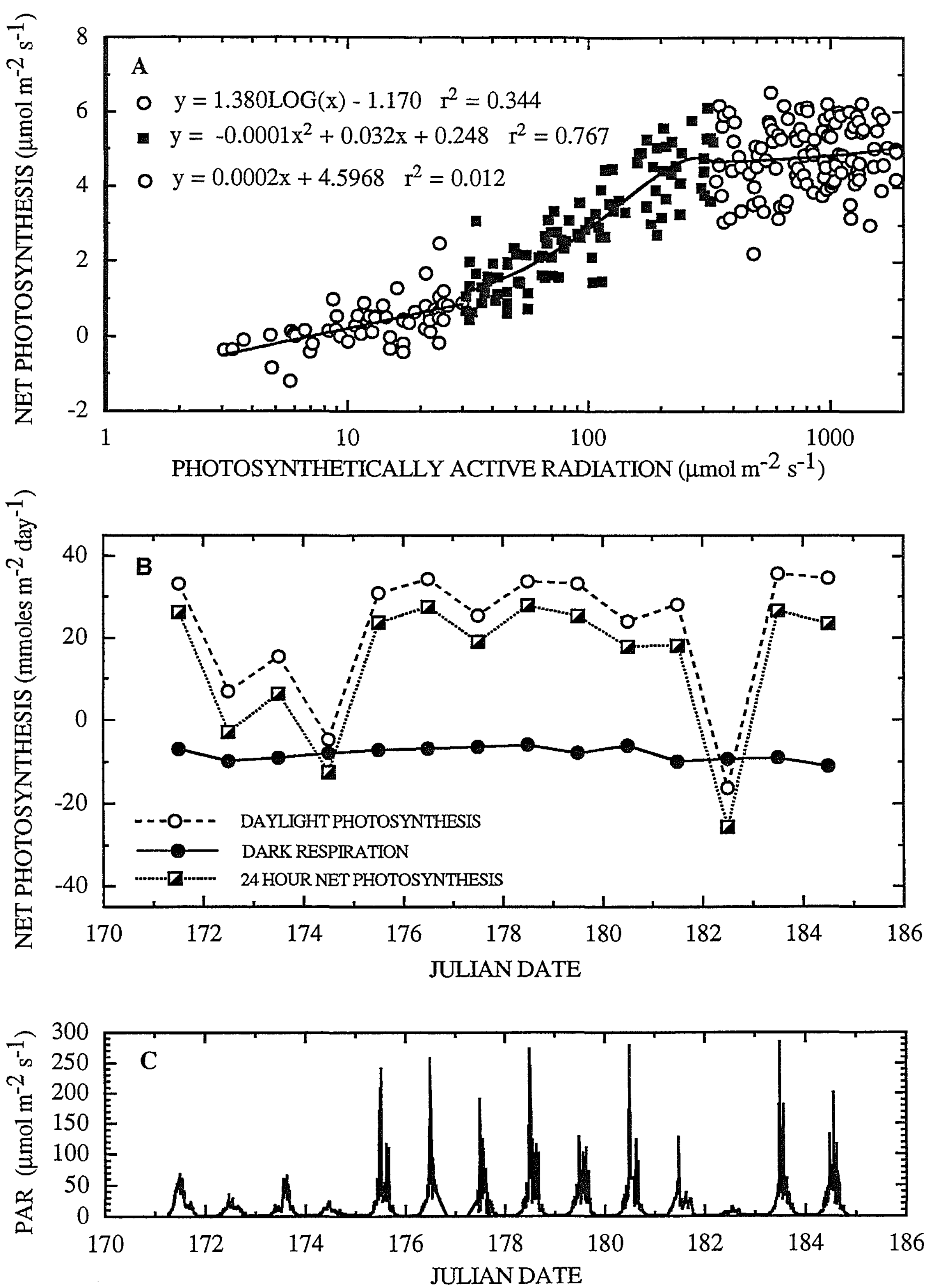
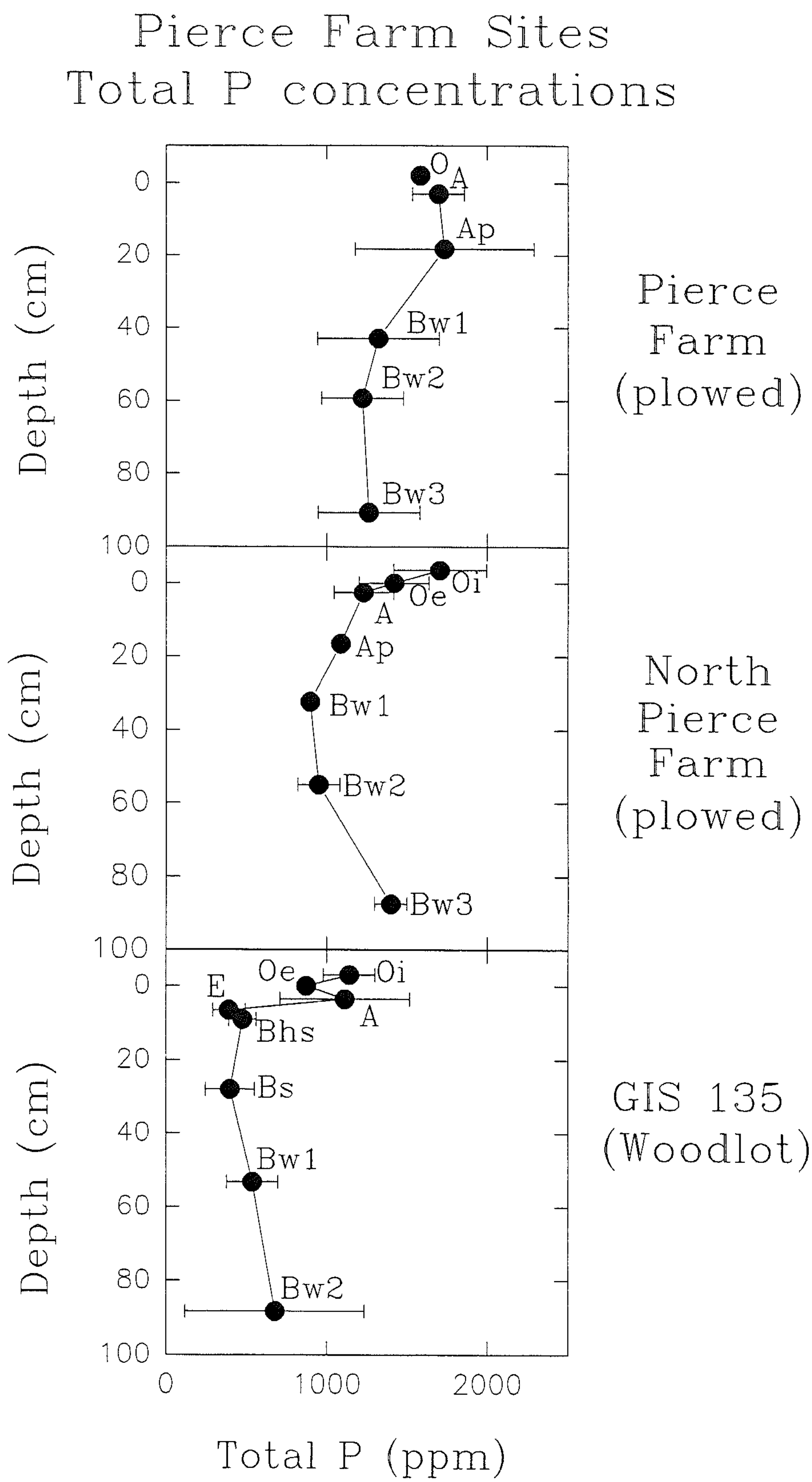


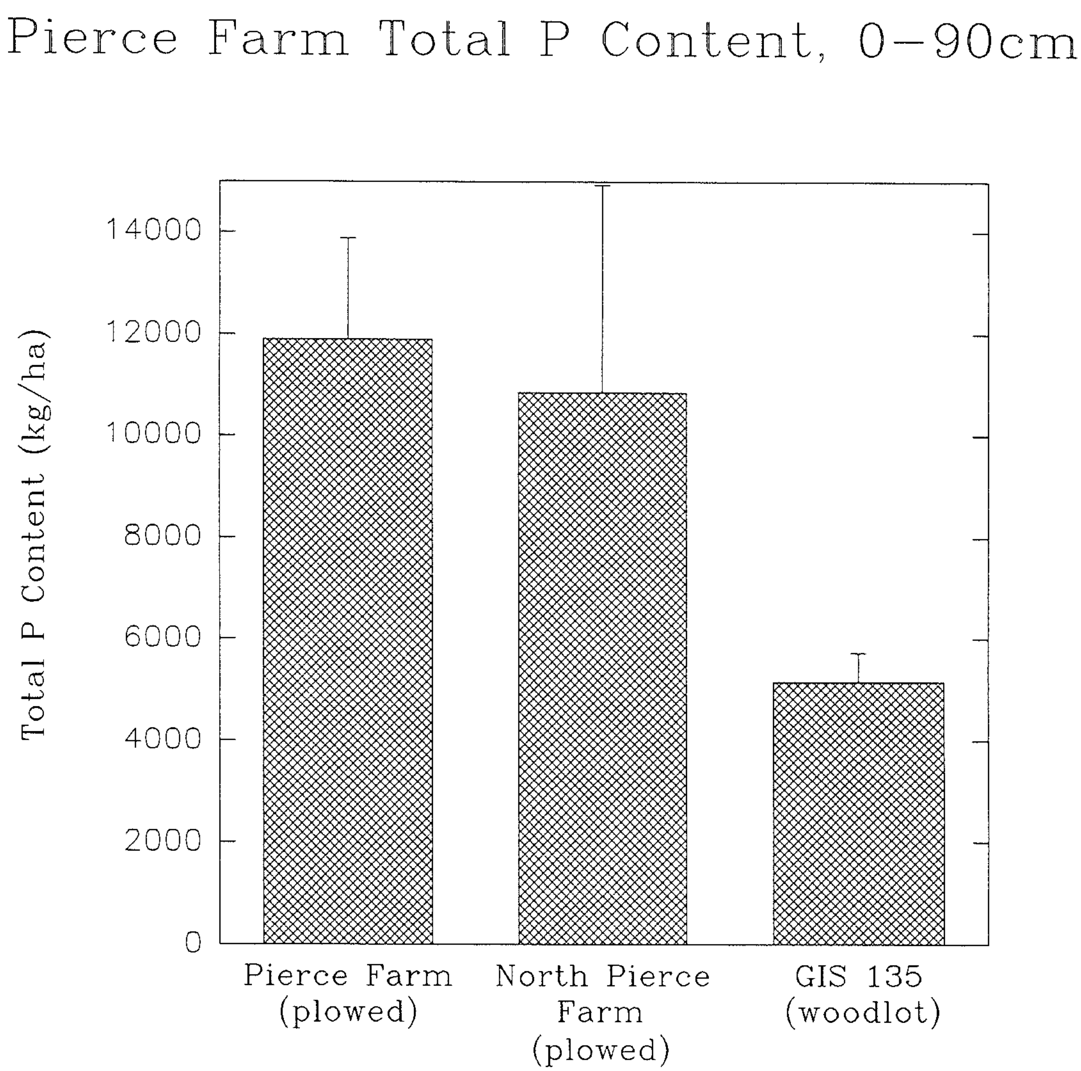
Figure 2. Light response of photosynthesis (A), net carbon exchange (B) and photosynthetically active radiation (C) in a hemlock sapling stand. Gas exchange of 1994 and 1995 foliage on five saplings was measured and PAR was sampled at four locations in the stand.

Fig. 1. Total P concentrations according to horizon on three sites near Pierce Farm. Error bars represent standard deviation and may be narrower than symbol width. (n=3).



L. Schaider

Fig. 2. Total P content integrated over 90cm. The North Pierce Farm site was abandoned in the 1880s, and the Pierce Farm site was abandoned in the early 1900s. GIS 135 is a nearby woodlot with little disturbance history. Error bars represent standard deviation. (n=3).



L. Schaider

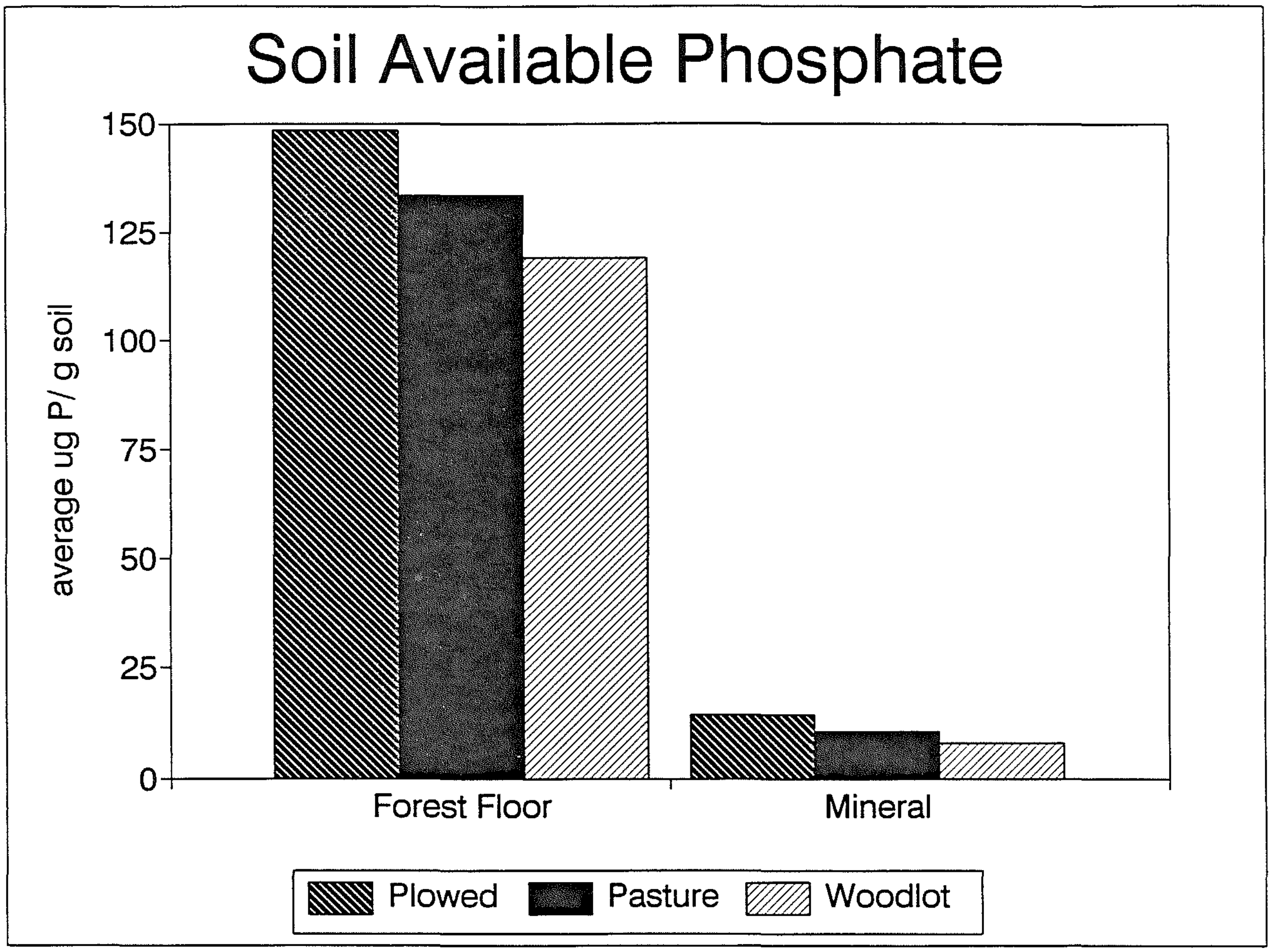


Fig. 1. Mean soil available P concentrations showing the trend of decreasing average concentrations from plowed to woodlot sites.

S. Stewart

and important to plants for many functions (i.e. construction of cell membranes, reproduction, storage of genetic information and energy processes), has been the subject of relatively few studies. The purpose of this study is to examine the spatial heterogeneity of P-availability to plants in plowed (vegetation removal and soil mixing disturbance), pastured (vegetation removal only), and woodlot (little to no disturbance) sites.

In this study, soil samples were taken from six sites at 27 points on a 5 x 10 m grid. Soils were extracted for sixteen hours using a 1.0M $NaHCO_3$ solution, filtered, and phosphate concentrations were determined on a Lachat Auto-analyzer, using a molybdate blue-ascorbic acid method.

Preliminary data shows forest floor samples had a much greater concentration of phosphate, with an average of 133.6 mg phosphate-P/ g-soil, while the mineral soil had a lower mean concentration of 11.1 mg phosphate-P/ g-soil. Woodlot sites have the lowest mean of available phosphate concentrations in the soil (119.0 mg phosphate-P per g-forest floor and 8.1 mg phosphate-P per g-mineral soil), followed by pastured sites (133.3 mg phosphate-P per g-forest floor and 10.8 mg phosphate-P per g-mineral soil), while plowed sites had the greatest mean concentrations (148.3 mg phosphate-P per g-forest floor and 14.4 mg phosphate-P per g-mineral soil; see Fig. 1). Furthermore, the mineral soil phosphate concentrations fell between 0-5 mg phosphate-P per g-soil for 50% of the samples in the woodlot and pasture sites, while in plowed site less than 10% of the samples taken fell between 0-5 mg phosphate-P per g-soil (Fig. 2).

Reasons for these phosphate concentration differences are not known presently and require further study; however, could be related to differences in forest productivity, soil pH, or species diversity.

The Effects of Soil Warming on Root and Microbial Respiration: The TRUTH Experiment

Katariina Tuovinen

Scientists predict a global temperature increase of approximately 3°C within the next hundred years (Peterjohn *et al.* 1994), yet the implications of such a rise in temperature on the global carbon cycle are not fully understood. In 1991, a soil warming experiment was initiated at Harvard Forest to investigate the impacts of increased soil temperature on soil processes.

In fall of 1994, the TRench UnTrench Heat (TRUTH) Experiment was set up to determine the percentage of total soil respiration attributable to root and microbial respiration and to explore the effects of a 5°C temperature increase on each component. Twelve (2 m by 2 m) plots consisting of four treatments (n=3) were established in the Prospect Hill Tract of Harvard Forest: 1) trenched, disturbance control (no roots, no heat); 2) trenched, heated (5°C); 3) untrenched, disturbance control; and 4) untrenched, heated. CO_2 efflux was measured weekly (Fig. 1) in addition to soil temperature and soil moisture.

Results indicate that soil moisture is not limiting to soil respiration in 1996 in contrast to 1995. During 1996, results indicate that 70% of total respiration in disturbance control plots is due to microbes and 30% is due to roots while 76% in heated plots is attributable to microbes and 24% to roots. Heating the soil 5°C increases total respiration 19% in both trenched and untrenched plots while heating increases the microbial respiration 29% and decreases root respiration 4%. The relationship between temperature and CO_2 flux is exponential with Q_{10} values of 2.70 for trenched plots and 2.92 for untrenched plots. With these findings, this experiment is attempting to discover the TRUTH about soil warming and soil respiration.

Peterjohn W.T., J.M. Melillo, P.A. Steudler, K.M. Newkirk, F.P. Bowles, and J.D. Aber. 1994. Responses of trace gas fluxes and N availability to experimentally elevated soil temperatures. Ecological Applications 4(3):617-625.

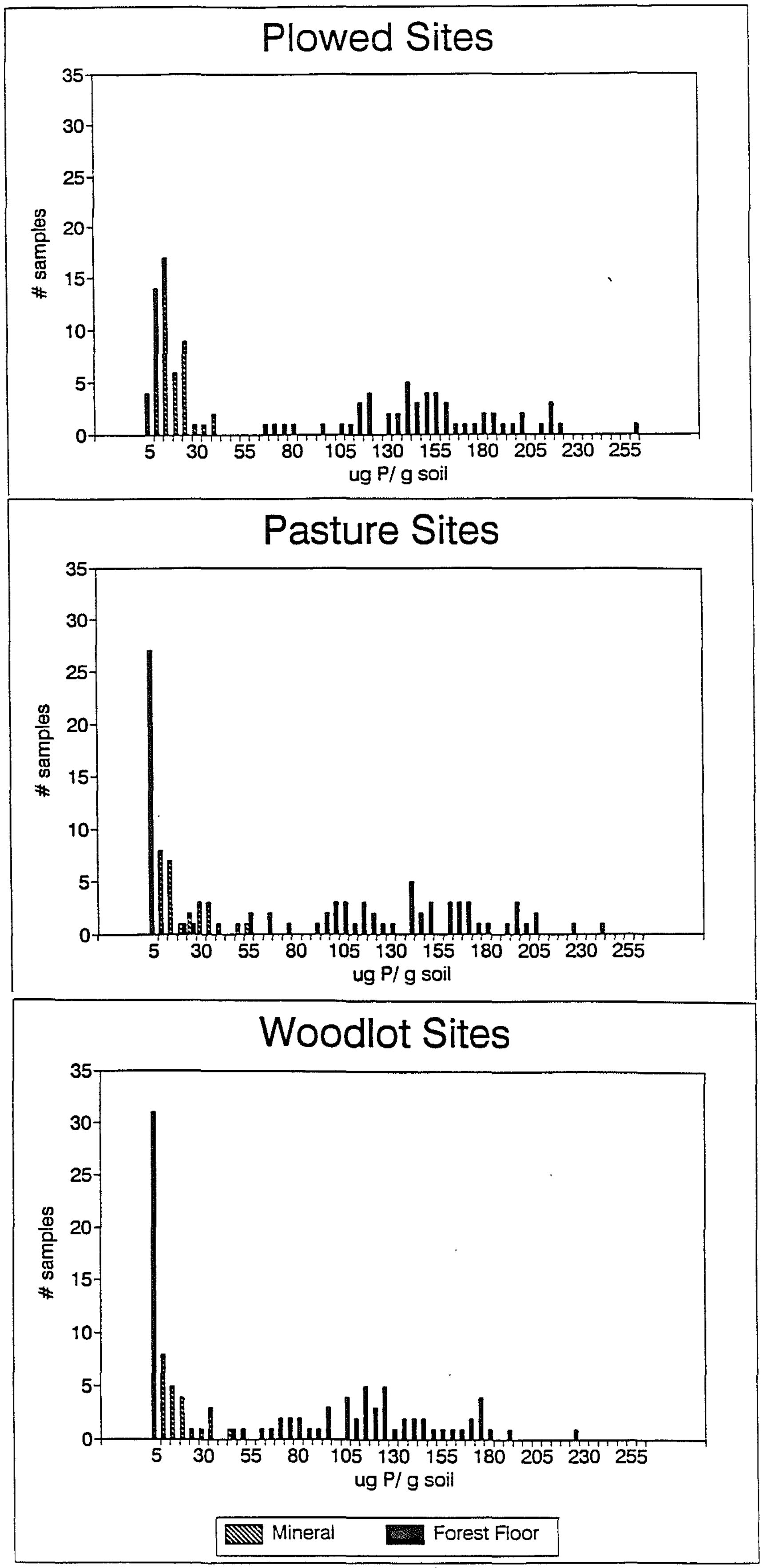


Fig. 2. Distributions of soil P concentrations across landscape types.

K. Tuovinen

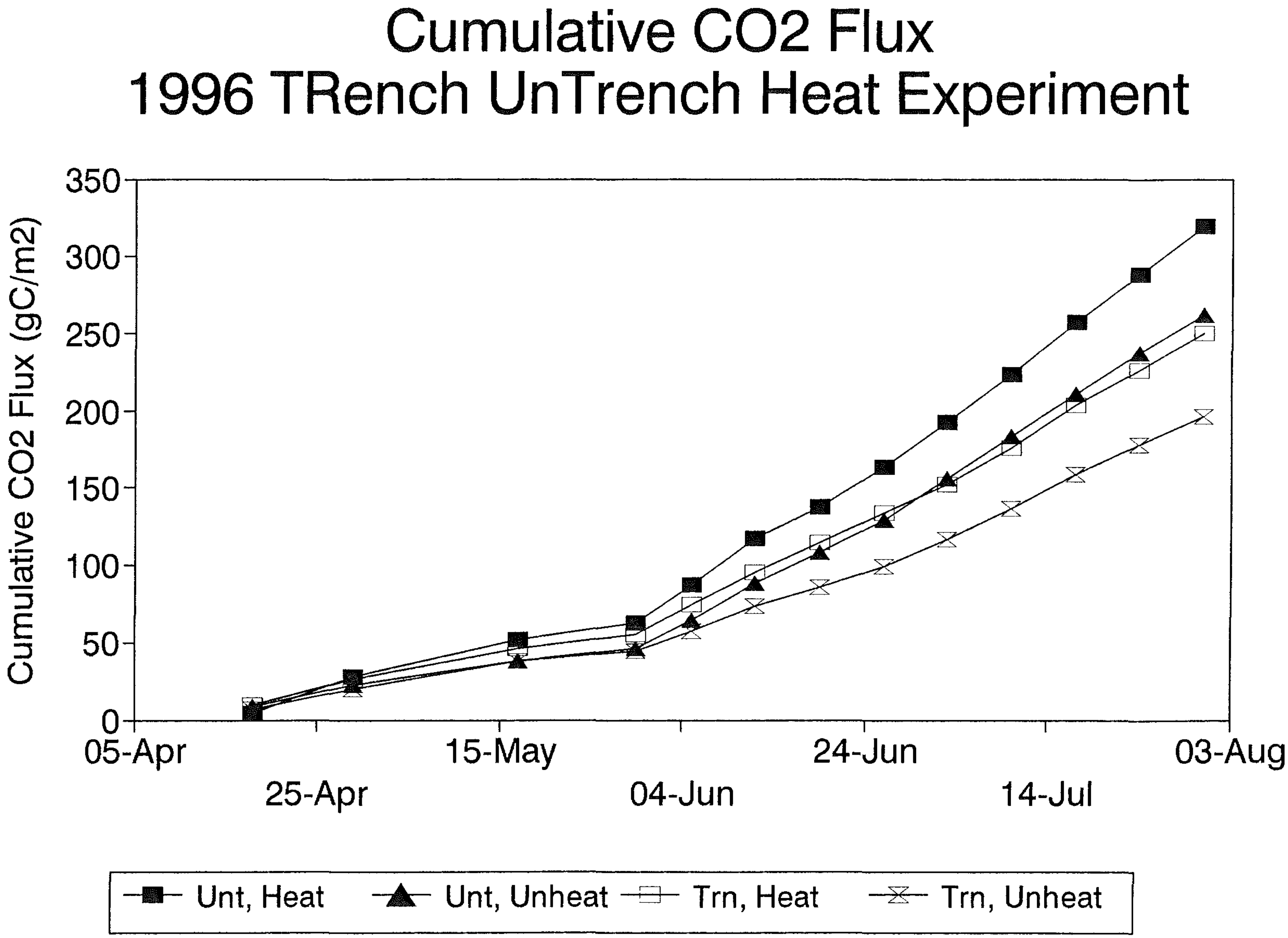


Fig. 1.

Central Massachusetts Vegetation Study: A Comparison of Overstory Vegetation Trends with Specific Focus on the Towns of Berlin, Leyden, and Pelham

Alexandria Wolf

As the second phase of a regional vegetation survey of Central Massachusetts, eight additional towns around the periphery of the study area were sampled to include under-represented landscape positions. In 8-12 randomly located 20m x 20m plots, we estimated percent cover of all vascular species in eight cover classes. Three towns, Berlin, Leyden, and Pelham were selected to represent northern, southern, and central portions of the study area and to describe broad trends in overstory vegetation.

Overstory composition was compared using presence-absence data for the following overstory species: *Carya glabra*, *Quercus alba*, *Tsuga canadensis*, *Fagus grandifolia*, *Acer saccharum*, *Acer rubrum*, *Pinus strobus*, and *Quercus rubra*. Preliminary results suggest that: 1) *Carya glabra* and *Quercus alba* are more frequent in the warmer, lower towns in the southeast (Berlin, Bolton, and Clinton), 2) *Tsuga canadensis* and *Fagus grandifolia* have greater relative frequency in the cooler, higher elevations of the northern towns (Leyden), and 3) *Acer rubrum*, *Pinus strobus* and *Quercus rubra* are common throughout the study area in places that have a history of agriculture, forest cutting, or other disturbance. Berlin, Leyden, and Pelham exemplify these overall trends. In the southern town of Berlin, *Carya glabra* and *Quercus alba* are present in relatively high amounts (30% and 50%, respectively). Whereas, *Tsuga canadensis* and *Fagus grandifolia* are absent. Leyden contains species characteristic of more northern areas such as *Tsuga canadensis* (90%) and *Fagus grandifolia* (80%) and lacks *Carya glabra* or *Quercus alba*. Pelham has a mixture of northern and southern species. The eight towns surveyed this summer generally follow the overstory trends established in the first phase of the study.

Paleoecology: Comparison of Modern Pollen Rain and Local Vegetation of Small Ponds in Central Massachusetts

Christopher Wurster

Little is known about how ecosystems respond to long-term disturbance. The New England landscape has been cleared by European activity, and subsequent agricultural abandonment has led to reforestation. The study of fossil pollen is a useful tool for determining past vegetation responses such environmental changes. An understanding of how recent vegetation is represented in the modern pollen rain is critical for interpreting fossil pollen data. In addition modern pollen assemblages may be used to help interpret paleoenvironments, and past forest composition. This study compared the abundance of different taxa around small ponds throughout central Massachusetts with the modern pollen found in the surface sediment of the ponds to determine pollen source area. We also collected modern pollen assemblages at a wide range of sites to see how well the modern pollen rain records vegetational gradients, and to obtain modern analogues for fossil pollen assemblages.

Local representation of *Tsuga* in the pollen record is good; however *Pinus, Betula* and *Quercus* are over-represented whereas *Acer rubrum* is under-represented. Our preliminary results generally agree with those found in a similar but more intensive study by Steve Jackson (1990). We used ordination to test how well modern pollen records vegetational patterns in the landscape. Our results suggest surface pollen has a predominantly local origin; however, a significant portion of the pollen assemblage is from sub-local and regional sources. We found no significant relationship between modern pollen assemblages and elevation. This suggests that European activity may have homogenized forest composition in New England.

1996 HARVARD FOREST SUMMER SEMINAR, DINNER DISCUSSION, FIELD TRIP, AND WORKSHOP SCHEDULE

June 5 - Tuesday - Research Seminar

"Forest landscape dynamics in central New England: Ecosystem structure and function as a consequence of 5000 years of change"
David Foster, Director, Harvard Forest

June 12 - Wednesday - Research Seminar

"Root gaps, wood prints, and sustainable forest management"
Dennis Knight, University of Wyoming and Harvard Forest

June 19 - Wednesday - Research Seminar

"Holocene vegetation history in eastern North America"
Thompson Webb III, Brown University and Harvard Forest

June 25 - Tuesday - Dinner Discussion

"Women and minorities in natural resources"
Lead by the students

June 27 - Thursday -- Research Seminar

"Controls on soil nitrogen cycling: the interaction of vegetation and land-use history"
Jana Compton, Harvard Forest

July 2 - Tuesday -- Research Seminar

"From leaves to landscapes: the role of spatial-temporal heterogeneity in forest dynamics"
Timothy Sipe, Gustavus Adolphus College

July 9 - Tuesday -- Research Seminar

"Recycling in forested ecosystems; factors regulating decomposition"
Charles McClaugherty, Mount Union College

July 17 - Wednesday -- Research Seminar

"Five years of the soil warming experiment"
Kathy Newkirk, Marine Biological Laboratory

July 24 - Wednesday -- Research Seminar

"Long-term forest dynamics in northeastern North America - a paleoecological perspective"
Janice Fuller, Harvard Forest

July 31 - Wednesday - Research Seminar

"Ecological synthesis: or, what does an ecosystem scientist do at the computer all day?"

John Aber, University of New Hampshire

August 6 - Wednesday - Research Seminar

"Alternative reproductive strategies of a marine amphipod: why are some males all thumbs" or "What can sex tell us about evolution?"

Rachel Clark, Gustavus Adolphus College

August 7 - Wednesday - Research Seminar

"The relationshp of soil respiration measurements to the global carbon budget"
Dave Kicklighter, Marine Biological Laboratory

The Institute of Ecosystem Studies presents:

FORUM ON OPPORTUNITIES IN ECOLOGY

July 23, 1996

Morning Sessions: Rewards and Motivations in Ecology Careers

Session One: 9:30-11:10 A.M.

9:35	Jon Polishook	Staff Microbiologist (*Industry*) Merck Research Laboratories, Rahway, NJ
9:48	Shabazz Jackson	Municipal Recycling Specialist (*City Government*) City of Beacon, Beacon, NY
10:01	Dr. Juliana Barrett	Stewardship Ecologist (*Applied Ecology*) The Nature Conservancy, Middletown, CT
10:14	Maribel Pregnall	Science Teacher (*Education*) Arlington Middle School, Poughkeepsie, NY
10:27	Mark Gallagher	Senior Scientist (*Consulting*) Coastal Environmental Services, Princeton, NJ
10:40	Dr. Ann Lewis	Assistant Professor of Forestry (*Academia*) The University of Massachusetts, Amherst, MA
10:53	Drayton Grant	Environmental Lawyer (*Law*) Rhinebeck, NY

Break: 11:10-11:25 A.M.

Session Two: 11:25 A.M.- 12:30 P.M.

11:25	David Stern	Supervisor of the Pathogen Program (*Environmental Research*) Department of Environmental Protection, Valhalla, NY.
11:38	Thomas Lalley	Producer, The Environment Show (*Science Media*) National Productions, WAMC, Northeast Public Radio, Albany, NY
11:51	Dr. Christine Padoch	Scientist (*Research Abroad*) The New York Botanical Garden, Bronx, NY
12:04	Louis Sorkin	Senior Scientist, Entomology & Arachnology (*Museums*) American Museum of Natural History, New York, NY
12:17	Josh Cleland	Environmental Associate (*Environmental Activism*) Scenic Hudson, Poughkeepsie, NY

ECOSYSTEM STUDIES

The tentative activities for the two days will be:

Monday, July 22:

2:00 p.m.	Tour of Plant Science Building (Dr. Kathie Weathers)
3:00 p.m.	IES - Harvard Forest REU student exchange (Dr. Charles Nilon)
4:00 p.m.	Research-in-Context Series: Environmental Science and Policy (Robert Goldstein, Pace University)
5:30 p.m.	Dinner at IES Recreation Area
6:30 p.m.	Research-in-Context Series: Diversity in the Scientific Community (Dr. Ann Lewis, Assistant Professor of Forestry, University of Massachusetts, Amherst)

Tuesday, July 23:

9:30-12:30	Speakers' presentations
12:30-1:30	Lunch (please bring your own bag lunches)
1:30-3:30	Small discussion groups

1996 SUMMER PROGRAM COMMITTEE ASSIGNMENTS

Recycling

Jessica R.
Jen D.
Derek P.*
Lauren I.
Gregg S.

Kitchen/Food

Chris L.
Laurel S.
Dana M.
Andi W.*
Shana S.

Social/Recreation

Katariina T.
Vickie H.*
Mark N.

Vehicles

Kevin P.

Grad School

ChadN.
Sara C.
Kevin D.
Sujay K.
Scott H.

Discussion Groups

Catherine A.
Kristen M.*
Chris W.

*Denotes Chairman of the Committee

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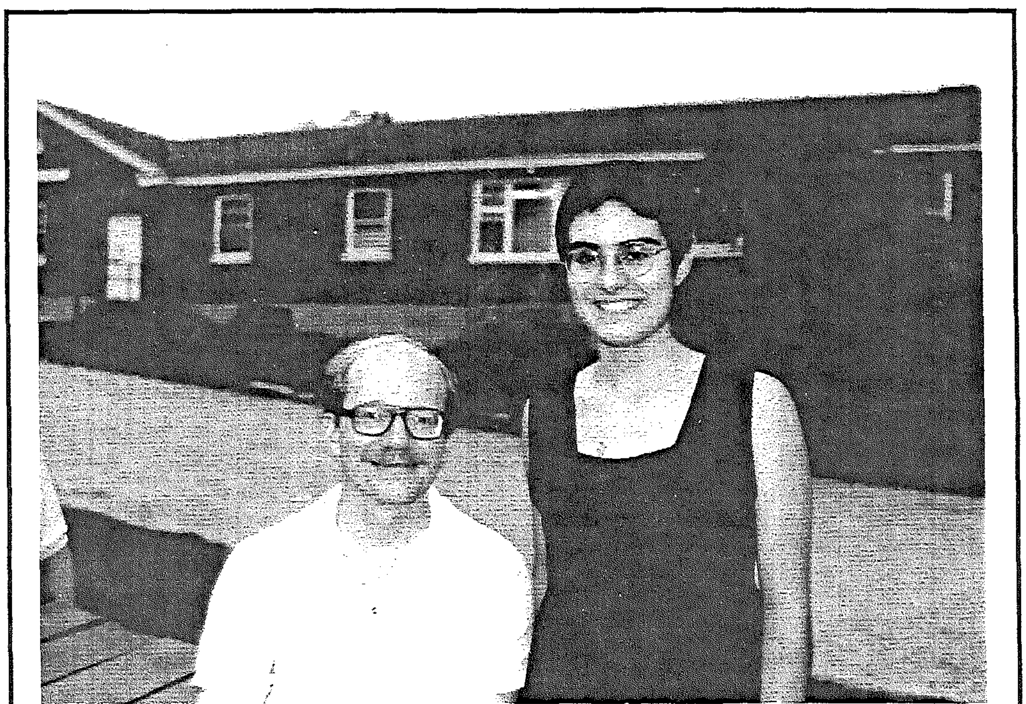
SUNY

PERSONNEL AT THE HARVARD FOREST 1995-96

Arthur Allen	Research Assistant
Michael Binford	Associate
Emery Boose	Computer Scientist
Jeannette M. Bowlen	Accountant
Jeanne Boutelle	Custodial Assistant
David M. Bowman	Charles Bullard Fellow
Grace Brush	Charles Bullard Fellow
Kristen Chamberlin	Research Assistant
Susan L. Clayden	Research Assistant
Willard Cole	Woods Crew
Jana Compton	Research Associate
John F. Connolly	Charles Bullard Fellow
Sarah Cooper-Ellis	Research Assistant
Kathleen Donohue	Research Associate
Guy D'oyly Hughes	MFS Candidate
Elaine D. Doughty	Laboratory Assistant
Natalie Drake	Palynologist
John A. Edwards	Forest Manager
Barbara J. Flye	Librarian/Secretary
Charles H. W. Foster	Associate
David R. Foster	Director
Janice Fuller	Research Associate
Balachander Ganesan	Charles Bullard Fellow
Douglas Godbold	Charles Bullard Fellow
Julian Hadley	Research Associate
Jeffrey D. Herrick	Research Assistant
Donald E. Hesselton	Woods Crew
Kenneth Holmberg	Research Assistant
Camilla Hughes	Visiting Scholar
David P. Janos	Charles Bullard Fellow
Dennis H. Knight	Charles Bullard Fellow
Joan Kraemer	Clerk Typist
Christopher Kruegler	Administrator
Oscar P. Lacwasan	Custodian
Richard A. Lent	Data Manager
Anita Lockesmith	Summer Cook
Jason McLachlan	Research Assistant
Patricia Micks	Research Assistant
Ellen G. Moriarty	Graphic Artist
Glenn Motzkin	Research Assistant
John F. O'Keefe	Museum Coordinator
David Orwig	Research Associate
Hugh M. Raup	Charles Bullard Fellow, *Emeritus*
Emily Russell	Visiting Scholar
Benjamin Slater	Research Assistant
Dorothy Recos-Smith	Secretary
Charles C. Spooner	Woods Crew
P. Barry Tomlinson	E. C. Jeffrey Professor of Biology
Robert B. Waide	Charles Bullard Fellow
Thompson Webb III	Charles Bullard Fellow
Alan S. White	Charles Bullard Fellow
John Wisnewski	Woods Crew
Steven C. Wofsy	Associate

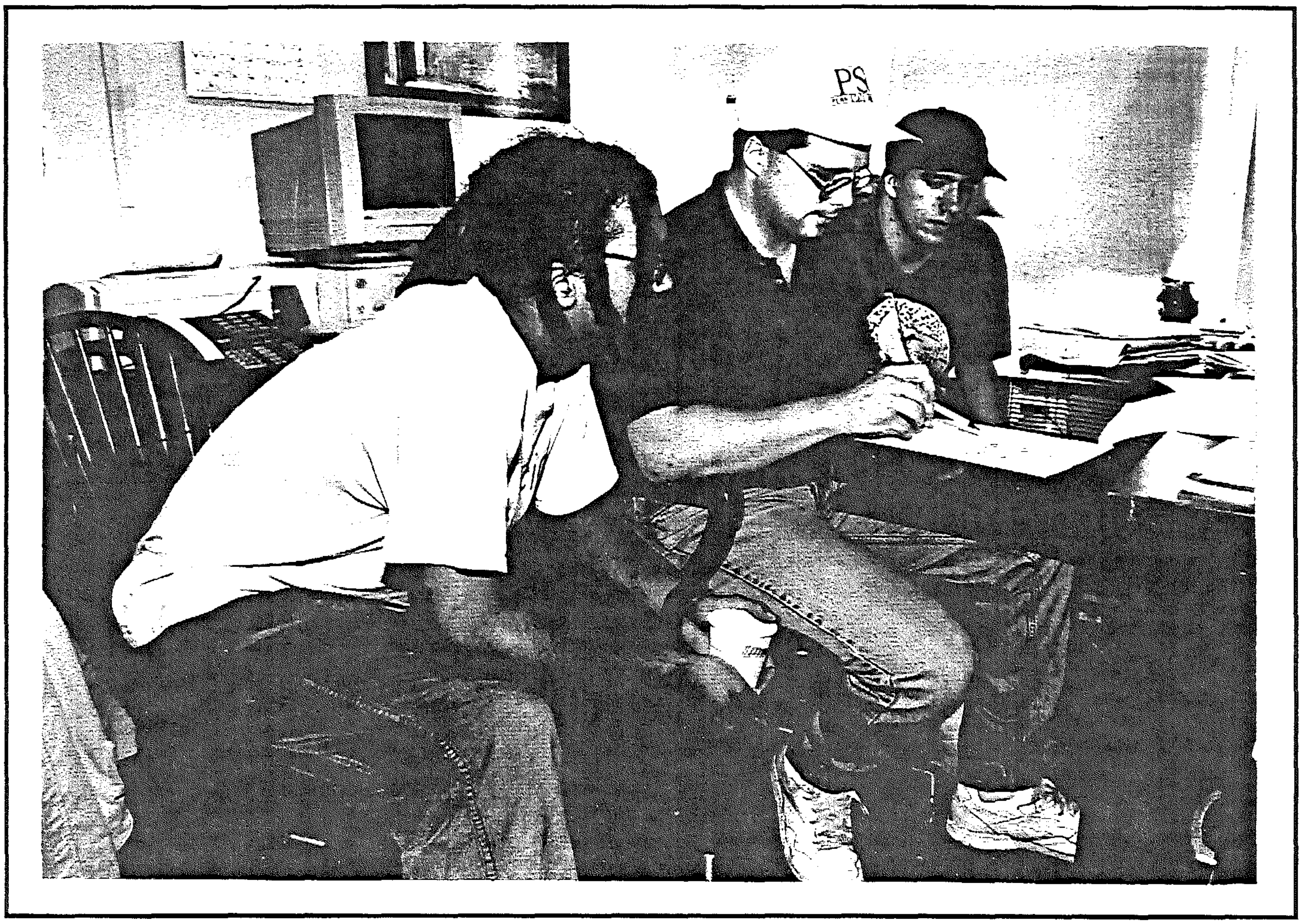
Kristin McCarthy



Emery Boose and Laura Hoffman

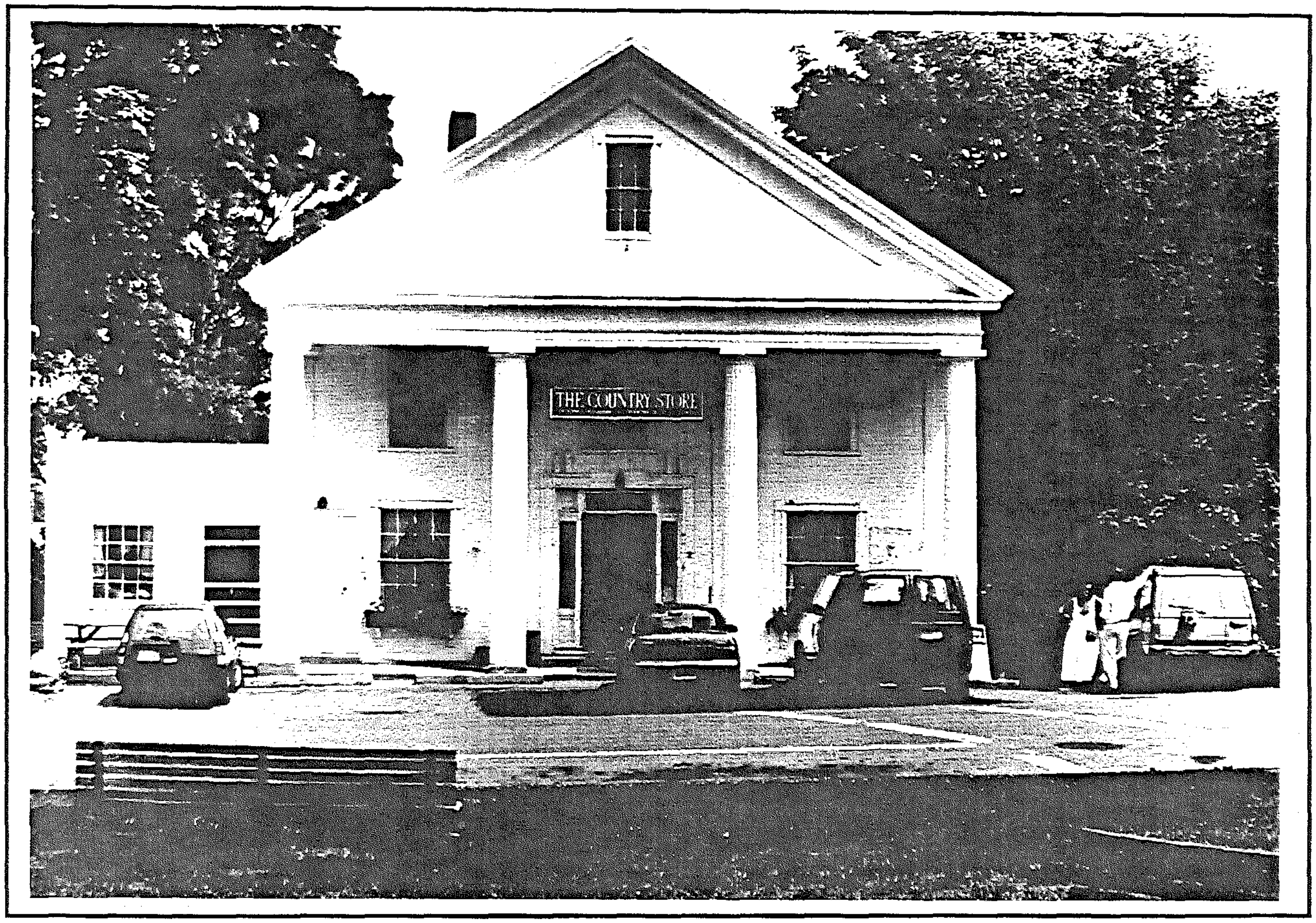
Front Row, left to right: Rich Bowden, Rachel Clark, Jen Dean, Tim Sipe, Missy Kibler; Second Row: Shana Stewart, Jessica Rigelman, Vicki Hunker, Scott Heath, Chuck McClaughtery, Karli Clark Third row: Kevin Puls, Mark Norris

Front row, left to right: Chad Nielsen, Lauren Interess, Mike Leneway, Derek Pelletier
Second row: Gregg Saunders, Sara Chun, Laurel Schaider, Dana MacDonald



Chris Lawinski, Dave Orwig and Kevid Dodds

Laurel Schaider, Lauren Interess, Sara Chun and Cat Mendenhall


THE COUNTRY STORE