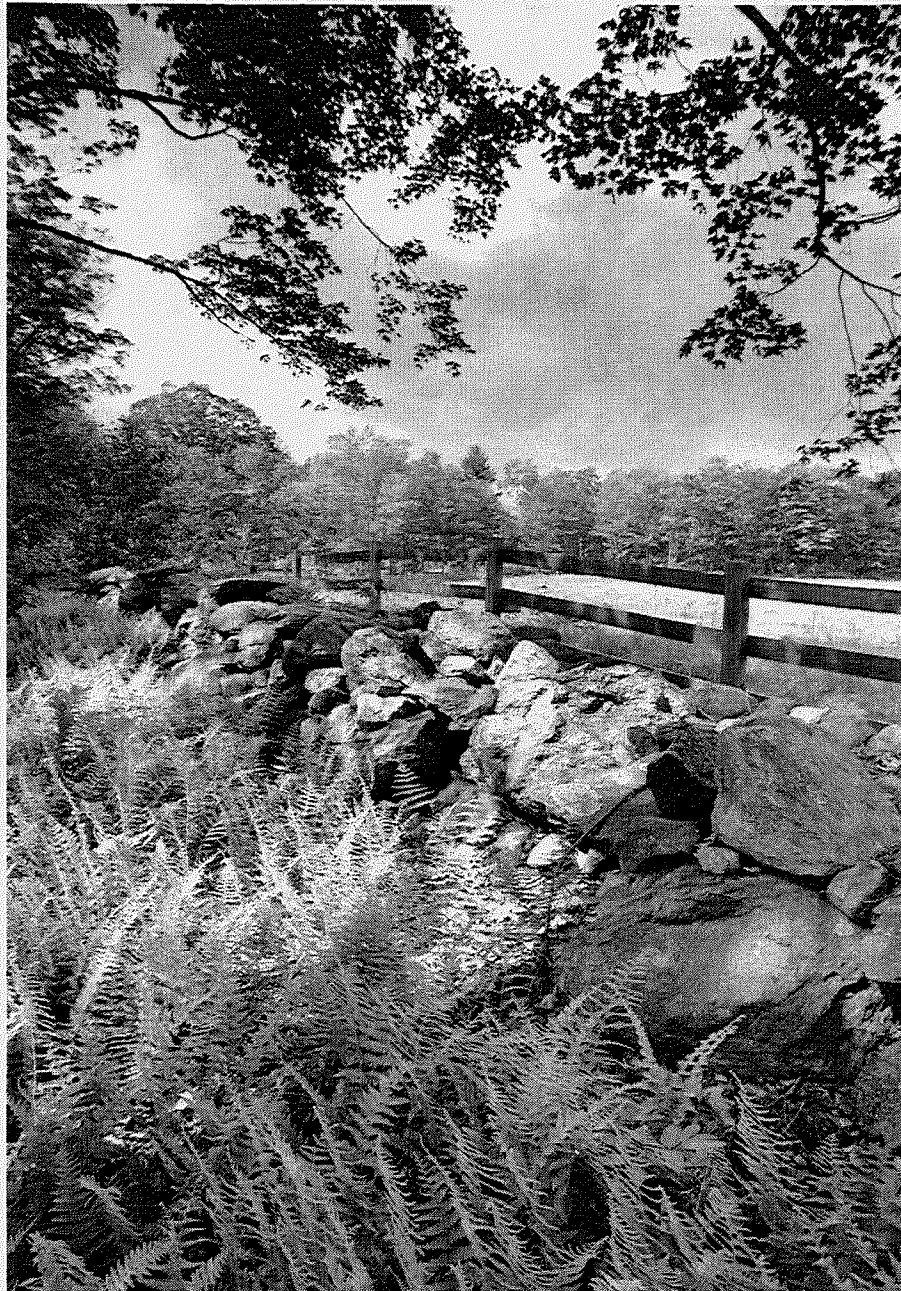# HARVARD FOREST

SUMMER RESEARCH PROGRAM

Abstracts from the 7th Annual
Harvard Forest Summer Research Symposium
5 August 1999

SEVENTH ANNUAL HARVARD FOREST SUMMER RESEARCH PROGRAM

5 August 1999

HARVARD FOREST, FISHER MUSEUM

INTRODUCTION TO THE HARVARD FOREST

Since its establishment in 1907 the Harvard Forest has served as a center for research and education in forest biology. Through the years researchers at the Forest have focused on silviculture and forest management, soils and the development of forest site concepts, the biology of temperate and tropical trees, forest ecology, forest 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 New England and beyond resulting from human and natural disturbance processes, and to apply this information to the conservation, management, and appreciation of forest ecosystems. This activity is epitomized by the Harvard Forest Long Term Ecological Research (HF LTER) program, which was established in 1988 through funding by the National Science Foundation (NSF).

Physically, the Harvard Forest is comprised of approximately 3000 acres of land in 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 (located in the 5000-acre Pisgah State Park), a virgin forest of white pine and hemlock that was 300 years old when it blew down in the 1938 Hurricane; the 100-acre Matthews Plantation in Hamilton, Massachusetts, which is largely comprised of plantations and upland forest; and the 90-acre Tall Timbers forest in Royalston, Massachusetts. In Petersham a complex of buildings that includes Shaler Hall, the Fisher Museum, and the John G. Torrey Laboratories provide office and laboratory space, computer and greenhouse facilities, and a lecture room and lodging for seminars and conferences. An additional nine houses provide accommodation for staff, visiting researchers, and students. Extensive records including long-term data sets, historical information, original field notes, maps, photographic collections and electronic data are maintained in the Harvard Forest Archives.

Administratively, the Harvard Forest is a department of the Faculty of Arts and Sciences (FAS) of Harvard University. The Harvard Forest administers the Graduate Program in Forestry that awards a Masters degree in Forest Science and faculty at the Forest offer courses through the Department of Organismic and Evolutionary Biology (OEB), the Kennedy School of Government (KSG), and the Freshman Seminar Program. Close association is also maintained with the Department of Earth and Planetary Sciences (EPS), the School of Public Health (SPH), and the Graduate School of Design (GSD) at Harvard and with the Department of Natural Resources Conservation at the University of Massachusetts, the Ecosystems Center of the Marine Biological Laboratory at Woods Hole, and the Complex Systems Research Center at the University of New Hampshire.

The staff and visiting faculty of approximately 50 work collaboratively to achieve the research, educational and management objectives of the Harvard Forest. A management group comprised of the Director, Administrator, Coordinator of the Fisher Museum, and Forest Manager meets monthly to discuss current activities and to plan future programs. Regular meetings with the HF LTER science team provide for an infusion of outside perspectives. Forest management and physical plant activities are undertaken by our four-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 operation of the Harvard Forest is derived from endowments and FAS, whereas major research support comes primarily from the National Science Foundation, Department of Energy (National Institute for Global Environmental Change), U.S. Department of Agriculture, NASA, and the Andrew W. Mellon Foundation. Our summer Program for Student Research is supported by the National Science Foundation, the A. W. Mellon Foundation, and the R. T. Fisher Fund.

Summer Research Program

The Harvard Forest Summer Student Research program, coordinated by Edythe Ellin and assisted by Thia Cooper, attracted a diverse group of students to receive training in scientific investigations, and experience in long-term ecological research. Students work closely with faculty and scientists, and many conduct their own independent studies. The program includes weekly seminars from resident and visiting scientists, discussions on career issues in science (e.g. career decision, ethics in science), and field trips on soils, land-use history, and plant identification. An annual field trip is made to the Institute of Ecosystem Studies (Millbrook, NY) to participate in a Forum on Jobs in Ecology. At the Annual Summer Student Research Symposium students present major results of their work.

SEVENTH ANNUAL HARVARD FOREST SUMMER STUDENT SYMPOSIUM

5 August 1999

HARVARD FOREST- FISHER MUSEUM

9:30 A.M.	Introduction	
9:45	Effect of chronic nitrogen addition on soil respiration in temperate forests	Shira Bell
10:00	CO_2 respiration response to the wetting of the O horizon in a northern hardwood forest	Jason Eaton
10:15	Soil response to infestation of hemlock woolly adelgid in central Connecticut hemlock stands	Steve Currie
10:30	Understory dynamics of hemlock woolly adelgid infested stands in southern Connecticut	Saskia van de Gevel
10:45	A paleo-ecological investigation of Cape Cod's freshwater lakes	Jason Murnock
11:00	Coffee Break	
11:15	A survey of water relations in two fern species (*Osmunda spp.*) as a basis for studies of embolism formation and repair	Emily Huhn
11:30	Breaking new ground in plant-water relations: The dynamics of embolism formation and repair in *Salix nigra*	Barbara Muñoz
11:45	Contribution of boles and branches to wood respiration in an old-growth eastern hemlock (*Tsuga canadensis*) stand	Raoul Blackman
12 Noon	Photosynthesis and respiration of maturing new shoots of eastern hemlock (*Tsuga canadensis*)	Sarah Cook
12:15 P.M.	Comparison of semi-continuous logging and traditional dendrometers in the measurement of carbon uptake and diurnal DBH fluctuation in *Acer rubrum*	Dave Patterson
12:30	Timber harvesting as a form of disturbance	Andrew Finley

12:45	Lunch	
1:45	Up against the wall: Mice and voles in deciduous forest	Ana Laborde
2:00	Effects of environmental factors on spatial distribution of understory plant species in a mixed conifer-hardwood forest	Henry Schumacher
2:15	Effects of microenvironmental variation within experimental gaps on the decomposition of red maple leaves	Tana Collazo
2:30	Estimating biomass in secondary dry tropical forests of the southern Yucatan	Larissa Read
2:45	Litter dynamics in successional dry tropical forests of the southern Yucatan Peninsula region, Mexico	Jessica Sisco
3:00	The effect of cultivation history on seed rain in the southern Yucatan Peninsula	Heidi Wasson
3:15	Concluding Remarks	
5:00	Barbecue	

Effect of Chronic Nitrogen Addition on Soil Respiration in Temperate Forests

Shira Bell

Many people are unaware that nitrogen deposition is a form of air pollution. It occurs through several human sources, including fossil fuel combustion and the production and use of fertilizers. A group of scientists headed by John Aber has been adding inorganic nitrogen to forest stands to examine nitrogen saturation. In the nitrogen addition stands, most of the nitrogen has been retained as organic nitrogen. Aber has arrived at three pathways for inorganic nitrogen immobilization: freeliving microbes, mycorrhizae, or abiotic processes. The first two pathways would produce a greater CO_2 flux in the nitrogen deposition stand than the control stand; the third would cause no change in CO_2 flux. $15g/m^2yr$ of NH_4NO_3 has been added to a red pine stand and a native hardwood stand since 1988.

This summer, I measured the difference in soil respiration between the nitrogen addition and the control plot using a Licor CO_2 Gas Analyzer. The highest CO_2 efflux was in the hardwood control plot. The lowest CO_2 efflux was in the pine nitrogen addition plot. The hardwood nitrogen addition and the pine control CO_2 efflux levels were approximately equal (Fig.1). Because the CO_2 efflux was smaller in the nitrogen addition plots, none of Aber's original hypotheses are correct. Because soil respiration is dependent upon fixed carbon concentrations, one reason for the lower respiration in the nitrogen plots is that the amount of fixed carbon in the ecosystem has decreased. Carbon is mostly fixed by leaves and needles, meaning that the next place to look to discover why soil respiration has dropped is in the foliage.

Contribution of Boles and Branches to Wood Respiration in an Old Growth Eastern Hemlock *(Tsuga canadensis)* Stand

Raoul Blackman

Wood respiration accounts for a significant proportion of forest ecosystem respiration. The distribution of wood respiration within trees is poorly understood. The aim of this study is to quantify rates of wood respiration in boles and branches of an eastern hemlock stand at Harvard Forest.

Wood respiration (Rw) of four Eastern Hemlock *(Tsuga canadensis)* trees 126 to 190 years old was measured in 1998. Rw was measured within chambers on the bole and lower, middle and upper branches. Sapwood temperatures were measured at 1 and 4 cm beneath the chambers. Sapwood thickness in boles was determined from cores. To estimate sapwood volume in branches, branches from adjacent trees were harvested. Regressions were developed between branch base diameter and sapwood thickness and volume.

Rw increased with temperature and increased from bole to upper canopy branches (Fig 1 & Fig 2). Growth respiration was calculated by projecting maintenance respiration from the fall to summer temperatures, and subtracting this from rates recorded in summer (Fig 3). Growth respiration declines as the summer progresses (Fig 4). Growth respiration declined from between

Chronic-N CO2 Flux

Be11

fig 1

Legend for fig 1:
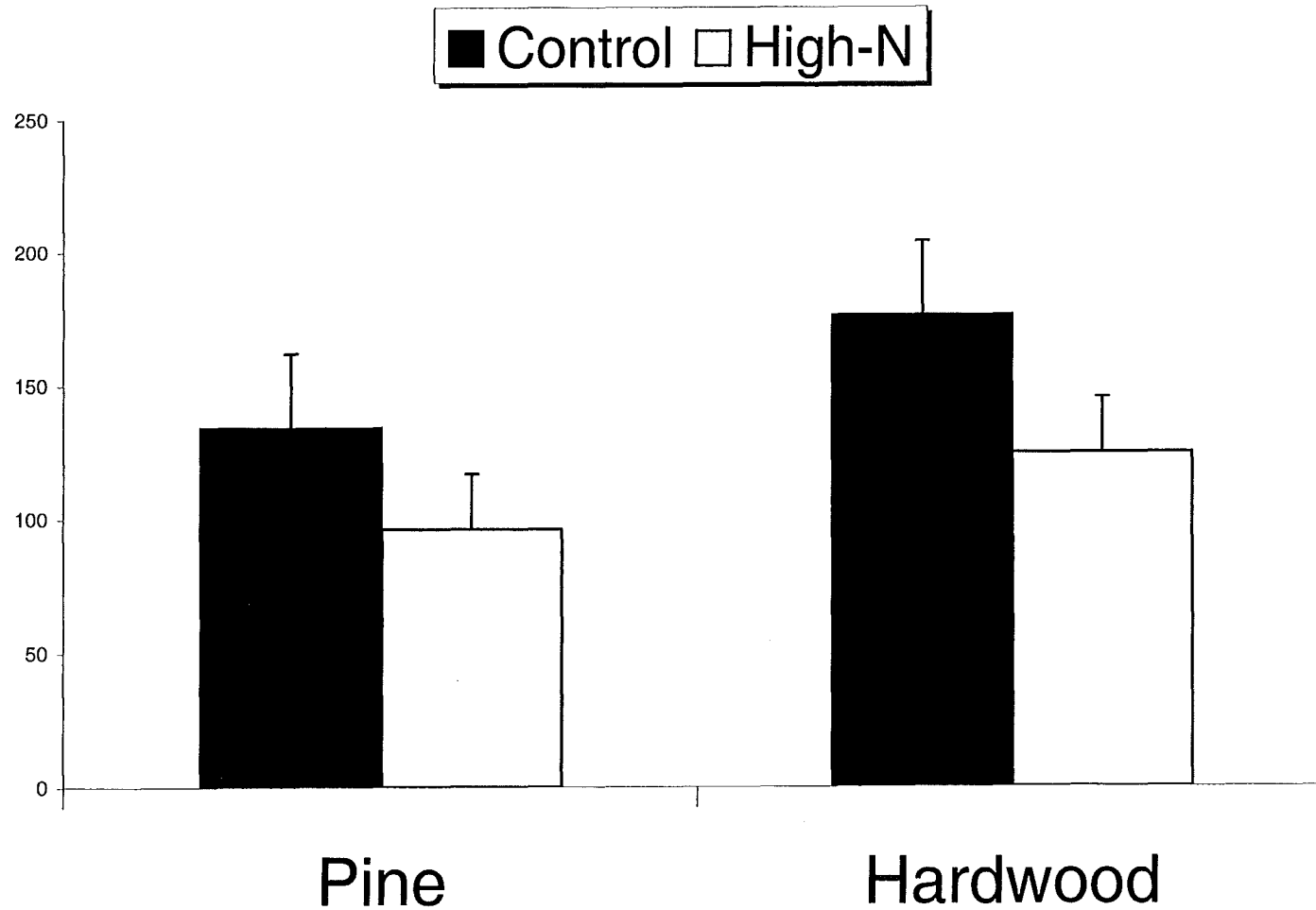
▲ Upper canopy branches $Q_{10} = 3.890$

✛ Upper canopy main stem $Q_{10} = 2.884$

■ Middle canopy branches $Q_{10} = 4.365$

● Lower canopy branches $Q_{10} = 3.090$
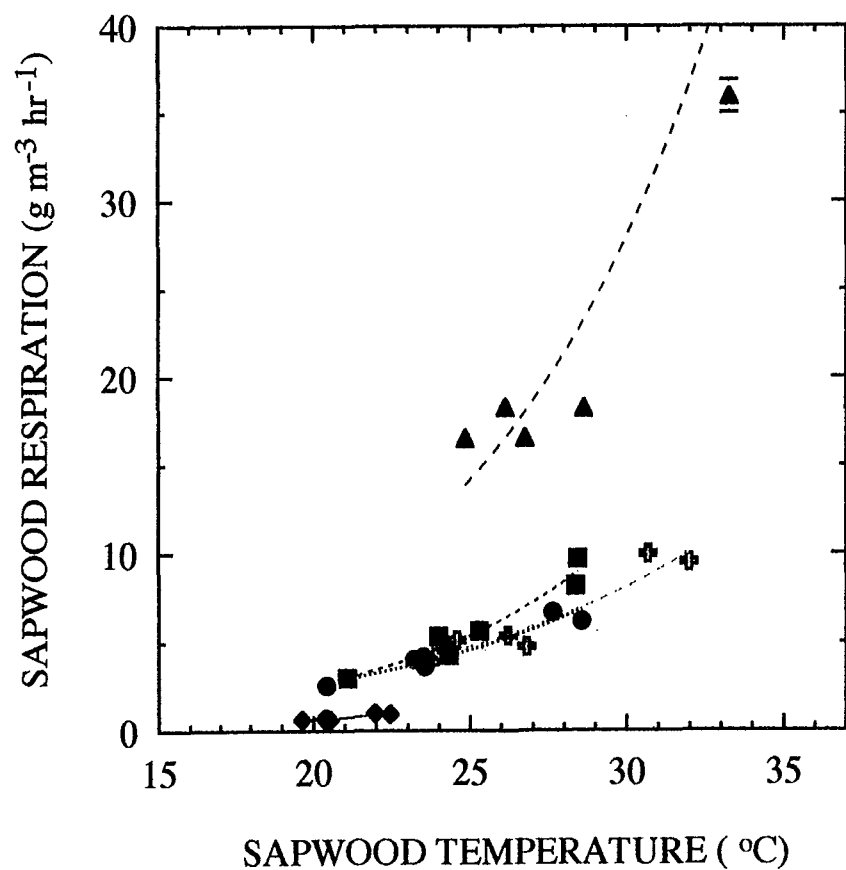
◆ Bole (1.2 m height) $Q_{10} = 6.166$

Y-axis: SAPWOOD RESPIRATION (g m^{-3} hr^{-1})

X-axis: SAPWOOD TEMPERATURE (°C)

R. Blackman

fig 2

Legend for fig 2:

▲ Upper canopy branches $Q_{10} = 2.951$

✛ Upper canopy main stem $Q_{10} = 2.042$

■ Middle canopy branches $Q_{10} = 1.905$

● Lower canopy branches $Q_{10} = 2.344$
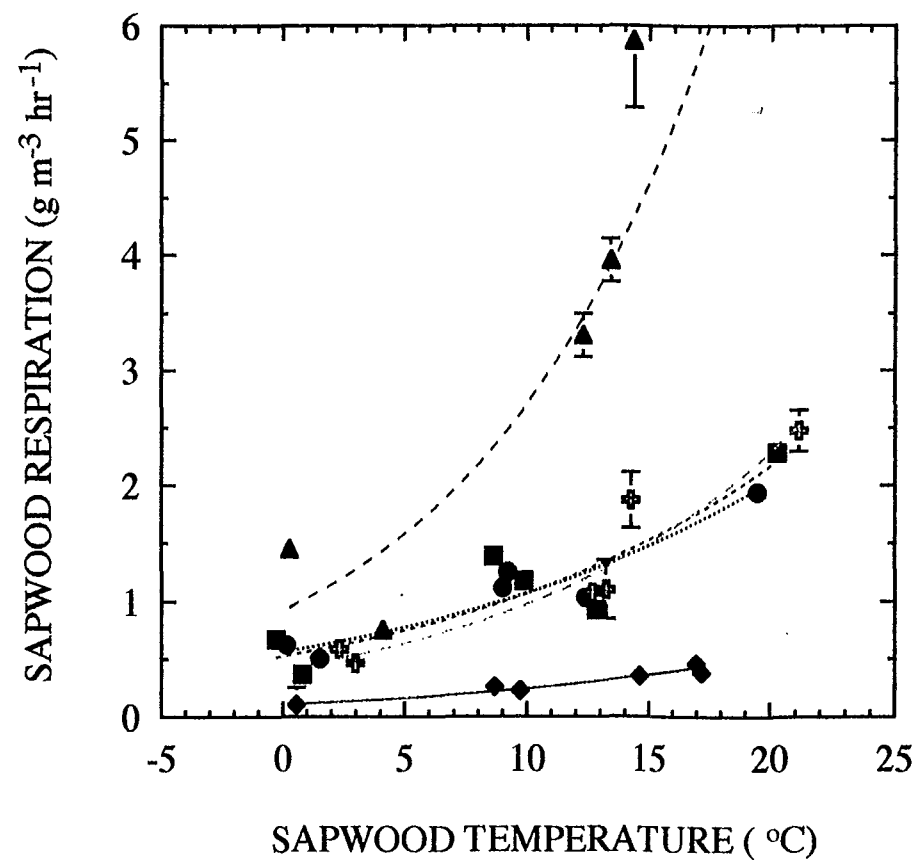
◆ Bole (1.2 m height) $Q_{10} = 2.291$

Y-axis: SAPWOOD RESPIRATION (g m^{-3} hr^{-1})

X-axis: SAPWOOD TEMPERATURE (°C)

Upper canopy measured respiration

Upper canopy main stem - estimated maintenance respiration

Lower canopy branches - measured respiration

Lower canopy - estimated maintenance respiration

Bole (1.2 m height) - measured respiration
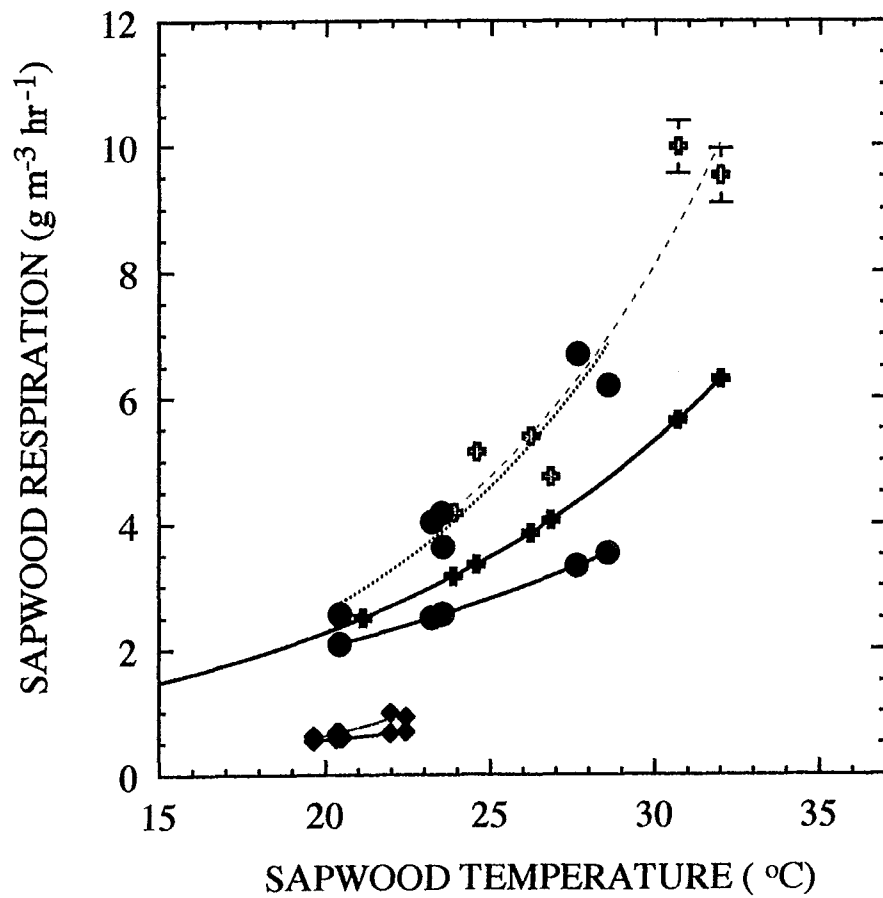
Bole (1.2 m height) - estimated maintenance respiration

UMS GROWTH RESPIRATON

MC GROWTH RESPIRATON

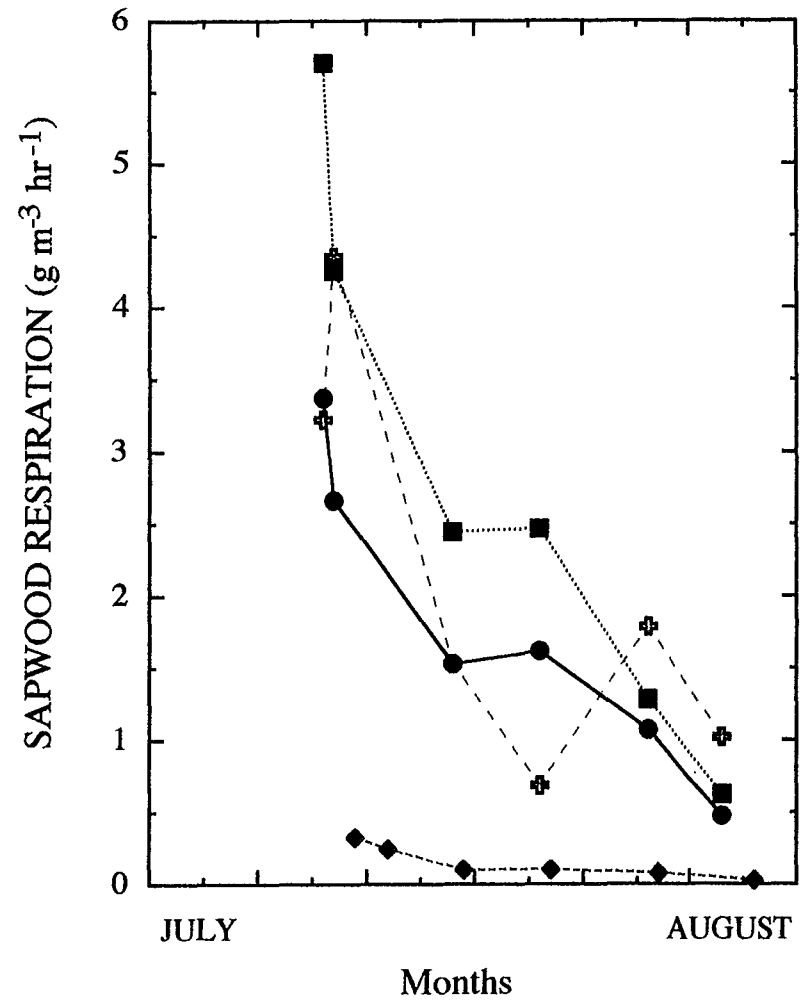LC GROWTH RESPIRATON

BOLE GROWTH RESPIRATON

fig 3

fig 4

R. Blackman

30 to 64% of total respiration in mid July to only 10 to 46% in late August. Exponential models of wood respiration (Fig 1 & 2) were applied to a data set of continuous sapwood temperatures from September 1997-August 1998. Estimated Rw was similar to estimated foliage respiration in summer and winter. Estimated Rw exceeded foliage respiration in spring and fall (Fig 5). Total annual Rw was about 40% of above ground respiration.

Effects of Microenvironmental Variation Within Experimental Gaps on the Decomposition of Red Maple Leaves

Tana Collazo

Natural and human disturbances frequently form gaps in the forest, leaving the forest floor exposed to direct sunlight and other elements. The amount of light and the climate vary in different parts of a gap. For example, the northern part of a gap is sunnier, warmer, and drier, while the southern part of a gap is shadier, cooler, and moister. Decomposition rates have been shown to vary with environmental conditions such as temperature and moisture. We looked at the decomposition of red maple (*Acer rubrum*) leaves placed in the northern and southern regions of four experimental gaps to see if microsite variation had any effect on decomposition. Red maple leaves from the previous fall were collected and oven-dried. The leaves were then weighed and placed in mesh litterbags. A total of forty bags were placed in the four gaps—five on the north side and five on the south side. After 30 days, we collected the litterbags and oven-dried the leaves. We calculated the percent mass loss through decomposition to compare decomposition rates between the northern and southern regions (Fig. 1). Our results showed no significant effect of gap microsite on leaf litter decomposition. This may be due to our brief study period. Decomposition rates also varied greatly between gaps (Fig. 2). This suggests that differences between gaps, such as soils and herbaceous cover, may also affect decomposition. A longer term and more spatially extensive study would likely provide more conclusive results.

Photosynthesis and Respiration in New and Year-old Foliage of Eastern Hemlock (*Tsuga canadensis* L.) as Affected by High Temperature

Sarah Cook

To accurately estimate total photosynthesis of coniferous forests in early summer, it is important to understand the carbon exchange of new foliage during development. I measured CO_2 exchange at 15 to 35°C in the upper and lower canopy of four mature hemlocks (*Tsuga canadensis* L.). Measurements were made in early June, about 3 weeks after bud break, and again in July after the shoots had grown to maximum length. In early June the new shoots had reached 40% to 50% of maximum length (Fig. 1), but their maximum photosynthesis at 25°C was only approximately 15% of year-old foliage, and net carbon gain occurred only at high light levels (Fig. 2a). By mid-July, the new shoots had nearly the same photosynthetic characteristics as year-old foliage at 25°C (Fig. 2b). Both age classes of foliage showed decreased dark respiration rates from June to July (Fig. 3). The higher respiration rate of year-old foliage in June versus July may have been associated with carbon export to developing new shoots. A high air
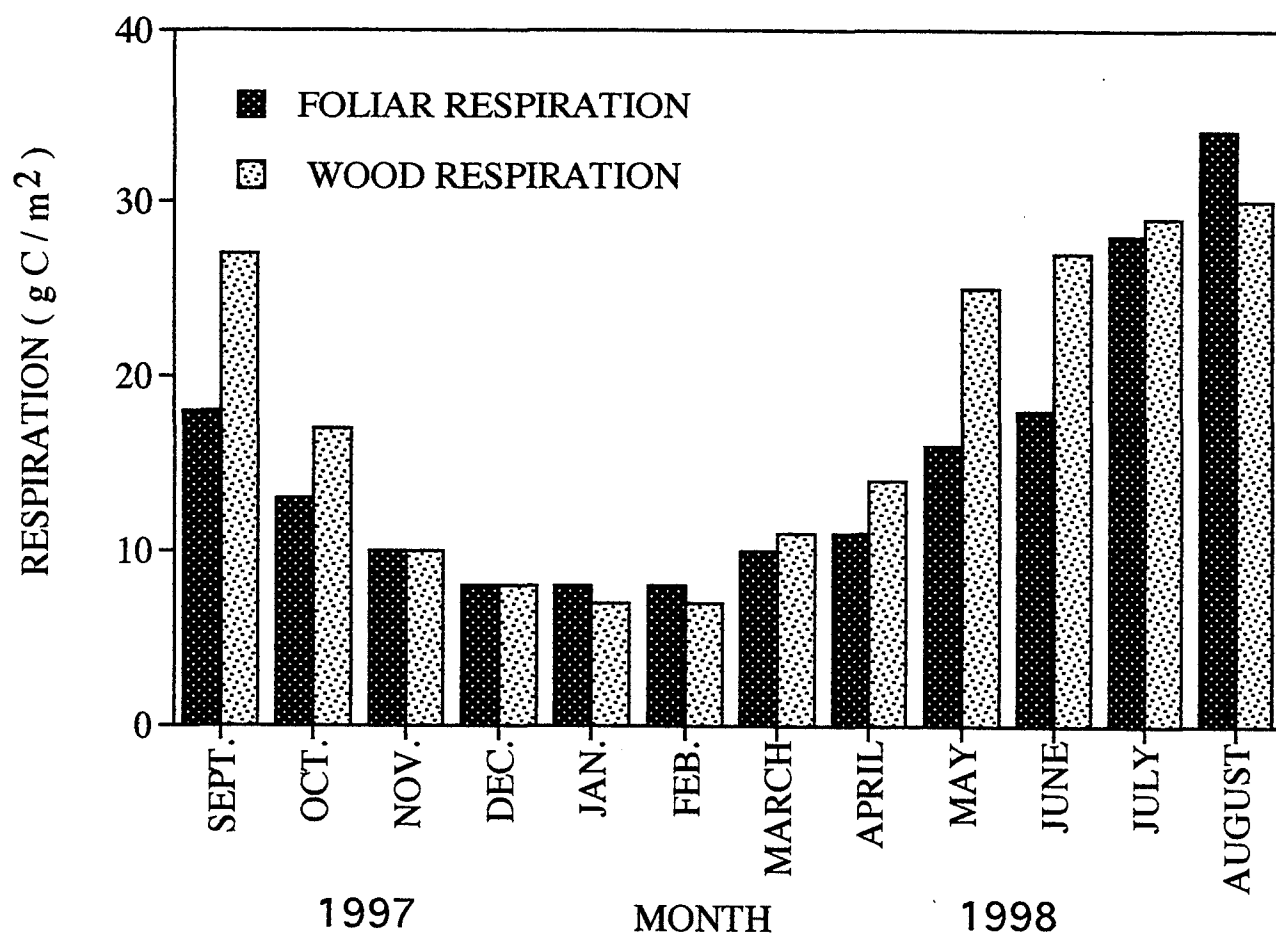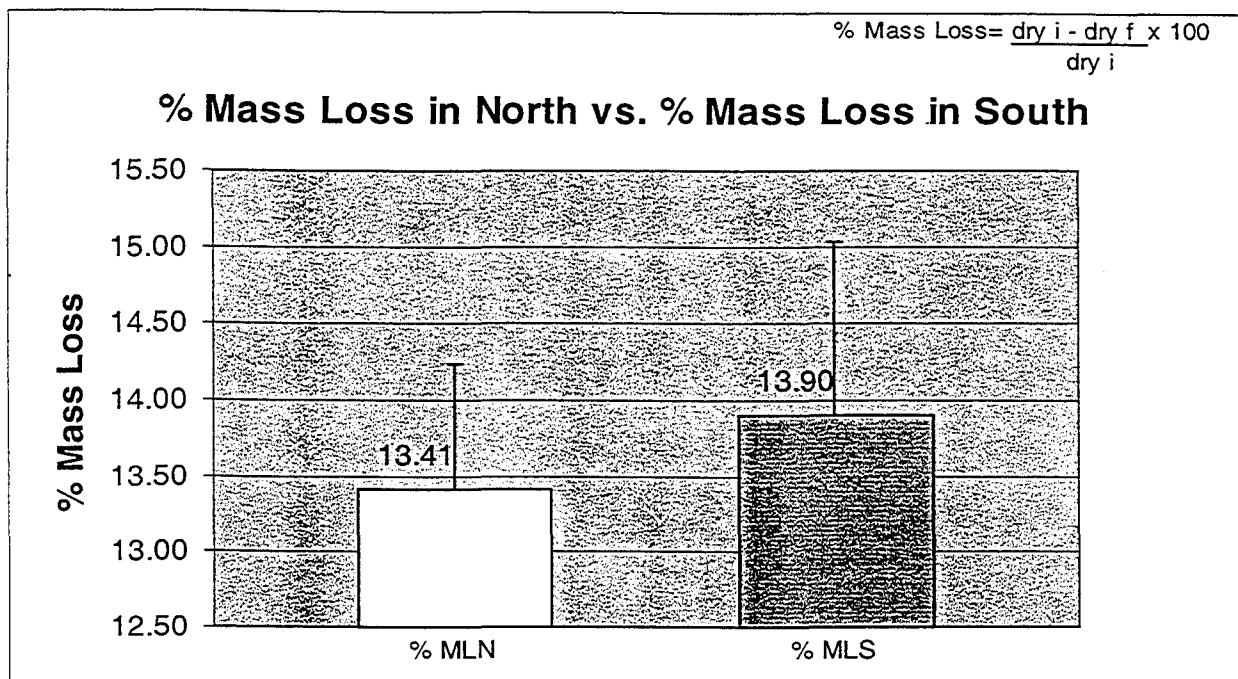
Figure 5

R. Blackman

$$\% \text{ Mass Loss} = \frac{\text{dry i} - \text{dry f}}{\text{dry i}} \times 100$$

% Mass Loss in North vs. % Mass Loss in South

% Mass Loss (y-axis): 15.50, 15.00, 14.50, 14.00, 13.50, 13.00, 12.50

% MLN: 13.41
% MLS: 13.90

Figure 1. Percent mass loss in the north and south parts of the gaps. Data bars represent mean values of percent decomposition. The line above them represents one standard error.
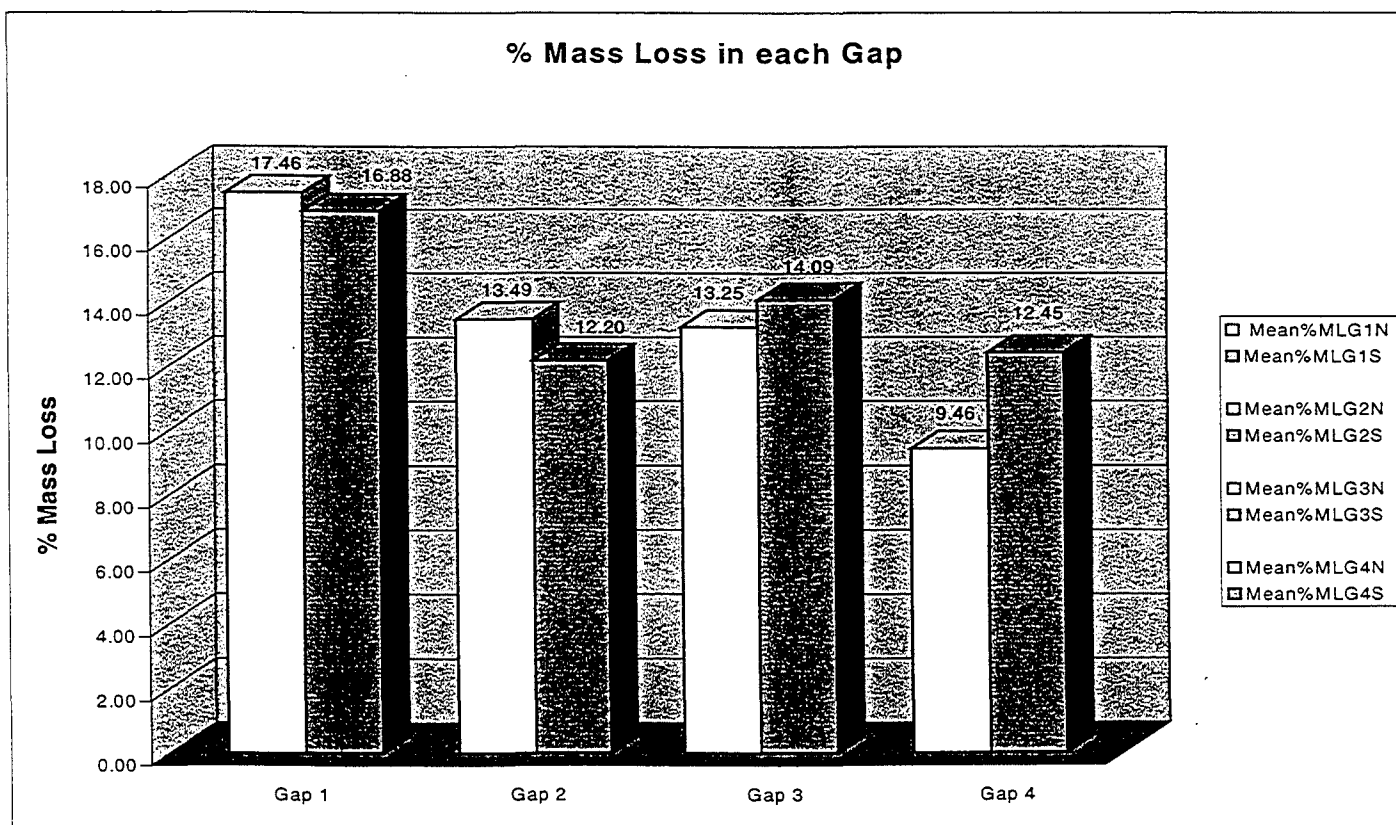
% Mass Loss in each Gap

% Mass Loss (y-axis): 18.00, 16.00, 14.00, 12.00, 10.00, 8.00, 6.00, 4.00, 2.00, 0.00

Gap 1: 17.46, 16.88
Gap 2: 13.49, 12.20
Gap 3: 13.25, 14.09
Gap 4: 9.46, 12.45

Legend:
☐ Mean%MLG1N
☐ Mean%MLG1S

☐ Mean%MLG2N
☐ Mean%MLG2S

☐ Mean%MLG3N
☐ Mean%MLG3S

☐ Mean%MLG4N
☐ Mean%MLG4S

Figure 2. Variation in percent mass loss in each gap. The lighter color represents the north part of the gap and the darker color, the south.
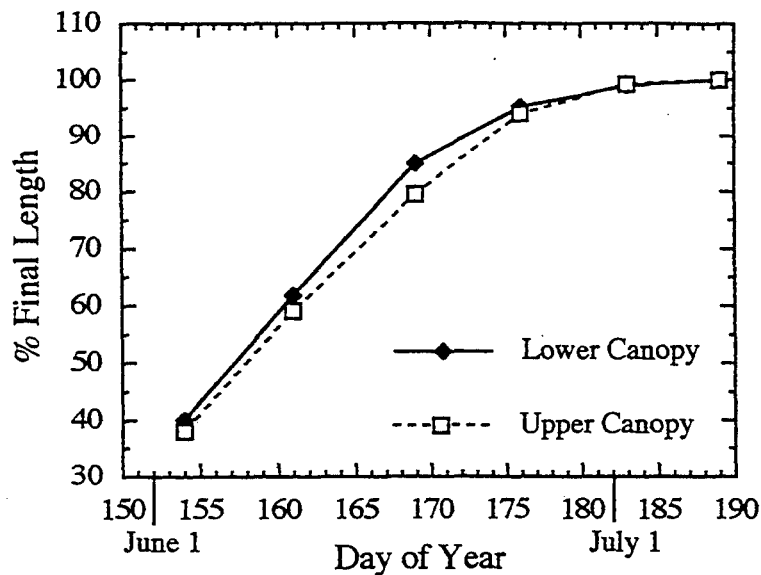
T. Collazo

Figure 1 . Growth (expressed as a percentage of final length) of new shoots from June 3 to July 9. Error bars are smaller than plot symbols.
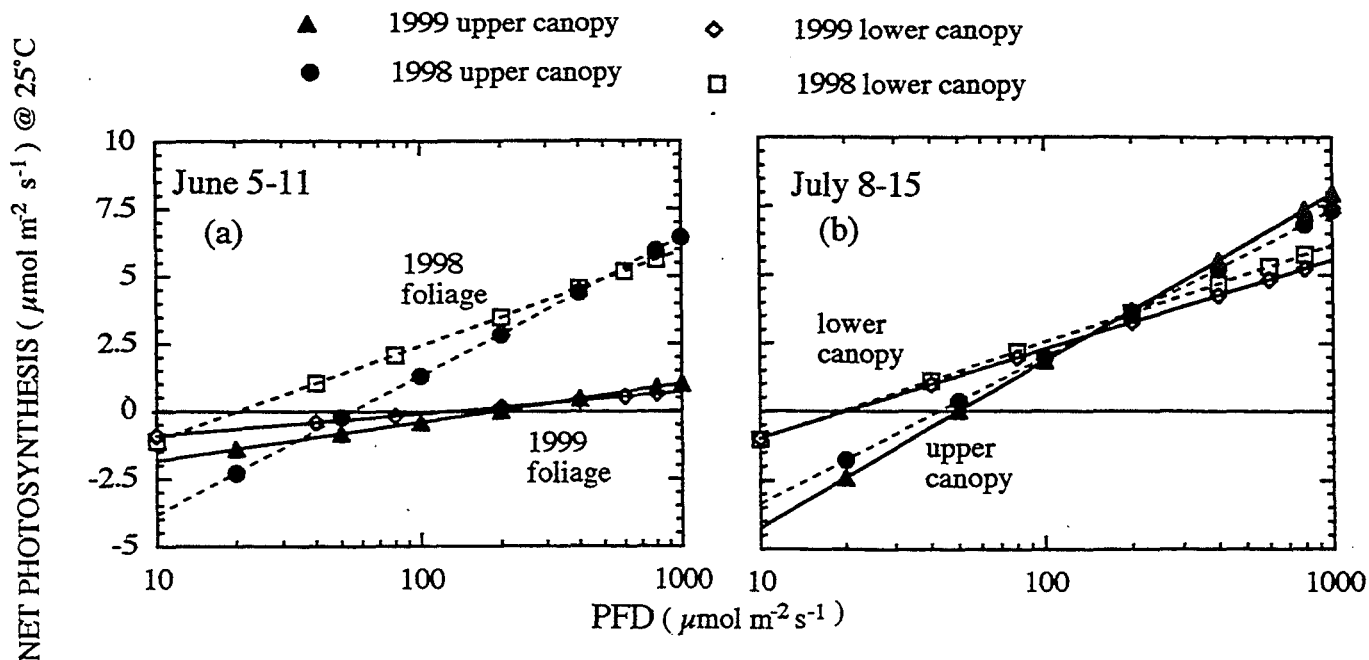

Figure 2 . Net photosynthetis rates (expressed per unit of final shoot area) versus photosynthetic photon flux density (PFD) of 1999 and 1998 shoots measured during June (a) and July (b) 1999. Error bars are smaller than plot symbols.
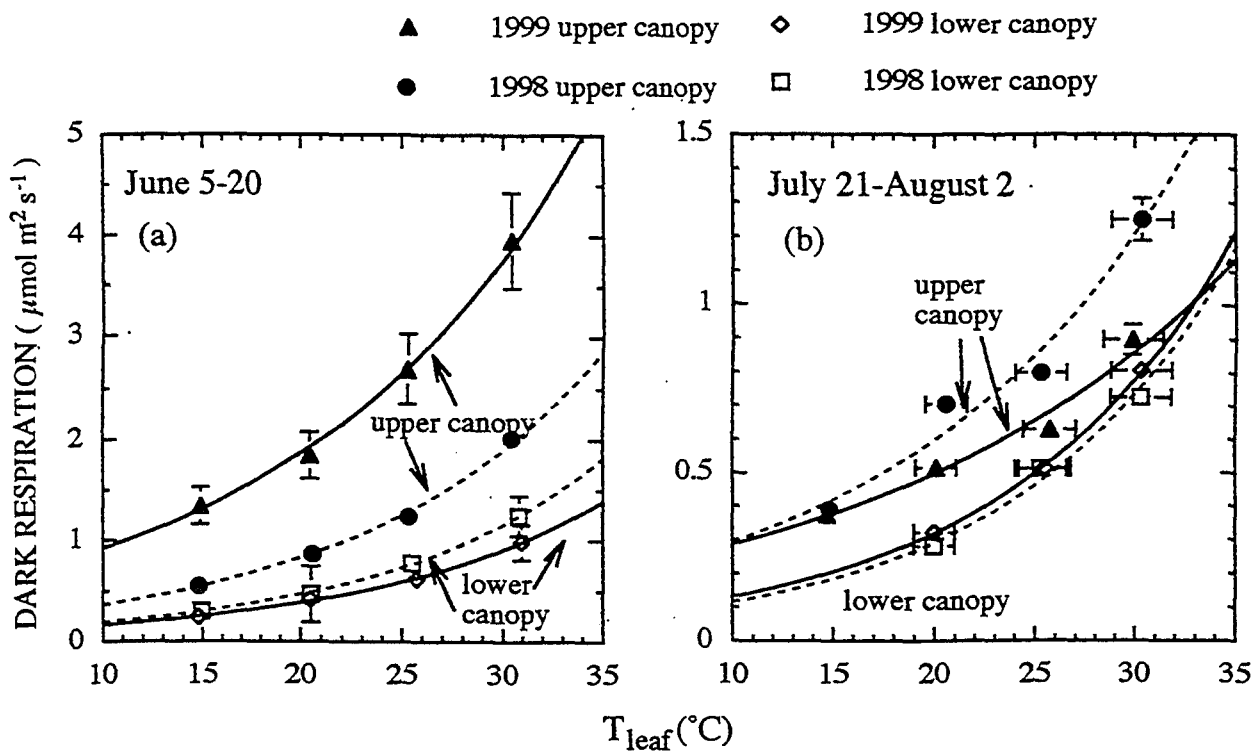
S. Cook

DARK RESPIRATION (μmol m^{2} s^{-1})

June 5-20

(a)

upper canopy

lower canopy

July 21-August 2

(b)

upper canopy

lower canopy

T_{leaf}(°C)

Figure 3 . Dark respiration rates (expressed per unit of final shoot area) versus temperature Of 1999 and 1998 shoots measured during June (a) and July-August (b). Error bars represent standard error.

NET PHOTOSYNTHESIS (μmol m^{2} s^{-1})

June 7-11

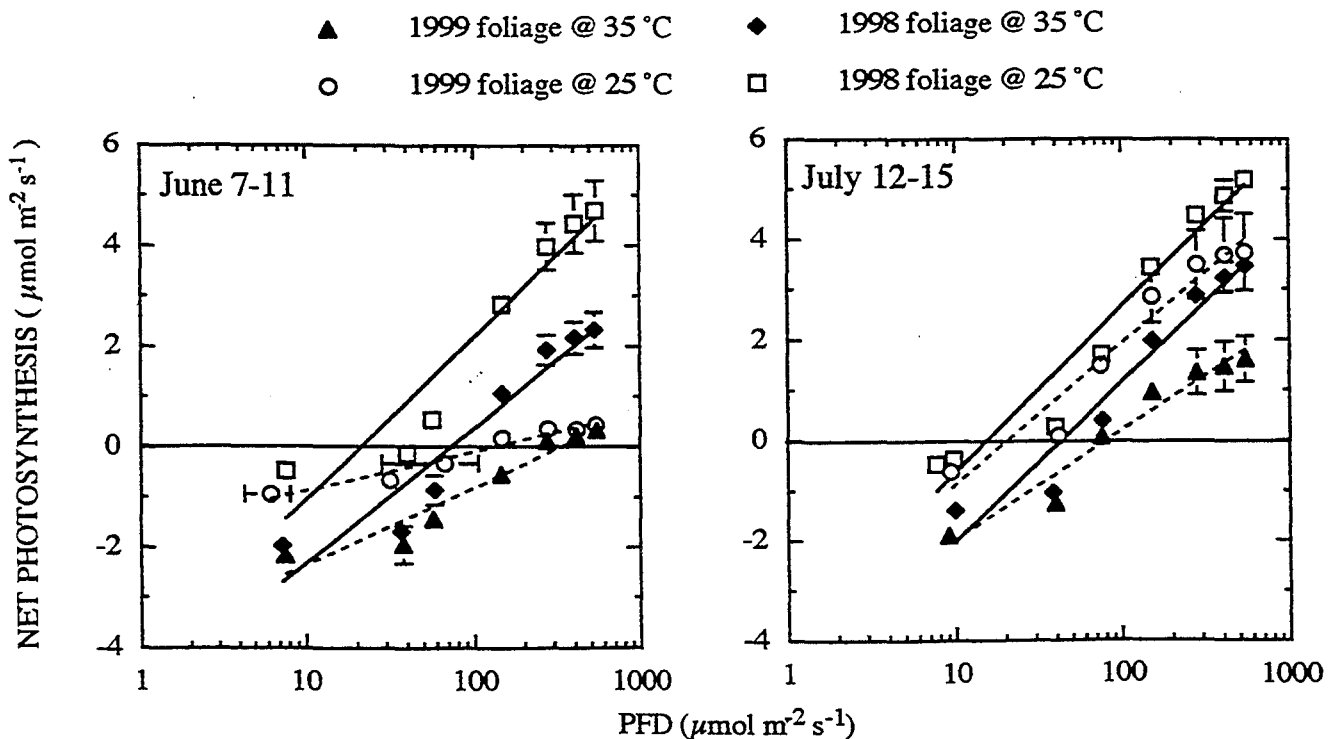July 12-15

PFD (μmol m^{-2} s^{-1})

Figure 4 . Net photosynthesis rates (expressed per unit of final shoot area) versus photosynthetic photon flux density (PFD) of lower canopy 1999 and 1998 shoots at 25 °C and 35 °C measured during June and July. Error bars represent standard error.

S. Cook

temperature of 35°C affected both age classes by reducing maximum photosynthetic rates and raising light compensation points (Fig. 4). In the normal light regime of the lower canopy where photosynthetic photon flux rarely exceeds 100 μmol m^{-2} s^{-1}, very high temperatures in June would virtually eliminate carbon fixation by the immature shoots. Very hot weather in either June or July could also dramatically decrease net stand carbon gain by increasing respiration and depressing photosynthesis in all foliage.

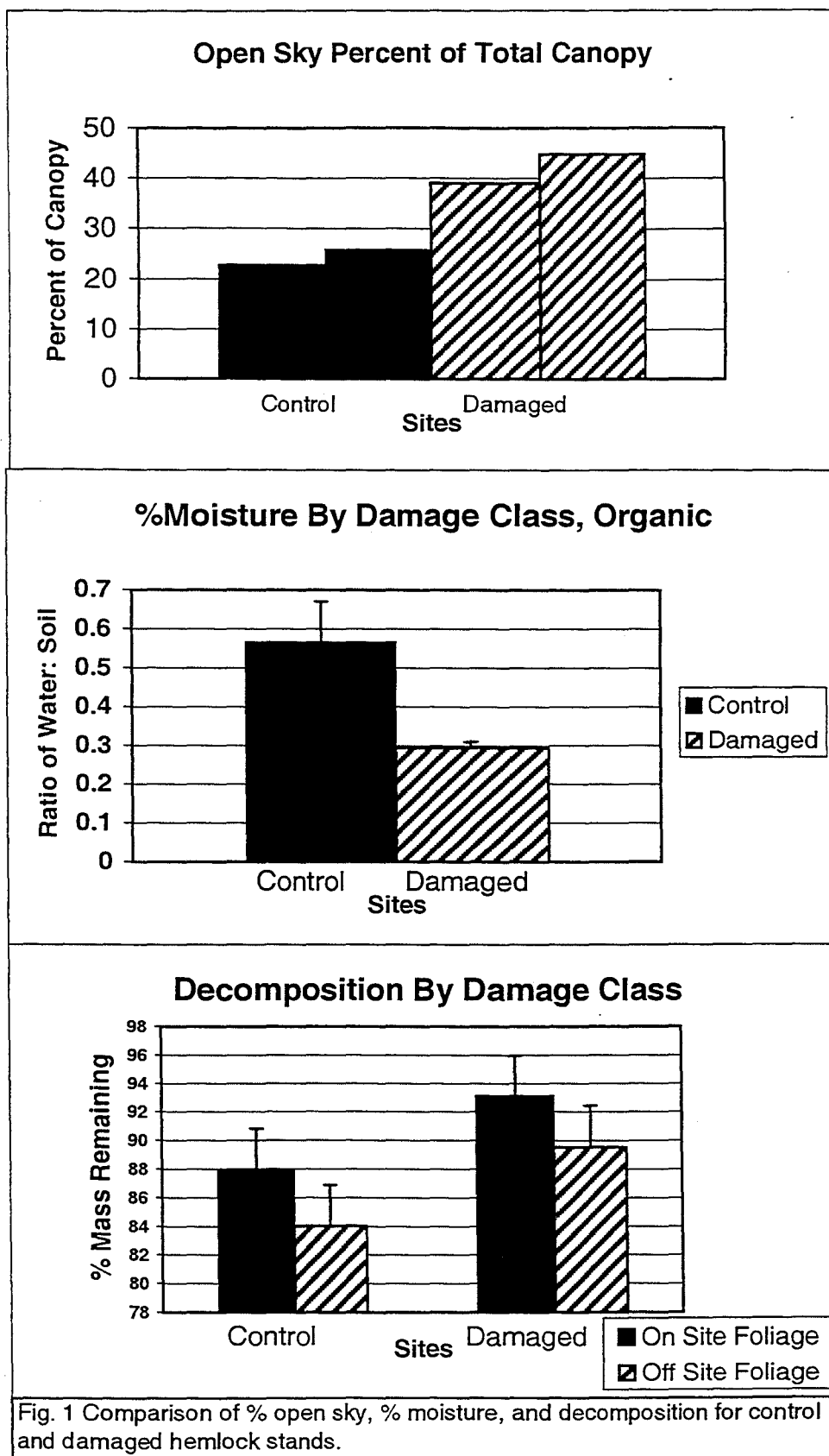## Soil Response To Infestation of Hemlock Woolly Adelgid in Connecticut Hemlock Stands

Steven Currie

Eastern hemlock (*Tsuga canadensis*) stands possess unique microenvironmental characteristics such as dense canopies, low light levels, cool soil temperatures, a large buildup of soil organic matter (SOM), and slow decomposition rates. The introduced hemlock woolly adelgid (HWA; *Adelges tsugae*) is causing a change in this strongly controlled microenvironment. HWA feed on ray parenchyma cells, causing needle loss, and ultimately branch and tree mortality. Thinning canopies may result in dramatic increases in light availability, which previously did not reach the forest floor. This study examines what happens to the microenvironment of HWA infested stands over time. The alterations of ecosystem functioning predicted to occur include:

1. An increase in light availability will cause a rise in soil temperatures.
2. Nitrogen mineralization and SOM decomposition rates will increase.
3. The sudden loss of a dominant species will cause nutrient leaching; however, if hemlock is rapidly replaced by hardwood species, available inorganic nitrogen may be consumed.

To evaluate decomposition, eight study sites throughout the Connecticut River Valley were selected based on levels of HWA infestation and stand deterioration. Two of these sites are controls, with no noticeable adelgid or canopy thinning. Each site consists of three 20 x 20 m plots containing six randomly placed temperature loggers which record every half hour from May to October at 1 and 5 cm depths. Sub-samples of soil cores are analyzed for gravimetric moisture. Percent open sky is calculated using hemispherical photos. Foliage from each site as well as from the Harvard Forest was collected in June and placed on the forest floor in 15 x15 cm bags with 1 mm mesh. On-site foliage will be used to evaluate decomposition based on the stands' foliar chemistry. Off-site foliage will test the influence of microclimate on decomposition. Litter will be collected after 1 month, 4 months, 12 months, and 18 months. Samples will be analyzed for lignin to nitrogen and carbon to nitrogen ratios.

Upon the first collection, results (Fig. 1) showed that sites more heavily damaged by HWA (greater percent open sky) have lower gravimetric soil moisture and mass loss values. Control sites with lower percent open sky show higher gravimetric soil moisture and mass loss values. In addition, off-site foliage mass loss values are greater than that of on-site foliage for both control and damaged stands. This suggests that moisture, as well as foliar quality, may be controlling decomposition in these stands. Observations to date can only be considered preliminary trends. Relationships between variables will be evaluated with further data analysis.

Open Sky Percent of Total Canopy

%Moisture By Damage Class, Organic

Decomposition By Damage Class

Fig. 1 Comparison of % open sky, % moisture, and decomposition for control and damaged hemlock stands.

S. Currie

CO$_2$ Respiration Response to Wetting of the O Horizon in a Northern Hardwood Forest

Jason Eaton

Carbon dioxide is a greenhouse gas; understanding how it moves in the environment is important. We examined the relationship between moisture and CO$_2$ in forest soils. It has been established that as temperature increases, so does the rate of CO$_2$ flux. We believe that it is also moisture dependent. We arranged two 9m^2 plots: one control and one wet up. In each plot we inserted 6 PVC collars in the soil, which were measured for respiration with an infrared gas analyzer, twice before the addition of water and five times after adding water. The time of measurement spanned 44 hours, with the first measurements taken eighteen hours before wetting and the last twenty-six hours after wetting.

Two-thirds of the way through the first set of measurements we received a sudden, but brief, downpour of rain. The control shows a wetting response to the storm only, while the wet up shows a response to the natural, plus the artificial wetting. Because we were trying to relate the respiration response to the organic layer, we were careful to add just enough water to the plot to wet the organic layer but not the mineral layer. Destructive samples were taken to determine gravimetric water content.

Our results showed that the rate of CO$_2$ respiration from the organic horizon is not only temperature dependant but also closely tied to soil moisture content. Though our experiment did not have enough samples to produce a statistical difference, these results offer good preliminary data to warrant further study.

Timber Harvesting as a Form of Disturbance

Andrew Finley

In addition to natural disturbance factors (e.g., insects, wind, fire), timber harvesting potentially influences forest health and composition in the North Quabbin Study Area (NQSA). When considering the future of forests in the NQSA and similar landscapes, we must be equipped to answer questions at a landscape scale. In the past, we have asked questions of how individual timber harvests affect local areas or stands. By developing a spatial and temporal perspective of timber harvesting, we may begin to approach questions of how and if timber harvesting is affecting entire landscapes.

The objective of our project is to characterize the extent to which timber harvests represent disturbance in the NQSA. We have developed a database of harvest occurrences as spatial entities and related information that enables us to quantify the disturbance at the landscape scale. The database was constructed with the aid of GIS (ArcView software), which permitted us to spatially capture each harvest occurrence and its attribute data. The NQSA database contains 1,867 harvest records, stretching back to 1985. Our analysis indicates 124.4 harvest occurrences annually and an annual average harvest occurrence of 16.6 hectares, which represents 2,063.4 hectares of harvest disturbance. Average and median harvest intensities are 45.2 and 28.4 cubic meters per hectare respectively. From 1985 to 1999, 62 percent of harvests have occurred on

non-industrial private land. This database will aid us in developing an understanding of how the cumulative effects of harvesting influence species composition, water quality, and future forest health.

A Survey of Water Relations in Two Fern Species (*Osmunda spp.*) as a Basis for Studies of Embolism Formation and Repair

Emily Huhn

Parameters related to water transport were studied on Interrupted Fern (*Osmunda claytoniana* L.) and Cinnamon Fern (*Osmunda cinnamomea* L.) plants growing in a temperate forest in central Massachusetts. There is very little physiological information on these unique species in the literature even though ferns constitute a large component of both temperate and tropical understory ecosystems. The vulnerability of the water transport system to cavitation was measured on stem segments subjected to a range of centrifugal tensions. Diurnal patterns in hydraulic conductivity as a function of leaf water potential (ψ_{leaf}) were also investigated. Pressure volume curves were generated on fronds of both species by correlating relative water loss to ψ_{leaf} measured with a pressure chamber. It should be mentioned that these species produce a resin that made hydraulic measurements difficult to obtain. The hydraulic conductivity of both fern species showed significant increases in embolism formation at tensions greater than 1.5 MPa (Figs. 1 and 2). Diurnal fluctuations in hydraulic conductance were not observed in either species (Figs. 3 and 4). The turgor loss point of Interrupted and Cinnamon Fern occurred at pressures of 2.0 and 1.8 MPa respectively (Fig. 5).

These data suggest that ferns do not normally operate near their cavitation thresholds in the field and it is hypothesized that they also lack the ability to repair embolized vessels. The evidence presented here will contribute to a larger study that includes taxonomically and structurally diverse species to give a more complete picture of embolism formation and repair.

Up Against the Wall: Distribution of Mice and Voles in Deciduous Forest

Ana Laborde

What is the influence of stone walls on the distribution of the White-footed Mouse (*Peromyscus leucopus*) and the Redback Vole (*Clethrionomys gapperi*)? Previous studies show contradicting patterns in distribution. A more expansive study including habitat description, live trapping, and a behavioral experiment was conducted in Harvard Forest at three sites with different understory composition and moisture levels but similar total basal areas and tree composition. At each site five transects were drawn across the wall each with stations at 5 meter intervals away from the wall. Traps were placed at each station and individuals were tagged and released. The habitat was characterized within a 2 m radius surrounding each station measuring aspects which could influence mammal distributions. *Clethrionomys* was caught at two of the three sites and was most frequently caught at the wall. In contrast, *Peromyscus* was caught at all three sites, but only 5 out of 87 captures were at the wall (Fig. 1).

Figure 1

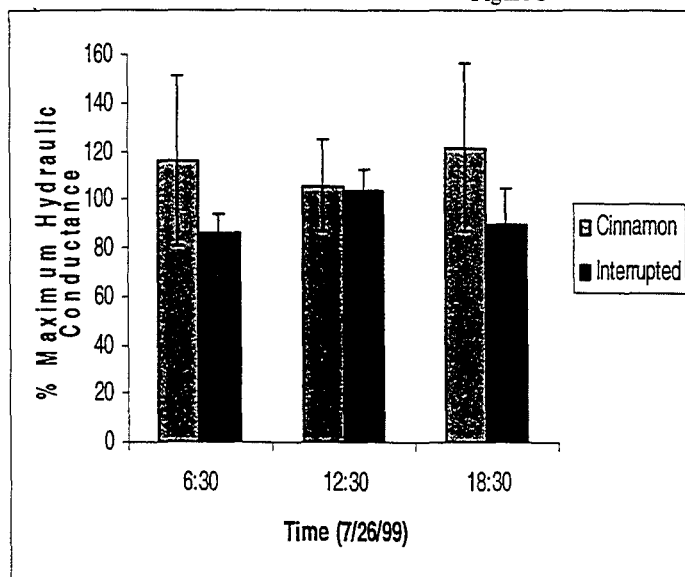**Vulnerability Curve (Interrupted Fern)**
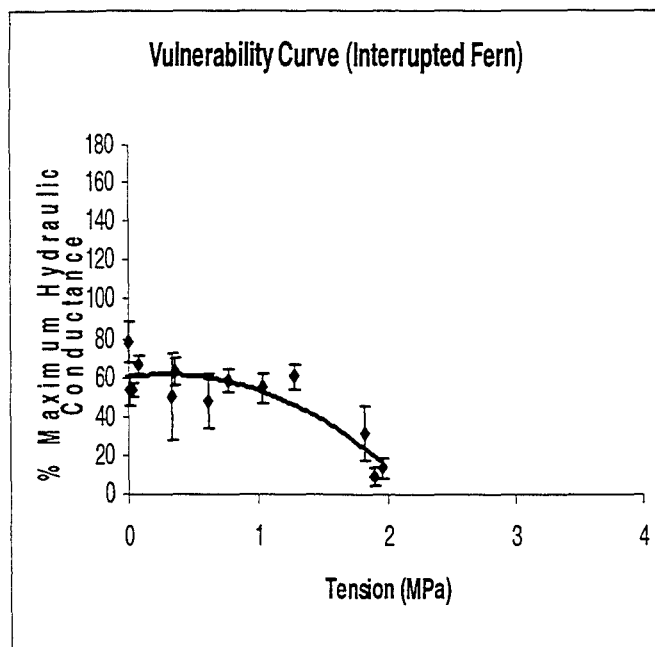
Hydraulic conductivity (H.C.) was measured in Interrupted
Fern stems before and after a high pressure flush to give %
maximum H.C. values for stems subjected to the range of
centrifugal tensions shown. Each diamond represents the
mean value of 5 stems. Resin blockage may account for the
fact that y-axis values start below 100%. H.C. shows a
significant increase in embolism formation at tensions
greater than 1.5 MPa.
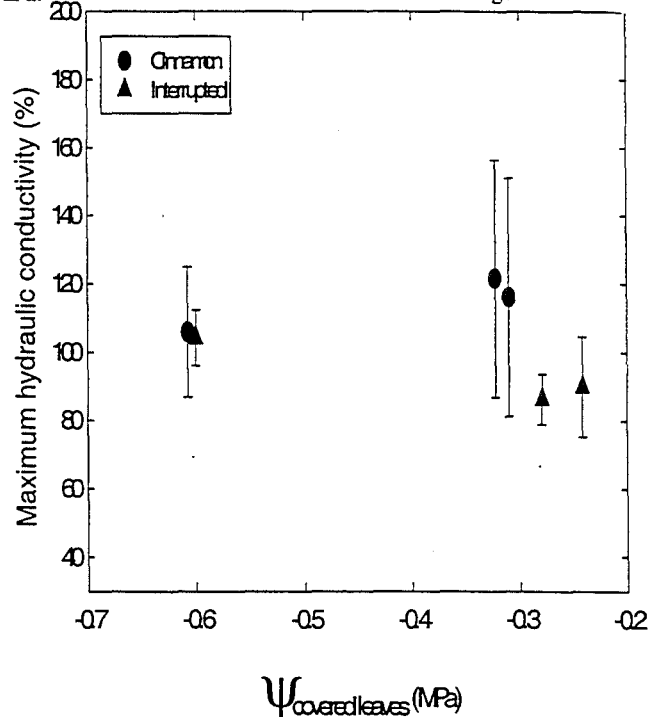
Figure 2

Vulnerability Curve (Cinnamon Fern)
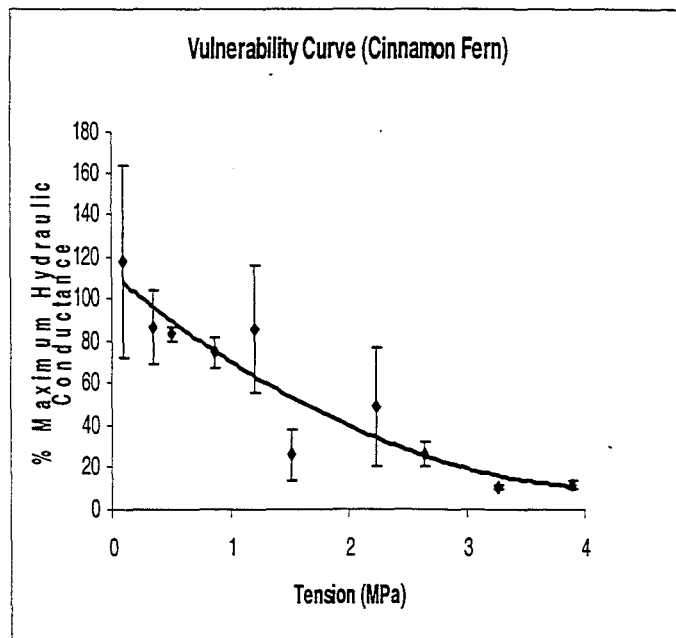
Hydraulic conductivity (H.C.) was measured in
Cinnamon Fern stems before and after a high
pressure flush to give % maximum H.C. values for
stems subjected to the range of centrifugal tensions
shown. Each diamond represents the mean value of
5 stems. H.C. shows a significant increase in
embolism formation at tensions greater than 1.5
MPa.

Figure 3

Hydraulic conductivity (H.C.) was measured on
both species after a high pressure flush to give %
maximum H.C. at three separate times during the
day. Bars represent the mean values of five stems
except for the Interrupted Fern bar at 12:30 which
represents the mean of 3 stems This graph reveals
that H. C. remains relatively constant throughout
the day.

Figure 4

The % H.C. values measured at three times on
7/26/99 were also correlated to leaf water potential.
It is clear that there was no real change in H.C.
within the range of water potentials measured.
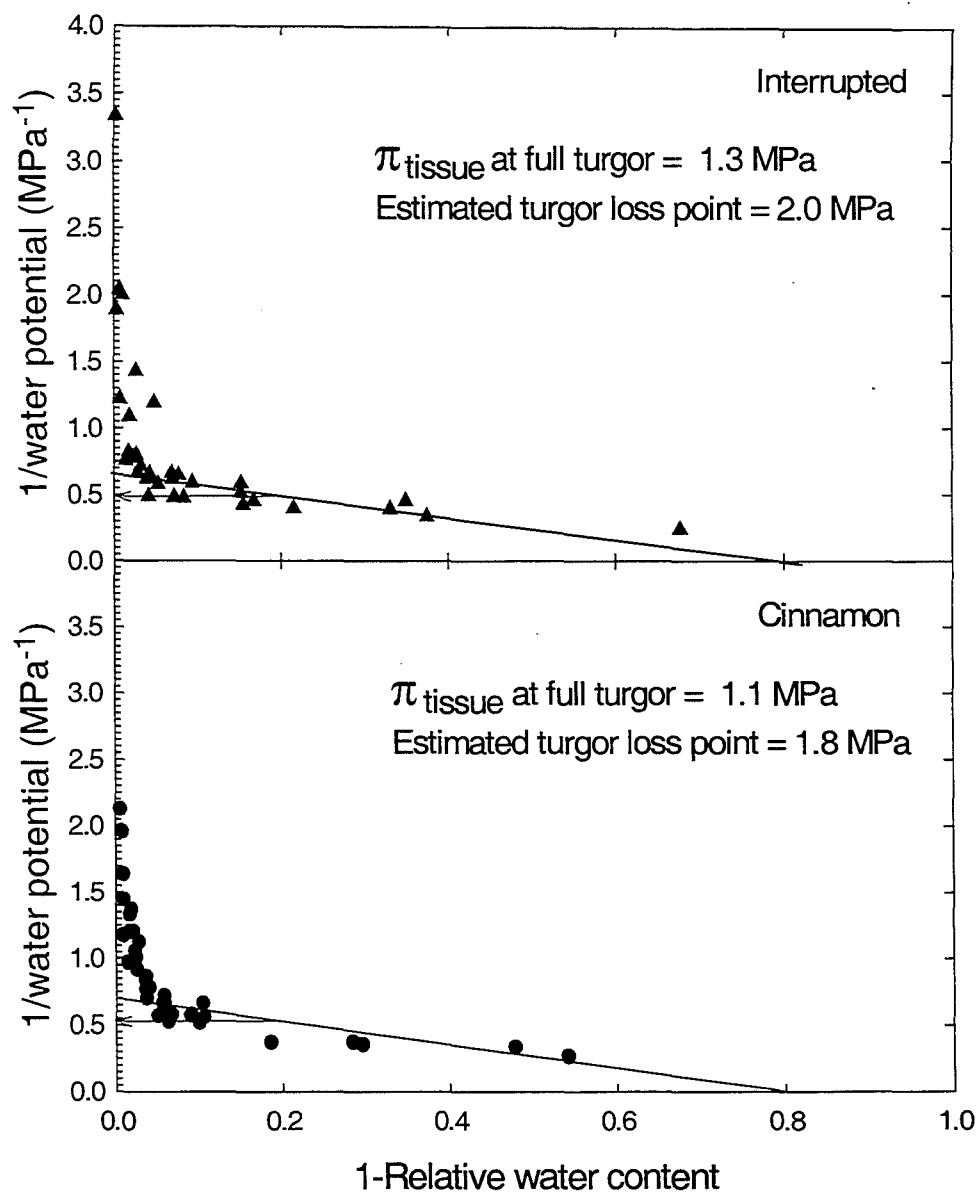
E. Huhn

Figure 5

Pressure volume curves were generated on fronds of both species by correlating relative water loss to leaf water potential. X-axis values represent the amount of water remaining in the frond while y-axis values are reported as the inverse of tension. Estimations of turgor loss point, the point at which all water has left living cells, were made for Interrupted and Cinnamon Fern and occurred at pressures of 2.0 MPa and 1.8 MPa respectively. Estimation techniques were based on procedures reported in the literature.

E. Huhn

FIGURE 1

Total Captures for all Sites

Total *Peromyscus* Captures vs. Distance from Wall

Total *Clethrionomys* Captures vs. Distance from Wall

A. Laborde
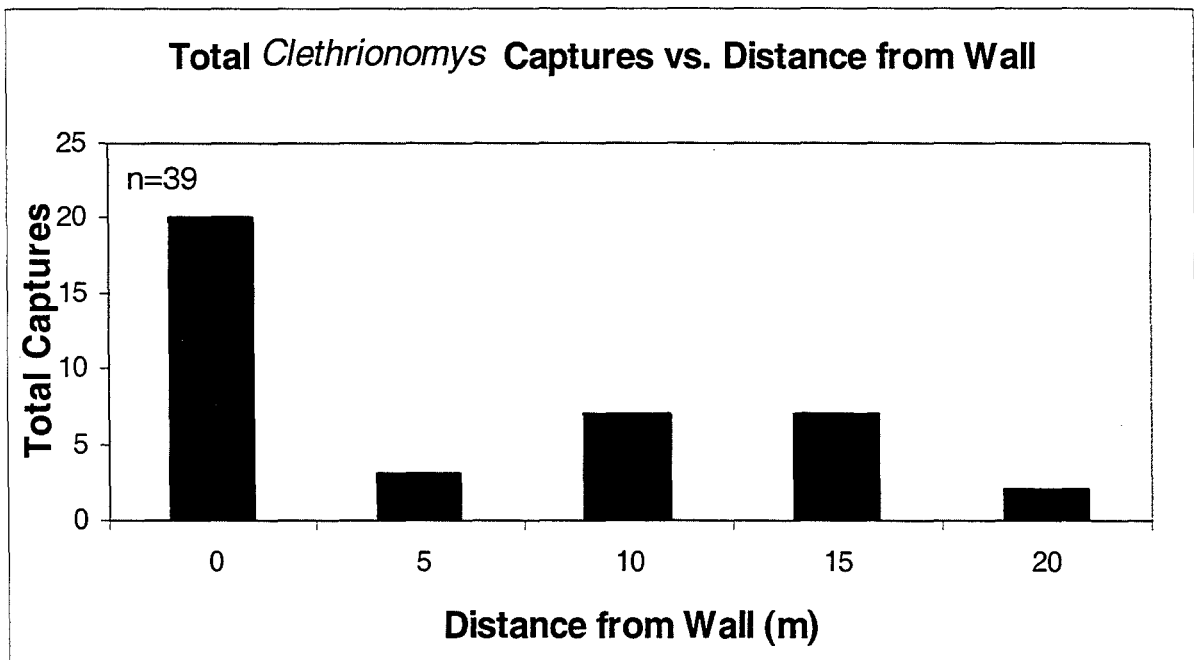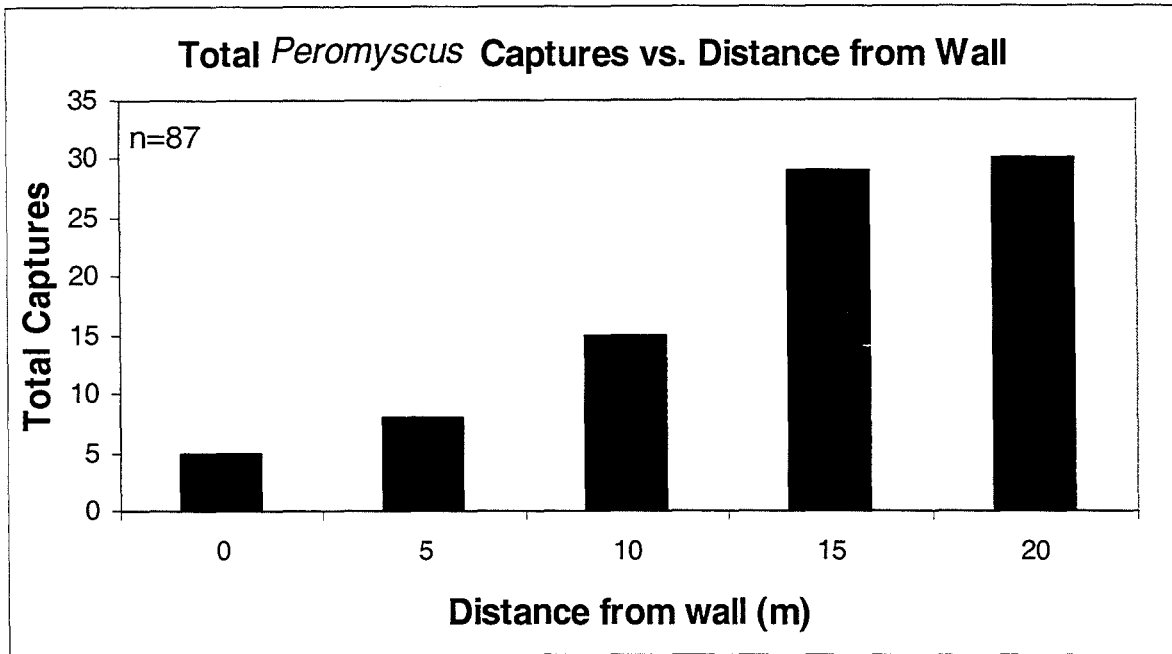
What factors are responsible for this pattern? Supporting evidence suggests competition and predation risks are not the responsible factors. Microclimate may affect *Clethrionomys*. At the driest site *Clethrionomys'* activity was restricted to the wall, probably due to its preference for moister microclimate. Differences in foraging tactics may also contribute to the patterns and should be examined. If there are foraging differences, the distribution of the mammals could affect the distribution of vegetation around the wall since mice cache seeds and both species are seed predators.

Breaking New Ground in Plant Water Relations: a Study of the Dynamics of Embolism Formation and Repair in *Salix Nigra*

Barbara Muñoz

There is currently a controversy surrounding the mechanism of long distance water transport in plants despite 250 years of study. Recent findings have shown the dynamic patterns of embolism formation and repair diurnally, and other studies suggest that refilling occurs even while neighboring vessels are still under large negative pressures. However, it is not clear whether water transport occurs through previously embolized vessels after refilling such that they become "functional" in water transport again.

The focus of this study was to examine if "functional" repair can occur in *Salix nigra*. Experiments were conducted to measure changes in transpiration before and after exposing two-year-old saplings growing in a greenhouse to different pressures (using a pressure collar and balance). The turgor loss point was determined to be ~1.1 MPa using pressure volume curve relationships (Fig. 1). The vulnerability of *S. nigra* was estimated to be around ~1.5 MPa (Fig. 2). The application of pressures greater than 1.5 MPa using a pressure collar stopped the flow of sap through branches permanently with leaf senescence occurring shortly after indicating that embolism formation was catastrophic in *S. nigra*. Thus, refilling of embolized vessels was not observed (Fig. 3). These findings suggest that a survey studying the dynamic nature of embolism formation is needed in order to determine whether other species can functionally repair embolized vessels. Understanding these mechanisms will give insight on issues surrounding evolutionary adaptations, plant distribution, and species sensitivity to drought.

Charcoal Analysis: Determining Fire History from Deep Pond, Falmouth, MA

Jason Murnock

To establish the fire history of an area, one may examine historical records if they exist, or perform charcoal analysis of the sediments. In this project, sediments from Deep Pond of Falmouth, Massachusetts were analyzed for pollen, charcoal and organic content to reconstruct the local changes in fire and vegetation history over the period of European settlement.

Each depth of the core represents a different period of the past: the deeper the sediment, the older its origins. Percent organic content was determined by weighing the samples, firing and
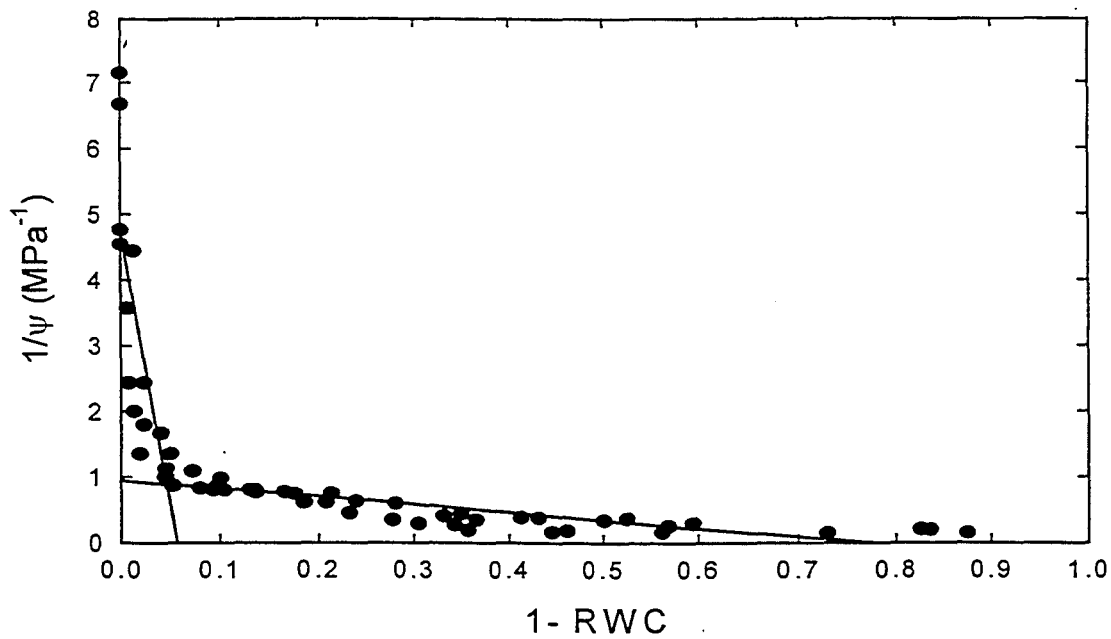
fig. 1. Pressure volume curve (PVC) representing water loss versus covered leaf
water potential. PVC shows elastic bulk modulus, symplastic water fraction,
turgor loss point, and point of full turgor.
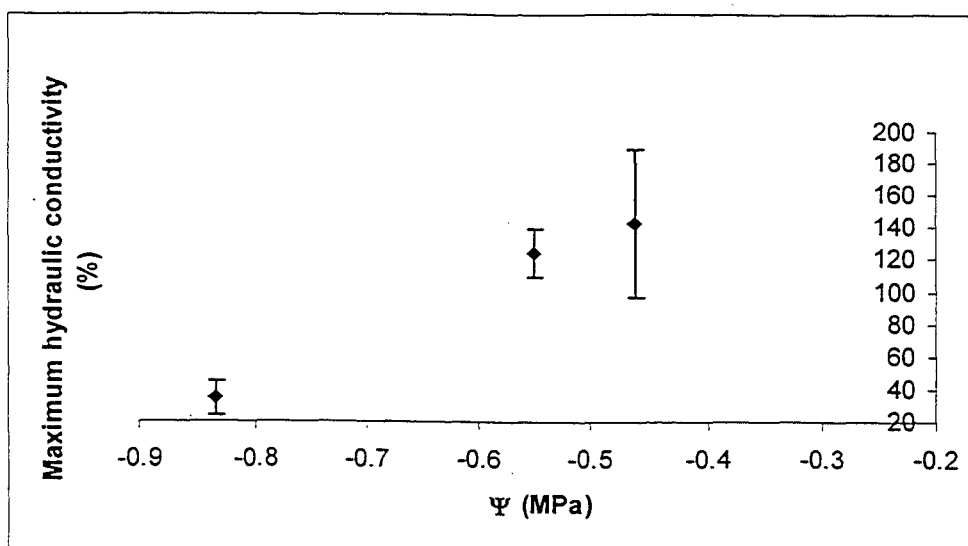
fig. 2. The relationship of covered leaf water potential to percent of
maximum hydraulic conductance. The symbols represent standard
error (n=5).

B. Muñoz
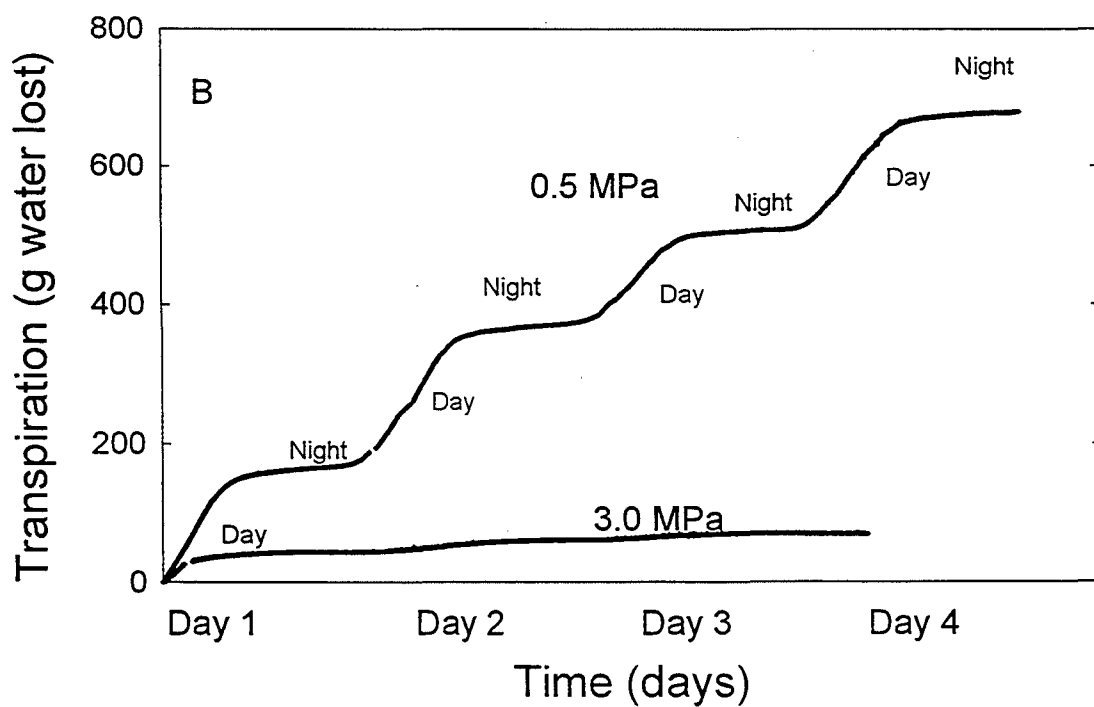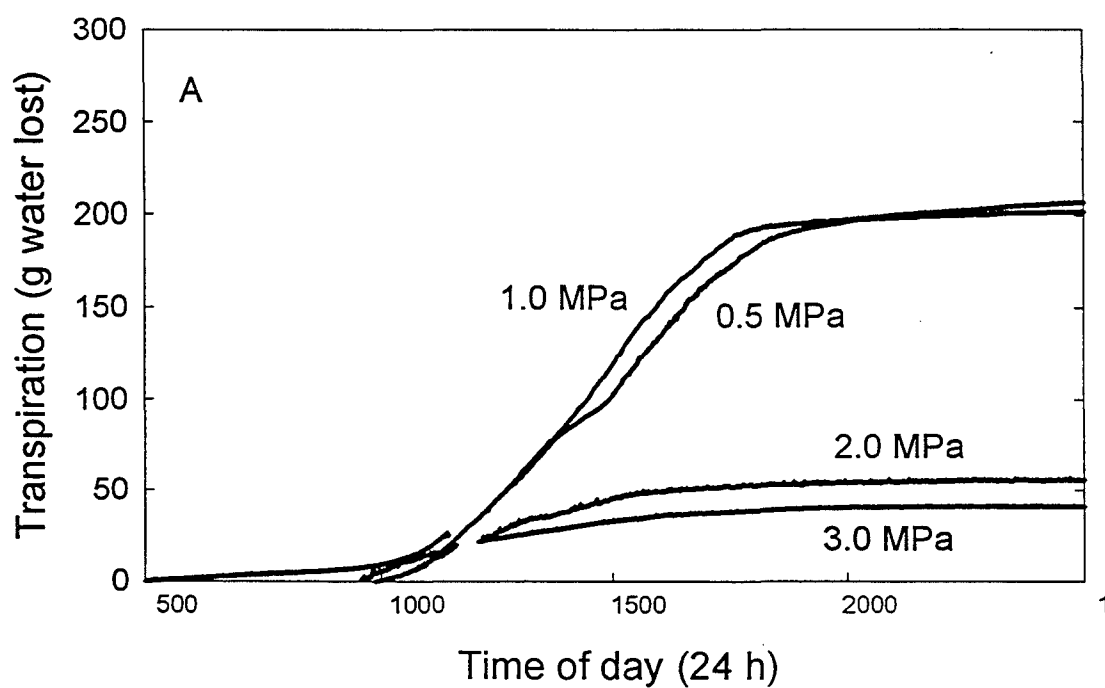
Fig. 3. The effect of applied pressures to intact *S. nigra* stems on transpiration. Panel A represents data for a 24 h period, each line is a different plant. Panel B represents the transpiration after the application of pressures (0.5 MPa and 3.0 MPa) monitored for several days. The values near the lines represent the pressures applied to stems in both panels.

re-weighing. Charcoal abundance was quantified using macroscopic (>200 microns) and microscopic (<200 microns) analyses. In general, microscopic charcoal represents fires that have occurred over a large area of the landscape. Macroscopic charcoal represents more localized fires as it is less likely to disperse as far.

Based on the rise in agricultural-indicator pollen, the period of European settlement is represented by the core's depth of approximately 80-85cm. The sharp decline in organic matter occurs slightly before the pollen data at 85-90cm, suggesting a sharp increase in erosion or deforestation. Settlement of the watershed, then, is represented in the core around 80-90cm. Macro- and microscopic charcoal is higher before European settlement, suggesting a higher occurrence of fire at that time. This pattern could be due to changes in land use, vegetation composition or climate. The abundance of microscopic charcoal is also higher in more recent sediments, suggesting a higher occurrence of regionally-produced charcoal, which may reflect increases in fossil fuel burning.

Comparison of Traditional and Semi-continuous Logging Dendrometers in the Measurement of Carbon Uptake and Diurnal DBH Fluctuation in *Acer rubrum*

David Patterson

With increasing concentrations of CO_2 in the atmosphere, terrestrial carbon sinks have become an important area of research. Forests are known to play a role in long and short-term carbon storage; however the extent of their impact is unknown. Data taken from the Environmental Monitoring Station (EMS) tower at the Harvard Forest shows a net uptake of ~2 tons of C/ha/yr (Goulden *et al.* 1996). This is significantly higher than estimates obtained from forest inventories (*e.g.* Birdsey and Heath 1995) and land use histories (*e.g.* Houghton *et al.* 1999) that have been completed for U.S. forests.

In 1998, the Wofsy lab placed band dendrometers on ~800 trees in plots surrounding the EMS tower in order to obtain an independent estimate of the forest's carbon uptake. However, the accuracy of these dendrometers is not known. In an attempt to understand these errors a logging dendrometer was designed. The logging dendrometer uses a piston-based potentiometer attached to a data logger to detect changes in distance. The potentiometer was mounted on a red maple (*Acer rubrum*), from which the bark was removed to expose the growing tissue. The existing band dendrometer was also measured over the course of the study. The band dendrometer measurements show erratic growth with the largest increase coming during a 4-hour period, probably due to the bark absorbing rainwater.

The data from the logging dendrometer corroborates diurnal fluctuations in diameter shown by other studies done with various logging dendrometers (*e.g.*, Lassoie 1973). When diurnal variations are eliminated, the data shows a very steady increase of ~0.2mm in diameter over the course of the 13-day study (Fig. 1). With a longer study period and a larger population base a better understanding of tree growth patterns and dendrometer accuracy can be gained using this method. Annual carbon uptake could be obtained from these data as well as the effects of water absorbed by the bark. However, the existing band dendrometers give an accurate representation of seasonal growth, but do not show an appropriate response to weekly carbon uptake.
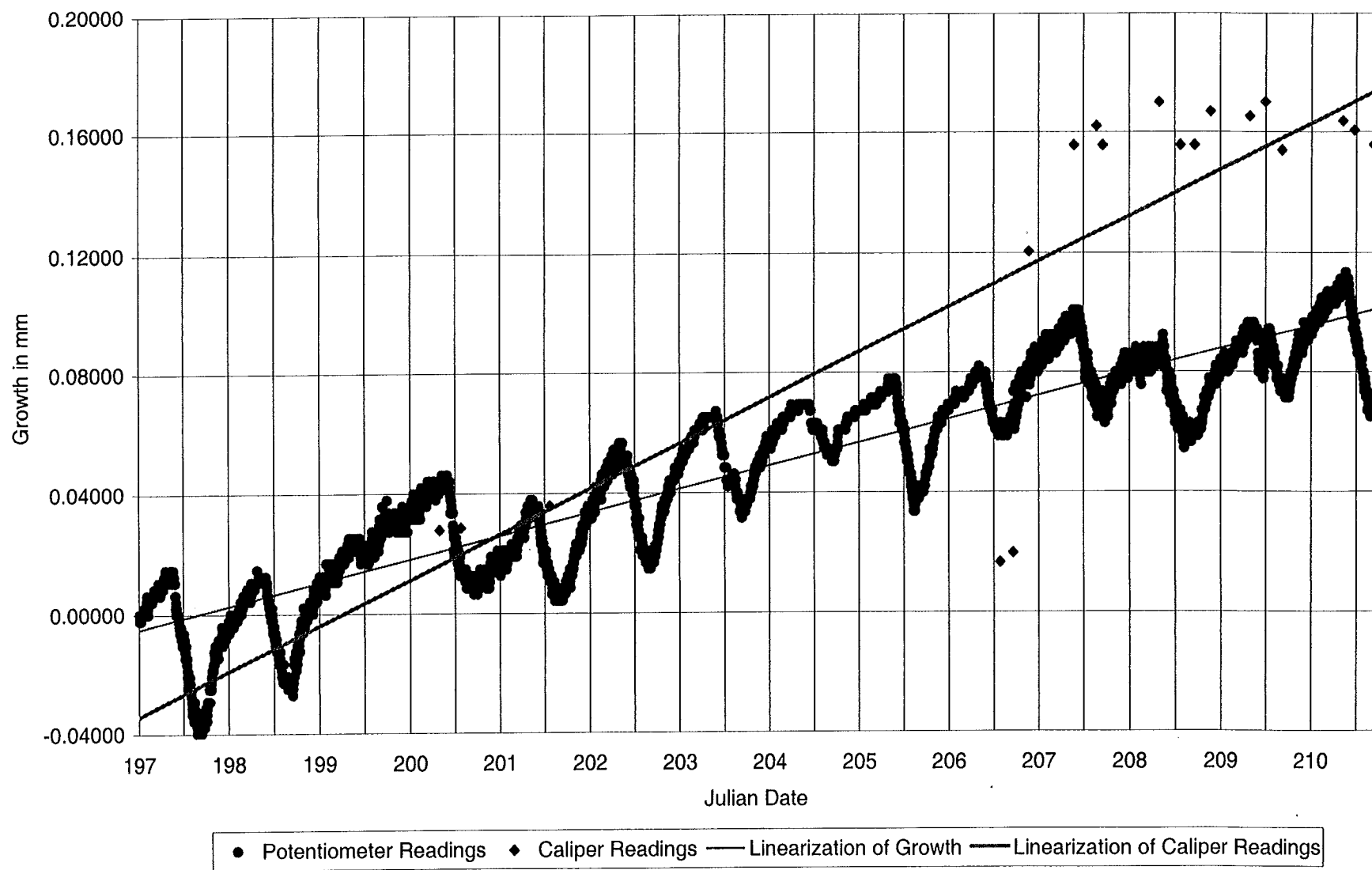
Figure 1. Growth and Daily Fluctuations in DBH of *Acer rubrum*

Patterson, D.

Birdsey, R.A. and L.S. Heath. 1995. Carbon changes in U.S. forests. Pp. 56-70 In: L.A. Joyce (ed) *Productivity of America's Forest and Climatic Change*. USDA For. Serv., Gen. Tech. Rep. RM-GTR-271, Rocky Mtn. Forest and Range Expt. Stn., Fort Collins, CO, 146 pp.

Goulden, M.L., J.W.Munger, S.-M. Fan, B.C.Daube and S.C.Wofsy. 1996. Exchange of carbon dioxide by a deciduous forest: response to interannual climate variability. Science 271: 1576-1578.

Houghton, R.A., J.L.Hackler and K.T. Lawrence. 1999. The U.S. carbon budget: contributions from land-use change. Science 285: 574-578.

Lassoie, James P. 1973. Diurnal dimensional fluctuations in a Douglas-fir stem in response to tree water status. Forest Science 19: 251-255.

Estimating Biomass in Secondary Dry Tropical Forest of the Southern Yucatan

Larissa Read

Three areas in the Southern Yucatan were sampled for basal area and canopy height to ascertain the effect of age on community structure and biomass. The regions (Arroyo Negro, El Refugio, and Nicolas Bravo) are located along a precipitation gradient, and each contains a post-agriculture successional sequence. A total of 36 sites were sampled. At each site, basal area was measured for three size classes: three $10m^2$ plots for 1-4.5cm dbh stems, a $100m^2$ plot for 4.6-9.5cm dbh stems, and a $500m^2$ plot for >9.5cm dbh stems. Clinometer readings taken at 13 grid-points in each $500m^2$ plot will be used to determine height.

Total basal area in each region increased as a function of age. At Arroyo Negro, a significant portion of total biomass is represented by stems >9.5cm dbh; contributions from the smaller size classes are highly variable. Additionally, contribution to total biomass by palms may form the majority of total basal area at a site, and should be incorporated into final biomass estimates. Average dbh in the largest size class varies with age, whereas average dbh in the smaller classes remains relatively constant at all ages, suggesting a constant progression of stems through the size classes.

Trends in basal area and community structure at Arroyo Negro appear similar to those at El Refugio and Nicolas Bravo. Incorporation of tree height measurements will allow for more accurate biomass estimates, and consideration of factors such as soil nutrient content and land history will help clarify variation between the regions.

Effects of Environmental Factors on Spatial Distribution of Understory Species in a Mixed Conifer-Hardwood Forest

Henry Schumacher

New England forests consist of a mosaic of different stand types, most notably hemlock stands within a predominantly deciduous, broad-leaved forest. These two stand types differ with respect to understory environmental conditions, especially light availability and pH. These differences in environmental conditions between stands possibly control differences in the distribution of understory herbs and shrubs. Hemlock stands have much lower understory species density and diversity than broad-leaved stands. We tried to explain differences in species composition between contrasting stand types based on responses of understory species to environmental factors.

We looked at the five most abundant species in Hemlock and Hardwood stands (Fig. 1) and tried to relate their spatial distributions to environmental factors. We found four kinds of species-environment relationships. Some species responded to one major factor which differed between stand types (*Mainthumum canadense* and *Mitchella repens*), whereas some species responded to one major factor which did not differ between stand types (*Dennsteadtia punctilobula* and *Lycopodium obscurum*). Other species responded in a complex way to many of the environmental factors measured (*Gaultheria procumbens* and *Trientalis borealis*), while *Medeola virginiana* did not respond to any of the environmental conditions.

We found that understory distribution was dependent upon canopy species composition. Understory species were often associated with one stand type, but never exclusively. It is important to get a better understanding of the controlling factors of understory distribution because of their importance in determining future forest dynamics.

Litter Dynamics Following Shifting Cultivation in the Southern Yucatan Peninsula

Jessica Sisco

Litter production and standing litter stock in the southern Yucatan were measured to determine how litter dynamics change as forests develop following shifting cultivation. At three sites, distributed over a broad geographic region, a total of 36 plots of varying successional age were sampled.

Four 1-m^2 traps were set out at each of the 36 plots. Litterfall was measured monthly from 1998 December to 1999 June. In 1998 November, litter standing stock (g/m^2) was measured at each plot by collecting all leaves and twigs less than 2 cm dbh from four 1-m^2 samples. Mean residence time of litter was calculated from the litterfall and litter standing stock measurements.

14

Hardwood

Species	Count	Abundance
Maianthumum canadense	75	5647
Trientalis borealis	61	672
Dennsteadtia punctilobula	47	1671
Gaultheria procumbens	33	1004
Lycopodium obscurum	29	434
Mitchella repens	16	217
Medeola virginiana	8	25

Hemlock

Lycopodium obscurum	24	92
Mitchella repens	19	188
Gaultheria procumbens	16	84
Medeola virginiana	16	111
Maianthumum canadense	8	144
Dennsteadtia puntilobula	5	17
Trientalis borealis	3	11

Figure 1: Five most abundant understory species found in Hardwood and Hemlock stands based on Presence/Abundance and Stem Abundance in all plots

H. Schumacher

Litter production, averaged over all plots, showed a large pulse during April. Mean monthly litterfall tended to increase with age of successional forests, and mean litterfall for the oldest successional stands was greater than that of mature stands. Mean residence time of litter ranged from 0.6 years to 1.1 years. Turnover time of litter stocks increased with increasing forest age (2-18 years), but then decreased in the oldest secondary stands (22-29 years). In dry tropical forests, increasing litterfall production and decreasing turnover time as a function of secondary forest age suggest that shifting cultivation alters litter dynamics and possibly nutrient cycling.

Understory Dynamics of Hemlock Woolly Adelgid (HWA) Infested Stands in Southern Connecticut

Saskia van de Gevel

Traditionally, hemlock (*Tsuga canadensis*) forests provide a deeply shaded understory which prevents most shade intolerant species from becoming established. With the introduction of hemlock woolly adelgid (HWA) into hemlock forests, this unique understory has and will continue to be dramatically altered. Over the past 50 years, the HWA has expanded its range from Virginia to the northern border of Massachusetts, and has resulted in mortality of hemlocks seedlings, saplings, and mature trees. As hemlock mortality increases, forest floor light availability also increases (Fig. 1). These gaps of light are quickly becoming utilized by competitive trees, herbs, and shrubs.

This summer we have continued to examine understory dynamics associated with HWA infestation in 460 (1m^2) subplots at 8 different sites in central Connecticut. These sites were chosen because they had 50-80% hemlock overstory, and various levels of HWA infestation. The majority of understory plots have experienced dramatic change since these plots were established in 1995. We have seen a large increase in dominance of species such as black birch (*Betula lenta*), red maple (*Acer rubrum*), and several fern species. These species have increased in cover and have started to decrease the available light. Over the past 4 years the opportunistic black birch seedlings have grown 1-3 meters and are on their way to becoming dominant trees.

We observed additional species which are surviving in the shade cast by these saplings, such as black oak (*Quercus velutina*), red oak (*Quercus rubra*), and black cherry (*Prunus serotina*). The few hemlock seedlings were under attack by the HWA and were deteriorating quickly. Unfortunately, there seem to be no signs of recovery, and as this research continues, it will be interesting to follow the decreasing vigor of surviving hemlock trees and how forests respond.

Effect of Land-use History on Seed Rain in the Southern Yucatan Peninsula

Heidi Wasson

Anthropogenic disturbances have affected ecosystems throughout the entire biosphere. In the dry tropical forests of the Southern Yucatan Peninsula Region, land-use history influences important ecosystem features such as species diversity. In this experiment, we compared seed

Mortality

Percent Hemlock Overstory Mortality

Study Site

Legend: 1995, 1997, 1999
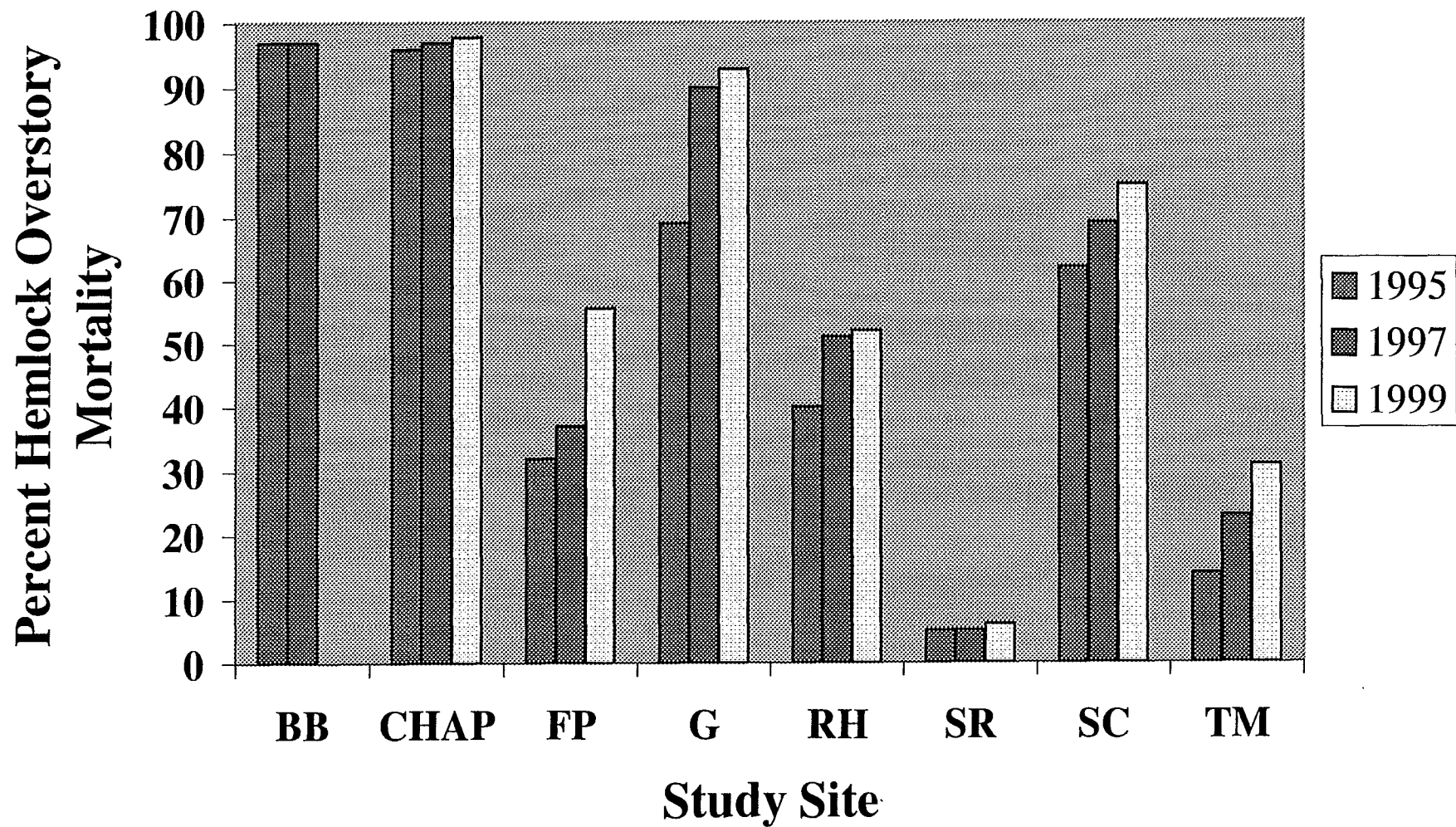
richness and composition in two villages with different intensities of previous cultivation. Nicolas Bravo was established ca. 1940 and has experienced a longer duration and more cultivation than El Refugio, which was established ca. 1970. Satellite photographs show more disturbances and fragmentation in Nicolas Bravo than in El Refugio

Seeds were collected from twelve leaf litter traps at each site: four traps in each of two young stands (3-4 and 9 years following cultivation) and four in one mature stand that has not been cultivated or logged for at least 50 years. The effect of age and landscape structure on seed richness varies with spatial scales. On a local scale ($50m^2$) approximately 10 morphospecies of seeds/trap were found and there was no significant difference for age or site. However, as shown in Figure 1, on a mesoscale ($500m^2$) the mean richness of the secondary forest was greater than that of the mature forest. Many studies have shown that secondary forest tends to be less diverse in tree species than mature forest.

Our result suggests that seed rain may not be the limiting factor in secondary growth tree diversity and one should look towards the state of soil nutrients or grade of precipitation as potential restrictive factors. A composition analysis showed that the suites of morphospecies found at the two sites were over 80% dissimilar. This large turnover may be caused by the different land-use histories and resulting landscape structures of the two sites.

Comparison of Seed Richness on a Mesoscale (500m^2)
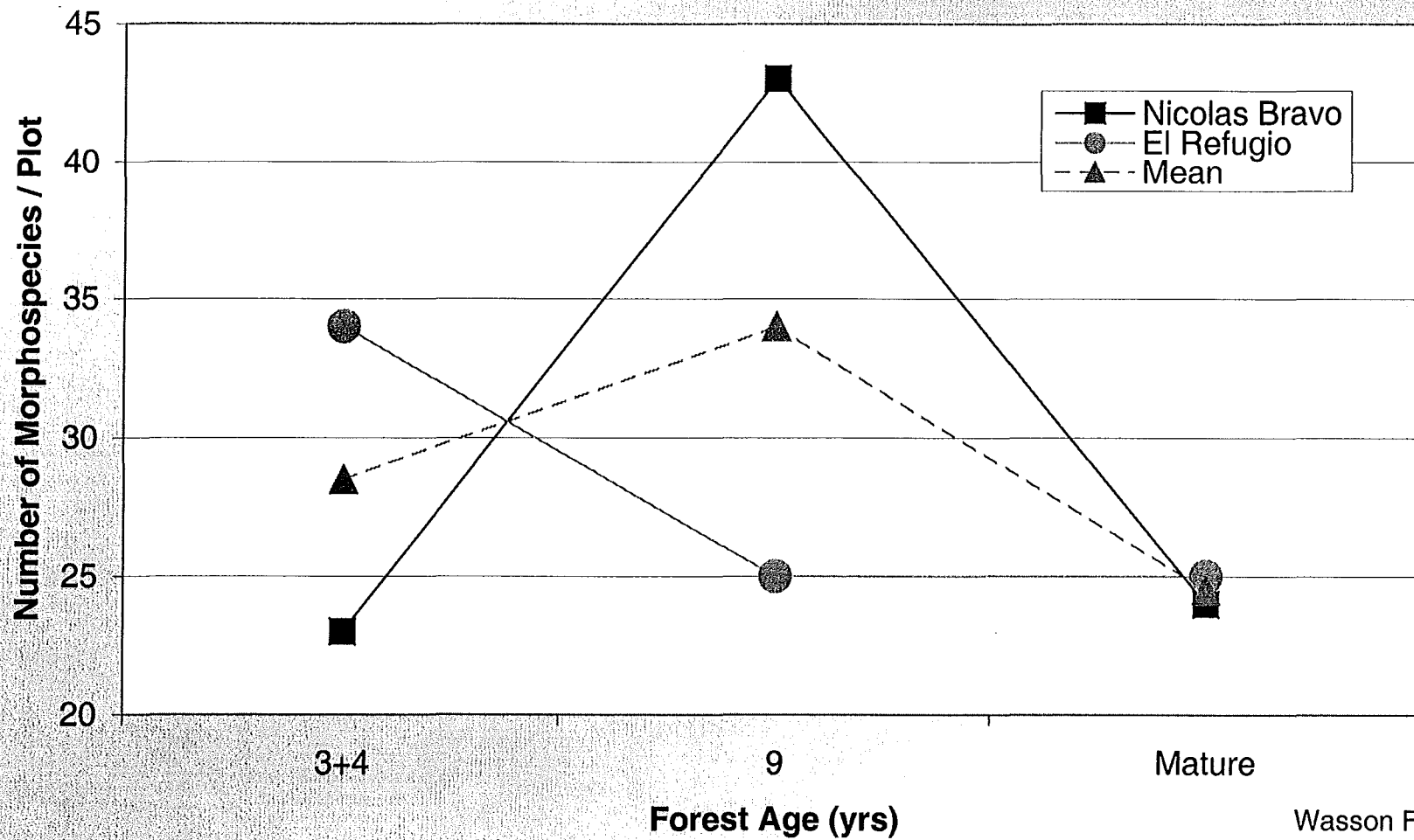
Wasson Figure 1.

1999 Student Summer Program Seminars and Workshops

All seminars and workshops at 7pm unless marked otherwise.

DATE	PROGRAM	SPEAKER
Wednesday, June 2	Seminar 1: Ecological Effects of and Constraints on Land Use Change in the Southern Yucatan Peninsula, Mexico	Deborah Lawrence
Wednesday, June 9	Seminar 2: History matters. Ecological insights from historical studies.	David Foster
Monday, June 14	Workshop 1: Ethics in Science: Animal research, authorship, falsifying data	Cathy Langtimn
Wednesday, June 16 6:15 pm	Seminar 3: Tree and Plant Identification	John O'Keefe and Glenn Motzkin
Wednesday, June 23	Workshop 2: Diversity in Science	Ann Lewis, Christine Muth, Heidi Lux, Elizabeth Farnsworth
Monday, June 28 6:30 pm	Workshop 3: Resumés	Chris Kruegler
Wednesday, June 30	Seminar 4: "What's all this talk about nitrogen - are we saturated yet?"	John Aber
July 6-9	Switch Days	
Wednesday, July 7 6:30 pm	Seminar 5: Storage of Carbon in Forests and Terrestrial Ecosystems	Steve Wofsy
Monday, July 12 to Tuesday, July 13	Institute of Ecosystem Studies Field Trip	
Wednesday, July 14	Seminar 6: Soil Respiration at the Harvard Forest and in the Amazon Basin	Eric Davidson
Wednesday, July 21	Workshop 4: Applying to Graduate School	Sebastian Catovsky, Christine Muth, Rebecca Anderson, Jesse Bellemere
Monday, July 26	Workshop 5: Writing an Abstract	Tim Parshall
Wednesday, July 28	Workshop 6: Structuring a Scientific Presentation	Susan Trumbore
Tuesday, August 3 6:30 pm	Seminar 7: Adaptation versus Exaptation- The Angiosperm/Gymnosperm Division	Barry Tomlinson
Thursday, August 5 9 am	Student Symposium	
Wednesday, August 11	Seminar 8: Management of State Lands for Biodiversity	Anne Marie Kittredge
Monday, August 16 6:30 pm	Seminar 9: Views of Wildlife Management and Land Use Practices in Western Hungary	Becky Field
Wednesday, August 18	Seminar 10: Landowner Attitudes towards an Ecosystem-based Approach to Management	David Kittredge
Friday, August 20	Program Ends	

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The Institute of Ecosystem Studies
presents...

A FORUM ON OPPORTUNITIES IN ECOLOGY

Tuesday, July 13, 1999
9:30 a.m. - 3:30 p.m.
at the IES Auditorium

This forum provides undergraduate and graduate students the opportunity to hear firsthand about a wide range of career paths in ecology, including:

- Academia
- Media
- Education
- Consulting
- Applied Ecology
- Industry

- Government
- Research
- Museums
- Activism
- Environmental Law
- Conservation

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

In the afternoon session (1:30 p.m. - 3:30 p.m.), speakers will join small groups for informal discussions about issues of concern to the student participants.

The forum is open to all students at no charge. Interested individuals should register for the program by calling Heather Dahl at (914) 677-9150. Since space in the afternoon session is limited, you are encouraged to register soon.

There will be a break from 12:30 p.m. -1:30 p.m.: please bring your own lunch and beverage.

Institute of Ecosystem Studies
Route 44A
Millbrook, New York 12545

PERSONNEL AT HARVARD FOREST 1998-1999

Marc Abrams	Bullard Fellow	Donald Hesselton	Woods Crew
Rebecca Anderson	MFS Candidate	Susan Johnson	Research Assistant
Audrey Barker Plotkin	Research Assistant		(part-time)
Jesse Bellemere	MFS Candidate	Ruth Kern	Research Associate
Emery Boose	Information and Computer	Roger Kitching	Bullard Fellow
	Manager	David Kittredge	Forest Policy Analyst
Jeanne Boutelle	Part-time Custodian	Matt Kizlinski	Research Assistant
Jeannette Bowlen	Accountant	Takashi Kohyama	Bullard Fellow
Matthias Burgi	Post-doctoral Fellow	Christopher Kruegler	Administrator
John Burk	Research Assistant	Oscar Lacwasan	Custodian
Alexis Calvi	Part-time Assistant	Cathy Langtimm	LTER Associate
Susan Clayden	Research Assistant	Deborah Lawrence	Research Associate
Richard Cobb	Research Assistant	David Lee	Bullard Fellow
Willard Cole	Woods Crew	Lisa Marselle	Summer Cook
Thia Cooper	Summer Program Assistant	Glenn Motzkin	Plant Ecologist
Edythe Ellin	Adminstrator	John O'Keefe	Museum Coordinator
Claire Dacey	Research Assistant	David Orwig	Forest Ecologist
Elaine Doughty	Laboratory Assistant	Julie Pallant	Assistant Information
Natalie Drake	Palynologist		and Computer Manager
Robert Eberhardt	MFS Candidate	Tim Parshall	Post-doctoral Fellow
John Edwards	Forest Manager	Diego Perez-Salicrup	Post-doctoral Fellow
Neal Enright	Bullard Fellow	Dorothy Recos-Smith	Staff Assistant
Rebecca Field	LTER Associate	Emily Russell	Visiting Scholar
Barbara Flye	Librarian/Secretary	Mayra Serrano	Research Assistant
Charles H. W. Foster	Associate	Ben Slater	Research Assistant
David Foster	Director	Charles Spooner	Woods Crew
Donna Francis	Research Associate	P. Barry Tomlinson	E.C. Jeffrey Professor of
Janice Fuller	Research Associate		Biology
Alexander Golub	Bullard Fellow	Susan Trumbore	Bullard Fellow
Julian Hadley	Research Associate	Dennis Whigham	Bullard Fellow
Brian Hall	Research Assistant	John Wisnewski	Woods Crew
Linda Hampson	Secretarial Assistant	Steven Wofsy	Associate
Jon Harrod	Research Associate	Maciej Zwieniecki	Research Associate

Top: Steve Currie, Ana Laborde, Barbara Munoz, Andy Finley, Tana Collazo, Jason Eaton
Bottom: Shira Bell, Jason Murnock, Emily Huhn, Saskia van de Gevel, Sara Cook, Henry Schumacher