HARVARD FOREST
Summer Student Research Assistants

*Abstracts from the 3rd Annual
Harvard Forest Summer Student Symposium
10 August 1995*

THIRD ANNUAL HARVARD FOREST SUMMER STUDENT SYMPOSIUM

10 August 1995

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Photography by Melissa Feldberg

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 Program

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 Richard Bowden of Allegheny College and Harvard Forest staff, was supported by the NSF Research Experience for Undergraduates Program, National Institute for Global Environmental Change, Mellon Foundation, and the Harvard Forest. Students worked closely with faculty and scientists, and many conducted their own independent research studies. The program included 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 and vegetation of the forest. In June, the group travelled to the Institute of Ecosystem Studies (Millbrook, NY) to participate in a Forum on Jobs in Ecology, which included discussions of environmental occupations with students and professionals employed in the field. The summer program culminated in the Third Annual Summer Student Research Symposium, in which students presented the major findings of their summer work.

THIRD ANNUAL HARVARD FOREST SUMMER STUDENT SYMPOSIUM

10 August 1995

HARVARD FOREST - FISHER MUSEUM

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

LAND-USE EFFECTS

9:24   Seedbank Content and Land-use History   Annabel Bradford
Harvard University

9:40   The Effect of Land-use History on the   Elizabeth Zacharias
Demographic Properties of   Harvard University
Gaultheria procumbens

9:57   Ericoid Mycorrhizal Fungi: a Potential   Satya Maliakal
Limit to Recolonizing Plowed   Brown University
Areas by *Gaultheria*

10:12   Ecosystem Effects of Changing Land-   Raul Romero
use in the Central Uplands of   Univ. Puerto Rico
Massachusetts

10:26   **BREAK**

10:56   Effects of Land-use on Lake   Jeff Milder
Sedimentation Rates: Upland vs   Harvard University
Lowland Sites

11:14   A Comparison of Cultivated, Pastured,   Todd Lieske
and Primary Woodland Land-use   Northland College
Histories of a Temperate Humid
Forest Using Carbon-Nitrogen
Ratios

11:31   Effect of Land-use and Vegetation on   Adrien Elseroad
Nitrification Potential   Cornell University

11:50   **LUNCH**

HURRICANE STUDIES

1:15 P.M.   Forest Succession of an Established   Jacqueline Bartee
Red Oak/Red Maple Stand at Harvard   Stillman College
Forest Simulated Hurricane
Disturbance

1:30	Influence of Microsite on Tree Seedling Establishment in an Unsalvaged 1938 Blowdown Area	Amanda Gardner Antioch College
1:45	The Effect of the 1938 Hurricane on Old Growth Forest Composition and Development in Pisgah	Jamie DeNormandie Harvard University
2:00	The Impact of the Great Colonial Hurricane of 1635 on the Landscape of New England	Melissa Feldberg Wesleyan College
2:15	Understory Vegetation Response to Simulated Hurricane Disturbance	Sarah Neelon Smith College

VEGETATION, ECOSYSTEMS AND HUMAN IMPACT

2:30	The Effects of Chronic Nitrogen Addition on Understory Plants	Susan Rainey Boston University
2:45	Trace Gas Fluxes in Soil Warming Plots After a Small Forest Fire	Anne Lawrence Allegheny College
3:00	**BREAK**	
3:15	Logged Areas of MA	Cinnie Chou Yale University
3:30	Use of Clearcuts by Early Successional Bird Species in the New England Landscape	Solai Buchanan Swarthmore College
3:45	Carbon and Nitrogen by Depth in MA and PA Forests	Karin Kryger Northland College
4:00	Comparison of Balsam Fir and Red Spruce Needle Temperature: a Possible Mechanism for Elevational Distribution	Jeffrey Herrick SUNY, Syracuse
4:15	Resources Affecting Seedling Development with the Forest Understory	Michelle Soucy Hampshire College
4:30	Dendroecological analysis of *Tsuga canadensis* (hemlock) stands in central New England	Fabian Menalled Univ. Massachusetts
4:45	Summer Evaluation	
5:30	Picnic	

Regeneration in a Red Oak/Red Maple Stand at Harvard Forest Following a Simulated Hurricane Disturbance

Jacqueline A. Bartee and Sarah Cooper-Ellis

Disturbance is a factor that determines or influences the ecological composition of forests. The following are three main types of disturbances that are vulnerable to the forests of central New England: fire, wind, and human land use. In the past hurricanes have been important in forming the composition of New England forests. When high winds target forests, they generally remove the dominant canopy trees from the environment. Large gaps result and trees in the understory respond by competitively fighting for that newly opened growth space. Suppressed and/or shade tolerant species then become the dominant trees and a path opens for new plants to enter the area and advanced regeneration begins.

A simulated hurricane was created in October 1990 at Harvard Forest. It was modeled after the 1938 hurricane. The blowdown site was a mature Red Oak/Red Maple stand in the Tom Swamp tract. The major species present are *Acer rubrum, Betula allegheniensis, B. lenta, B. papyrifera, Fraxinus americana, Pinus strobus, and Quercus borealis*. The leafout and sprouting of every tree in the plot are taken annually.

It was found that there was a steady decline in the percentage of leafout or sprouting among all species from the time of disturbance to 1995. The only species that had any type of increase in leafout or sprouting following the disturbance was *F. americana*. The percentage of trees with a leafout between one branch to 10% alternates from year to year with the changes being very slight. Trees with a 11% to 50% leafout increased in 1992 but has steadily decreased since. Following the actual blowdown, the number of trees with a leafout in the 51% to 90% range has decreased from year to year. For the past five years the number of trees showing 91% to 100% leafout and or no leafout alternates. Trees with no leafout did remain constant between 1992 and 1993. In *F. americana* there has been a decrease in sprouting for the past two years. *B. allegheniensis* has remained constant for the past two years. In the rest of the species there was a steady increase in sprouting over the past two years of the study. *P. strobus* and *Q. borealis* show a very minute increase of sprouting over the past two years mainly because *P. strobus* and *Q. borealis* generally do not resprout.

The increase in sprouts is surprising. When this project was initiated advanced regeneration was expected in the form of seedlings and saplings. Seedlings and saplings are present on the forest floor, but the trees at the blowdown are mainly regenerating through their basal and trunk sprouts. It will be interesting to see what will happen to the sprouts. Perhaps the severely damaged tree is using the last of its nutrients before it dies, and the sprouts are the result or recipients. On the other hand, the sprouts could be the damaged tree's attempt to salvage itself through new leaders, seeds, or more sprouts.

Figure 1. This graph shows the percentage of trees for each species that is sprouting or leafing out during the five years following the simulated hurricane disturbance.

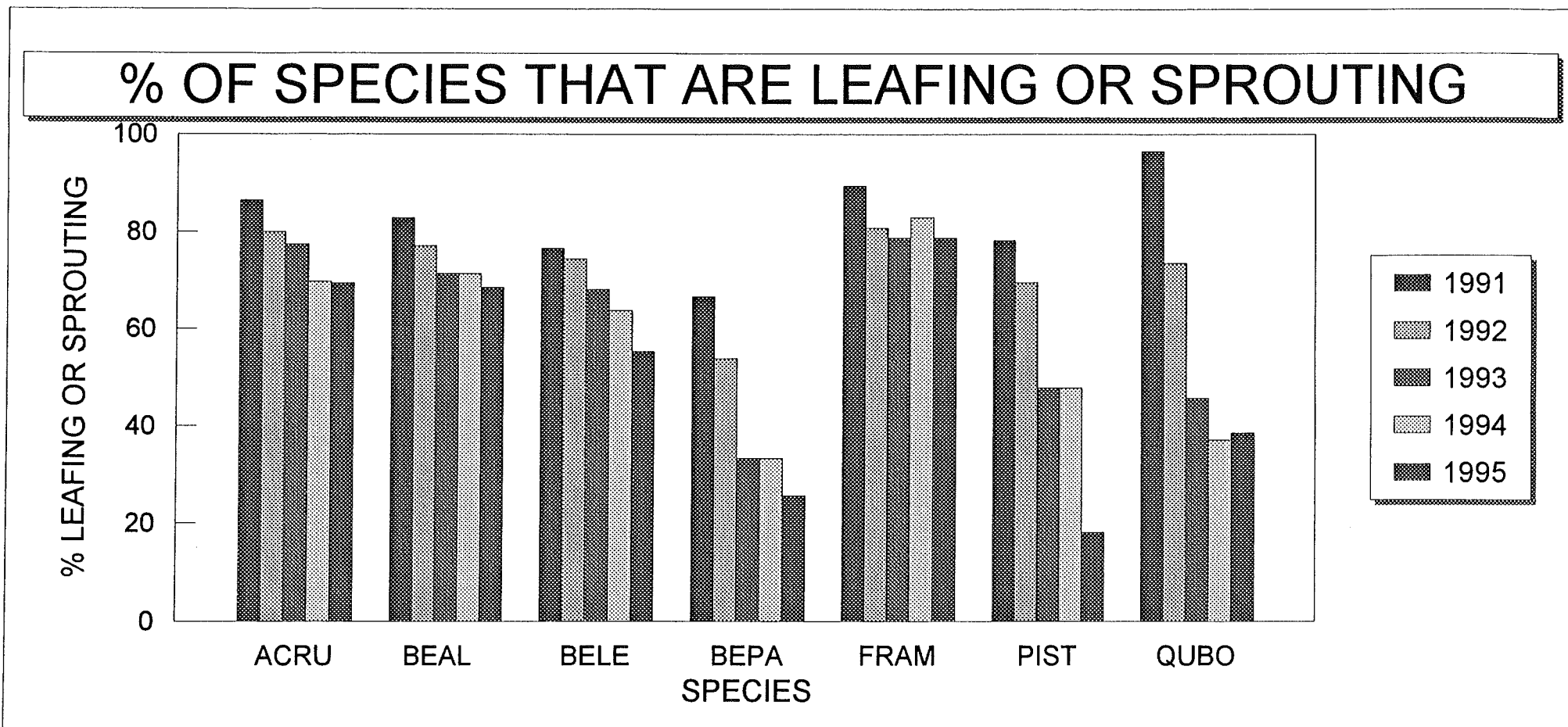

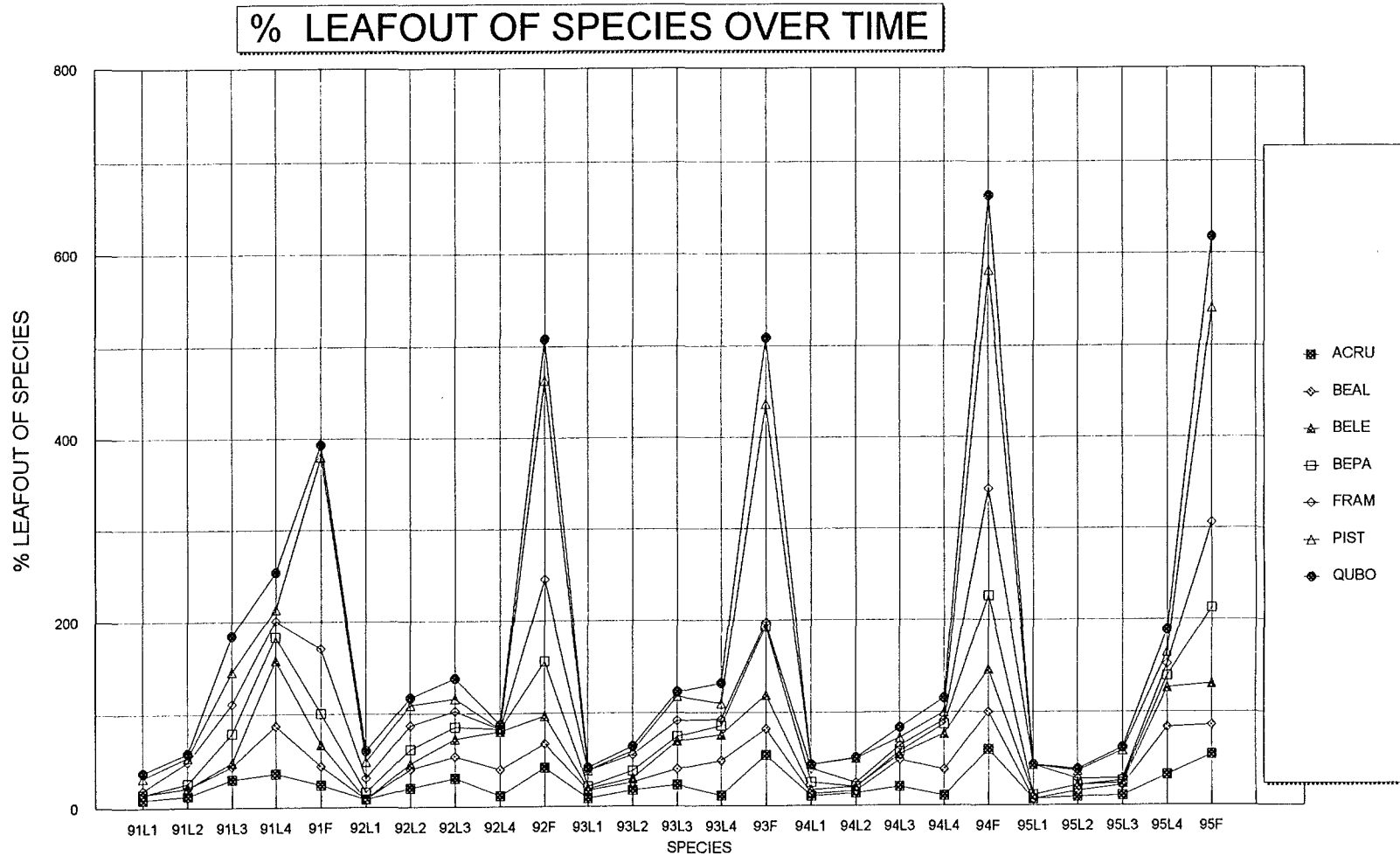% OF SPECIES THAT ARE LEAFING OR SPROUTING

J. Bartee

Figure 2. This figure shows the percent of leafout for the species at each level for the past five years. Leafout is a measure of the amount of tree crown in foliage. There are five leafout classes.

% LEAFOUT OF SPECIES OVER TIME

L1 = ONE BRANCH-10%   L2 = 11-50%   L3 = 51-90%   L4 = 91-100%   F = NO LEAFOUT

J. Bartee

Figure 3. This figure shows the sprouting for the species over the past five years. The presence/
absence of basal, trunk, and branch sprouts are noted.

% SPROUTING BY SPECIES OVER A 5 YEAR PERIOD

J. Bartee
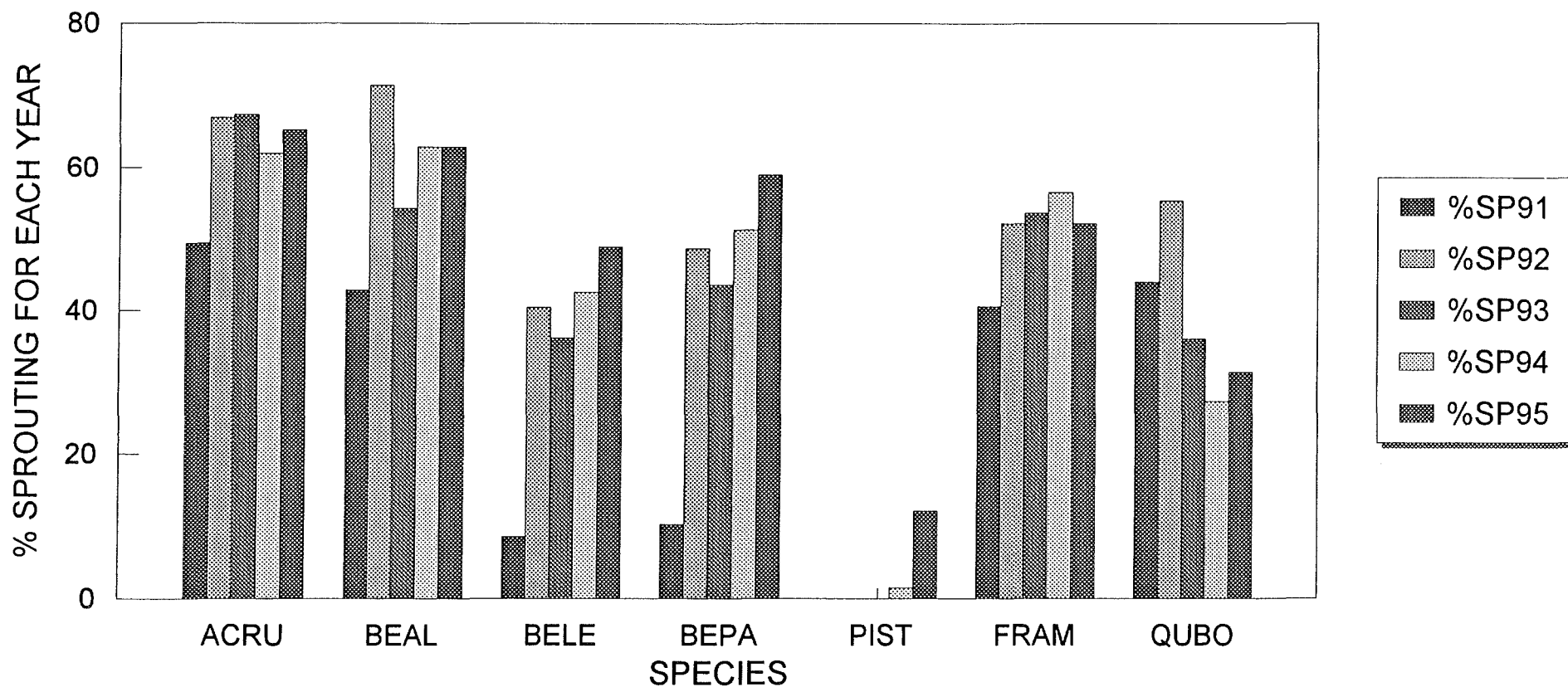
Seed Bank Content and Land-Use History

Annabel Bradford

Soil seed banks, stores of viable seeds, are valuable sources of propagules for regeneration after disturbance. Seed bank composition is determined by many factors, including input and output sources and the biology of individual species. Properties of species such as seed abundance, timing of seed release, seed longevity, and seed germination requirements are closely related to reproductive ecology--for example, whether a species is annual or perennial. Shade-tolerant species with large, fleshy seeds tend not to persist in the seed bank, while light-seeded, shade-intolerant species, especially weeds and ephemerals, can remain dormant in the soil for hundreds of years.

The purpose of this study is to examine the persistent seed bank at Harvard Forest. In particular, seed bank content across three land-use types, primary, pastured, and plowed, will be compared to determine whether past agricultural use leaves an imprint on seed banks. Within individual land-use types, the seed bank content of the organic and mineral layers, which represent different depths of forest soil, will be compared.

Methods used in previous studies vary widely; thus, a major concern was to devise a sound methodology for this study. Sample sites were chosen from among the long-term vegetation monitoring plots on Prospect Hill and controlled for overstory vegetation, soil type and drainage, and type and amount of hurricane damage. In our final protocol, 16" x 16" mats of forest floor were removed; remnants of the organic layer were saved for addition to the organic layer; and five mineral cores were taken.

With the organic mats tilted upside-down to avoid contamination by recently deposited seeds, the fibrous layer was removed and saved, and all samples were sieved. A constant volume of sample (700 ml) was massed and potted with 500 ml of 1:1 sterile sand:Promix. 700 ml of sample was refrigerated to stratify seeds, and 100 g was set aside for seed extraction.

Organic matter for seed extraction was separated from mineral matter using the floatation method described by Malone (1967). The organic matter was then deposited into a tower of decreasing-gauge sieves to separate seeds by size and thus facilitate extraction.

A preliminary comparison was made of the seed content of two organic samples, representing plowed and primary land-use types. Extracted seeds were organized into the taxonomy shown in Figure 1. There were marked differences between the samples, particularly in the numbers of black spherical seeds <2 mm in diameter and in the numbers of trigonius seeds (Fig. 2 and Graph 1). Since only two samples were surveyed, these results are extremely tentative.

Clearly, further work must be done. Additional extractions, species identifications, tetrazolium chloride testing for seed viability, and

FIGURE 1.

SEED CLASSES

Black Spherical

●
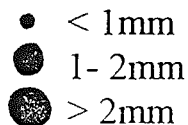
- ● < 1mm
- ● 1- 2mm
- ● > 2mm

Examples: Amaranthus
Chenopodium
Phytolacca

Tear-drop Shaped
(with or without partial or whole marginal wings)

- ● < 2mm
- ● > 2mm

Examples: Setaria
Arabis
canadensis

Trigonius

side view   view from base
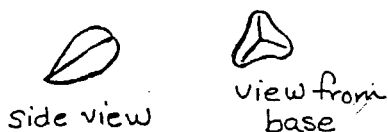
Examples: Rumex
Polygonum
Cyperus
Carex

Reniform

●

- ● ~2mm
- ● ~3mm

Examples: Trifolium
Robinia

Elliptical, Wrinkled

Examples: Rubus

Elliptical, Unwrinkled

Examples: Acalypha
Hypericum
Rhus

A. Bradford

FIGURE 2.

A. Bradford

Seed Class	Number of Seeds	
	Plowed	Primary
Black spherical <1mm	24	238
Black spherical 1-2mm	21	233
Black spherical >2mm	4	14
Tear drop shaped <2mm	227	221
Tear drop shaped >2mm	1	1
Trigonius	28	1
Reniform ~2mm	3	4
Reniform ~3mm	2	3
Elliptical, wrinkled	0	2
Elliptical, nonwrinkled	0	1

Seedbank Content by Seed Class

Number of Seeds/100g

250

200

150

100

50

0

Black spherical <1mm
Black spherical 1-2mm
Black spherical >2mm
Tear drop shaped <2mm
Tear drop shaped >2mm
Trigonius
Reniform ~2mm
Reniform ~3mm
Elliptical, wrinkled
Elliptical, nonwrinkled

Seed Class

Primary
Plowed
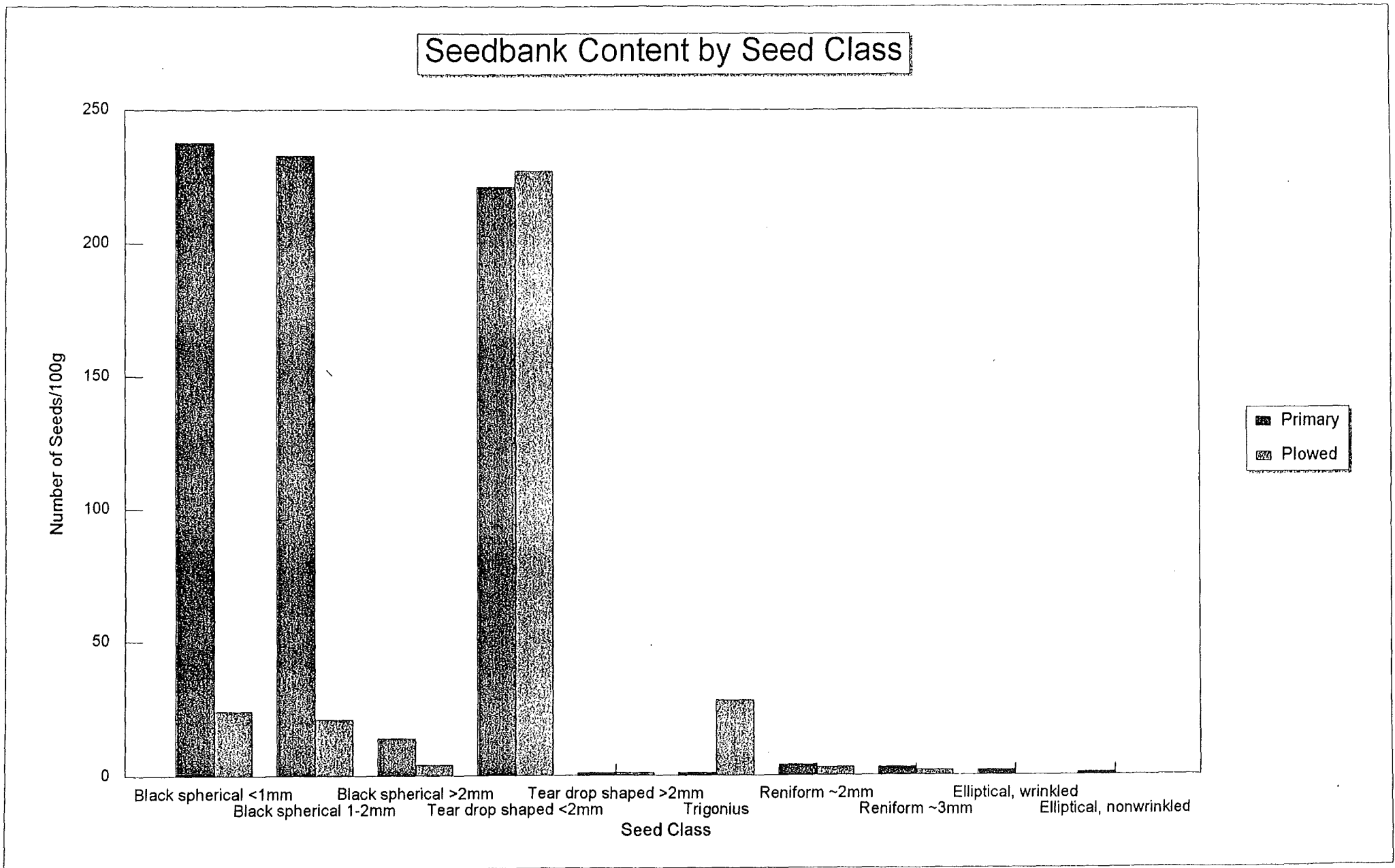
Graph 1.

A. Bradford

germination will be useful in our investigation. Considerable progress, however, has already been made in the development of a forceful methodology. Information on differences in seed bank composition across land-use types and on the Harvard Forest seed bank in general should help us anticipate what will emerge after disturbance and help explain community dynamics at the pulldown and in areas with individual treefall gaps.

Use of Clearcuts by Early-Successional Bird Species in the New England Landscape

Solai Buchanan

As much of the New England landscape has become reforested over the last 100-150 years, early-successional bird populations have experienced significant declines (Askins, 1993). Because early-successional species of birds rely upon ephemeral habitat types, land management has the potential to play a large role in the maintenance of early-successional bird populations. This study explored how variation in clearcut size and/or vegetative structure influences the diversity, distribution, and abundance of early-successional birds.

The study area consisted of 16 clearcuts that were located in Petersham, a rural, largely forested borough, in central Massachusetts. Clearcuts ranged in size from 4.5 ha to 0.05 ha. Using standard point count protocol (Ralph *et al.*, 1993), bird populations in clearcuts were quantified. To characterize the vegetative structure within the cuts, 11.3 m radius plots were established around each census point. Vegetative structure and composition within each plot was measured as is described by Noon (1980).

Figure 1 illustrates a significant ($p<0.00001$) logarithmic relationship between early-successional species diversity and clearcut area. These results are consistent with the theory of island biogeography which states that there is a logarithmic relationship between species diversity and habitat area. A linear fit of the log of early-successional species diversity as a function of the log of clearcut area produced a line ($P<0.001$) with a slope of 0.81. This relatively high slope indicates that, over the size of cuts that were sampled, the diversity of early-successional species in a cut is highly responsive to area increases.

Linear regression analysis, in which log (area), basal area, shrubs, canopy cover, and ground cover were incorporated as independent variables found that log (area) was the sole significant predictor ($p<0.01$) of early-successional species diversity. Linear regression analysis also found that log (area) was a significant positive predictor of the abundance of several early-successional species including *Dendroica pensylvanica* (Chestnut-sided Warbler) ($p<0.05$), *Geothlypis trichas* (Common Yellowthoat) ($p<0.05$), and *Pipilo erythrophthalmus* (Rufous-sided Towhee) ($p<0.05$). Additionally some vegetation characteristics were able to significantly predict particular early-successional bird species' abundance in a given site. For example,

Fig. 1 – Number of early successional species as a logarithmic function of clearcut area.

P << 0.00001
$R^2 = 0.88$

Number of species (y-axis, 0 to 6)

Area of clearcut (x-axis, 0 to 5)
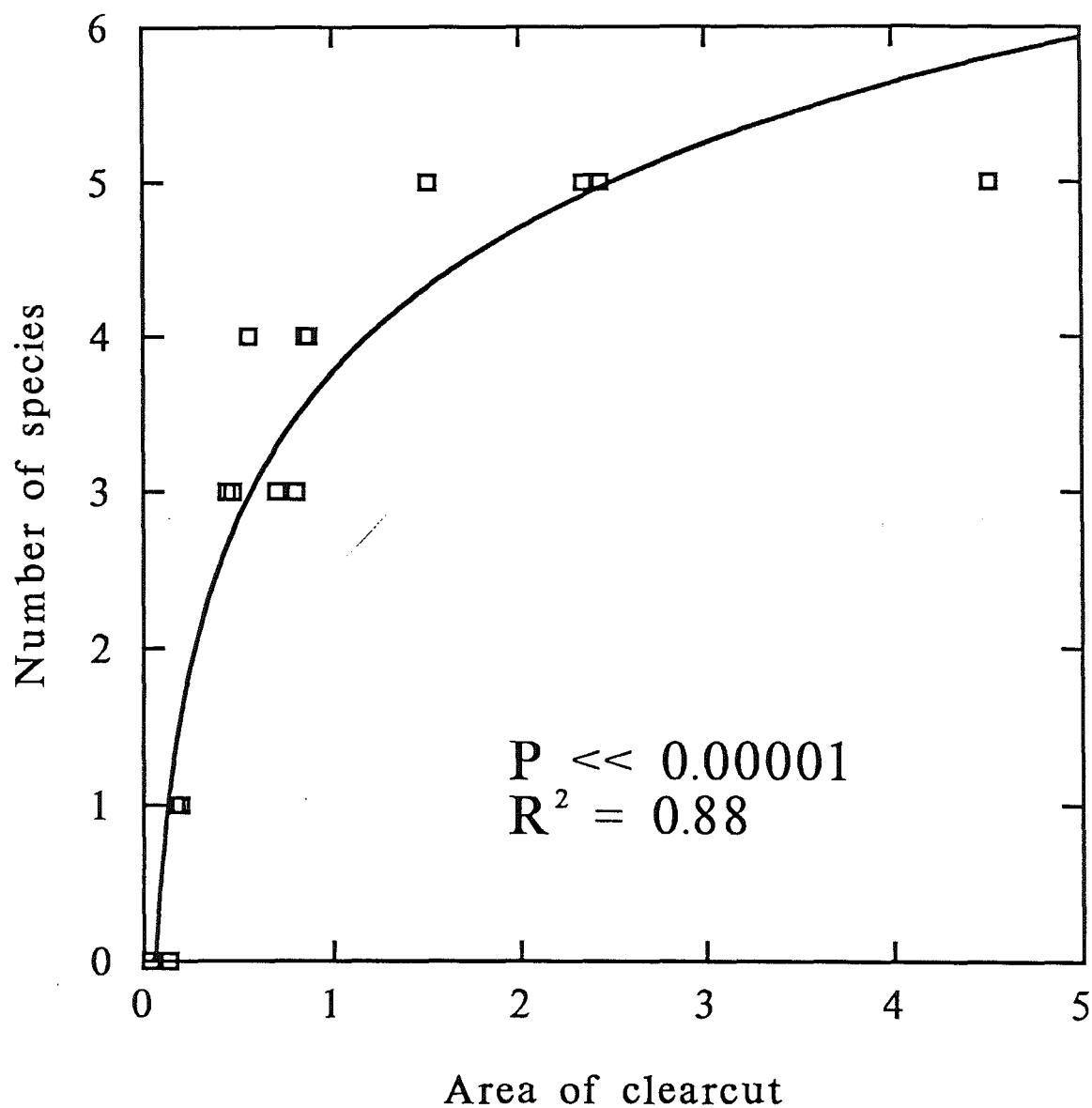
S. Buchanan

Dendroica pensylvanica abundance was positively related to number of the shrubs (p<0.05) and negatively related to the basal area of trees (p<0.1). The abundance of *Dumetella carolinensis* (Gray Catbird) (p<0.1) and *Pipilo erythrophthalmus* (p<0.05) was also positively related to shrub number.

Overall, these results indicate that small (1-2 ha) clearcuts do function as viable habitat for early-successional bird species. Therefore small areas could effectively be managed for early successional species without significantly fragmenting the surrounding forest communities. Moreover, the species area relationship found in this study is consistent with the theory of island biogeography. This indicates that in largely forested landscapes clearcuts are functionally islands. Moreover this suggests that these early-successional bird species exist as metapopulations and are able to persist because they assume the strategy of fugitive species.

Literature Cited

Askins, R.A. 1993. "Population Trends in Grassland, Shrubland, and Forest Birds in Eastern North America". In: *Current Ornithology*, Vol.11, D.M. Power, ed. New York: Plenum Press.
Noon, B.R. 1980. "Techniques for Sampling Avian Habitats". In: *The Use of Multivariate Statistics in Studies of Wildlife Habitat*, D.E. Capen, ed., Fort Collins, CO: USDA Forest Service,
Ralph, C.J., G.R.Geupel, P. Pyle, T.E. Martin, & D. F. DeSante. 1993. *Handbook of Field Methods for Monitoring Landbirds*. Albany, CA: Pacific Southwest Research Station.

Timber Harvesting Patterns in the NW Quabbin Region

C. Chou and D. B. Kittredge

Timber harvesting has represented a major disturbance in the forests of New England over the past two centuries and remains a widespread practice today. The patterns of harvesting across the landscape, however, have changed over time. Since the 1930's, most harvesting has been in the form of selective cuts in relatively small patches, reflecting the division of properties into smaller parcels. This summer, we looked at patterns of logging in ten towns northwest of the Quabbin Reservoir over the past ten years.

Since 1984, logging in Massachusetts has been regulated by the amended Forest Cutting Practices Act, or Chapter 132, which requires that a Forest Cutting Plan be submitted for every timber sale exceeding 25,000 board feet. Each cutting plan specifies data about the nature of the timber cut; the land owner, the acreage of the lot, the volume of timber, etc. A database containing this information was updated, and the location and shape of each logged site was transferred onto topographic maps from diagrams in the cutting plans. The polygons on these maps were then digitized and georeferenced using the Geographic Information Systems (GIS) programs Roots, Rootspro, and Idrisi,

Areas Harvested for Timber:
NW Quabbin Region 1984-1995

C. Chou
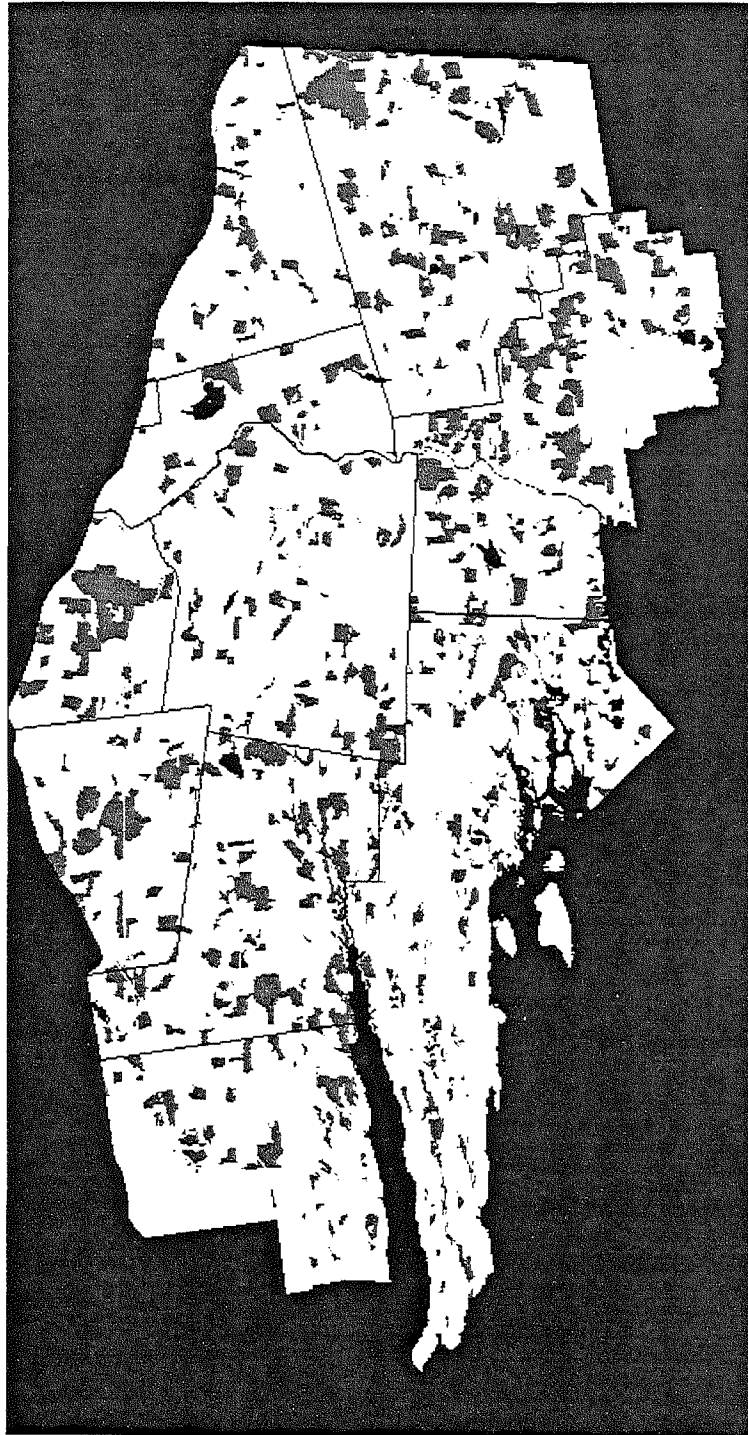
to form an image which could be analyzed and compared with existing maps.

Comparison of the timber cut image with a 1985 land-use map from MassGIS revealed that 21% of forests have experienced cutting within the past ten years. As expected, this cutting occurred in a patchy pattern across the study area. Most harvest areas were relatively small; the majority had areas of less than fifty acres. About 55% of all logging occurred on private lands. The amount of cutting planned for each year was irregular, peaking at 4006 acres in 1985 and falling to less than half of that value in 1990.

Landowners were classed into five categories dividing them roughly into private, state, local municipal, nonprofit, and industrial loggers. Of these, private owners held the most influence over the total amount of cutting done from year to year. From preliminary estimates, the size distribution of patches which have been cut are similar for the different owner classes, as well as the percentage of harvest area which has been cut twice or more within the time period.

In the next few weeks continued analysis will show the relative volumes each landowner class has proposed to harvest. We will try to determine whether or not there is a relationship between harvested areas and distance from roads, as well as generate data about the amount of harvesting in different watersheds. Eventually, we would also like to extend the map by nine more towns to the northeast of the Quabbin.

Additional questions have been raised in the course of this study. It would be interesting to see if the stated objectives of state and local municipal owners for the harvesting of their forests is reflected in their pattern of cutting. For example, MDC's main goal is to insure the quality of water. Have they harvested too much, or too little, or in the right locations for this?

The images created this summer provide a useful base of information concerning land-use history over the past ten years, as well as raise new questions of their own.

The Effect of the 1938 Hurricane on the Forest Structure and Composition of the Pisgah Old-Growth Forest

James DeNormandie

There are relatively few studies that have examined forest structure and composition both before and after a catastrophic wind disturbance has altered the forest. On a twenty acre parcel of old-growth forest located in the Pisgah State Forest in S.W. New Hampshire, the collection of a long term data set from 1907-1995 has made it possible to consider how the hurricane of 1938 altered forest structure, species composition, and subsequent forest development in the stand. Various types of information were gathered throughout the century that allowed the quantification of forest structure and

composition: species identification, dbh measurements, tree status (living or dead), tree cores, and individual tree growth and mortality has recently been tracked. The old-growth forest pre-1938 was dominated by a *Pinus-Tsuga-Hardwood* mix. The hurricane left the forest devastated and incredibly altered. The total basal area of the forest was drastically reduced from approximately 70 m^2/Ha to about 5 m^2/Ha after the disturbance. White pine was effectively lost from the stand while many large *Tsuga* were also blown down. A large increase in density was subsequently recorded as many post-disturbance species took advantage of the many resources that had been made available, especially light. Although there was a high level of destruction, a good amount of *Tsuga* and *Fagus* that had previously existed in the understory was released from suppression and grew to fill in parts of the overstory. Both the forest structure and the species composition changed from a relatively homogeneous state before the hurricane to an extremely heterogeneous one after the hurricane. The overall development of the stand followed the typical path of a recently disturbed area. After the initial increase in density in the few years after the storm, basal area has been steadily increasing while density has steadily decreased. It has also been possible to observe differences in the ability of individual species to react to the hurricane. *Tsuga* and *Fagus* are exhibiting a much increased ability to remain in the stand while other post-disturbance species such as *Betula* and *Acer* are suffering much higher mortality. Although the forest already has a very low tree species diversity, it will continue to drop with time as more of the post-disturbance hardwoods are lost to mortality.

The Effect of Land-use History and Vegetation on Nitrification Potentials

Adrien Elseroad

Agricultural practices of the 18th and 19th C impacted soil nitrogen dynamics through the clearance and cultivation of forested land. Preliminary work has shown that this land-use legacy has altered net nitrogen mineralization and nitrification even 70 to 100 years after abandonment. On Prospect Hill, at the Harvard Forest, net nitrification rates were found to be highest at previously plowed sites (Compton unpub. data). As nitrification is the primary pathway by which nitrogen is lost from ecosystems, this process can potentially result in ecosystem degradation. A short-term nitrifier assay (Schmidt and Belser 1994) was conducted to determine if the difference between net nitrification rates by land-use history could be due to differences in nitrifier population sizes.

Six sites were chosen based on land-use history and vegetation type, and three replications were examined at each site. For each vegetation type (conifer or hardwood), three land-use categories were selected: previously plowed, previously pastured, and permanent woodlot. Soil samples from 0-15 cm cores were placed on a rotary shaker for 24 hours with a phosphate buffer solution and ammonium at 22°C. The concentration of nitrate was measured after 2 hours, 4 hours, 18 hours, and 24 hours, and nitrification potentials were determined from the slope of the regression of nitrate vs time. Organic

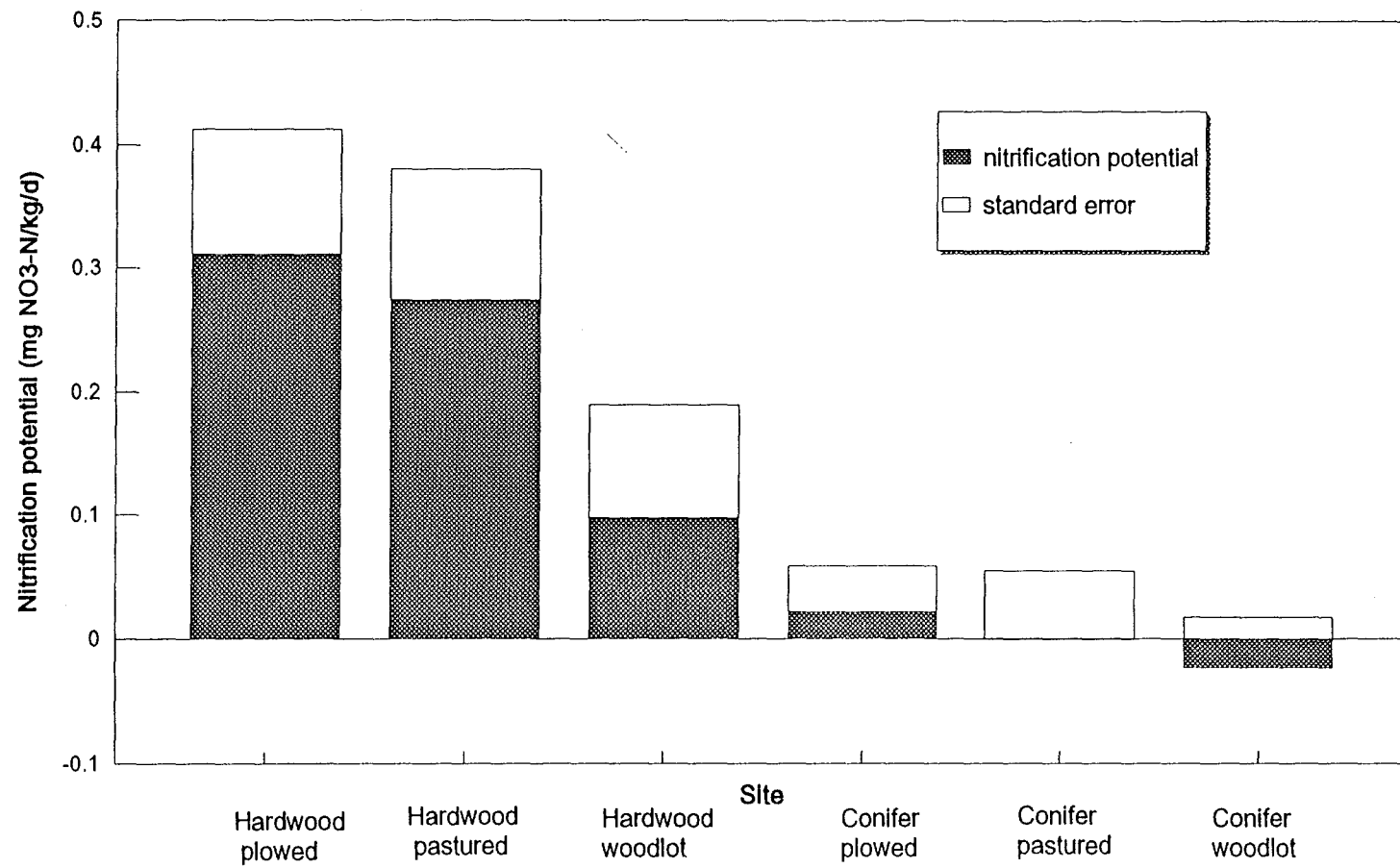## Figure 1. Nitrification potentials for six sites at Prospect Hill.
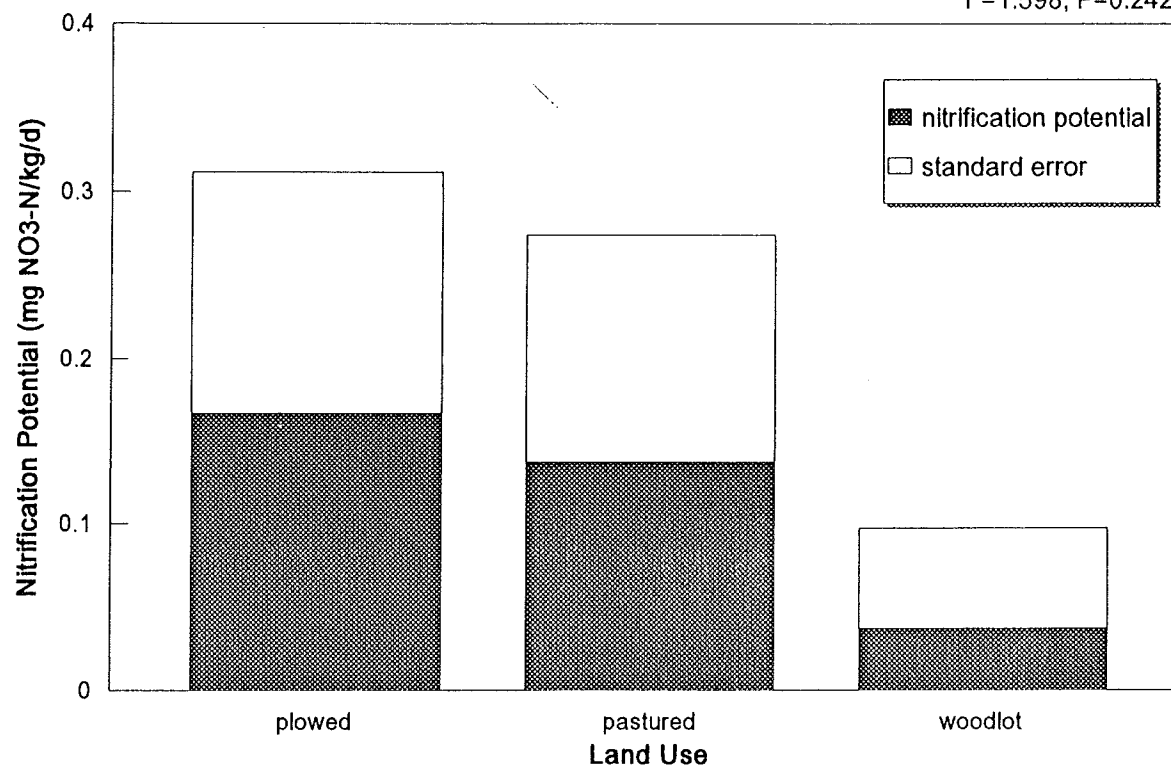
Figure 2. Nitrification potentials by land-use history at Prospect
Hill.

F=1.598, P=0.242

Legend: nitrification potential / standard error

Y-axis: Nitrification Potential (mg NO3-N/kg/d)

X-axis: Land Use (plowed, pastured, woodlot)

matter and moisture content of the samples were determined as well.

Vegetation type strongly impacted nitrification potentials than did land-use history (Fig. 1). Nitrification potentials at the hardwood sites were significantly higher than at the conifer site (F=13.539, P=0.00315). In contrast, land-use history effects on nitrification potentials were not found to be statistically significant, though a strong trend was apparent (Fig. 2). Plowed sites had higher nitrification potentials than either the pastured or woodlot sites. No relationship was found between nitrification potentials and the organic matter or moisture content of the samples.

Nitrification potential is an estimate of the maximum rate of nitrification possible under conditions of no resource limitations and laboratory temperatures. They represent an index of nitrifier population size since the production of nitrate is a function of the size of the nitrifier population. Results indicate that nitrifer populations may be greater at the previously plowed sites in the depth of soil sampled, though a greater sample size is necessary to determine the significance of this relationship. Anthropogenic soil amendments may help explain this trend. Liming or manure additions, if practiced, as well as the mixing of organic matter and mineral soil, may support greater nitrifier populations. However, at these sites, vegetation type may be a more significant factor determining the size of nitrifier populations than land-use history. The difference in nitrification potentials between hardwood and conifer stands is perhaps due to an inhibition effect in the conifer stands caused by the low pH of the litter.

The size of nitrifier populations may help explain why net nitrification rates are higher at previously plowed sites than at previously pastured or permanent woodlot sites. The alteration of soil properties caused by past agricultural practices may currently increase risks of soil nitrogen loss by favoring nitrifying soil bacteria, though this effect is confounded by vegetation type. Results indicate that this risk may be greatest at previously plowed, hardwood sites due to large nitrifier populations.

The Impact of the Great Colonial Hurricane of 1635 on the Landscape of New England

Melissa J. Feldberg

Hurricanes are natural disturbances capable of large-scale damage to forest ecosystems. These storms, although uncommon in New England, have had a major impact on the landscape and are therefore an important consideration in the reconstruction of the disturbance history of this area. The three most severe hurricanes to hit New England since its settlement occurred in 1938, 1815, and 1635. Because of the limited written history and relative lack of meteorological data, little work has been done attempting to reconstruct the 1635 storm. This study, which was part of a larger project attempting to identify and model all hurricanes to hit New England from settlement to the present, focused on obtaining information about the conditions of this storm

1635 Predicted Damage

1635 Actual Damage

Portsmouth
F1

Boston
F2

Plymouth
F2

Cape Sable
(No Damage)

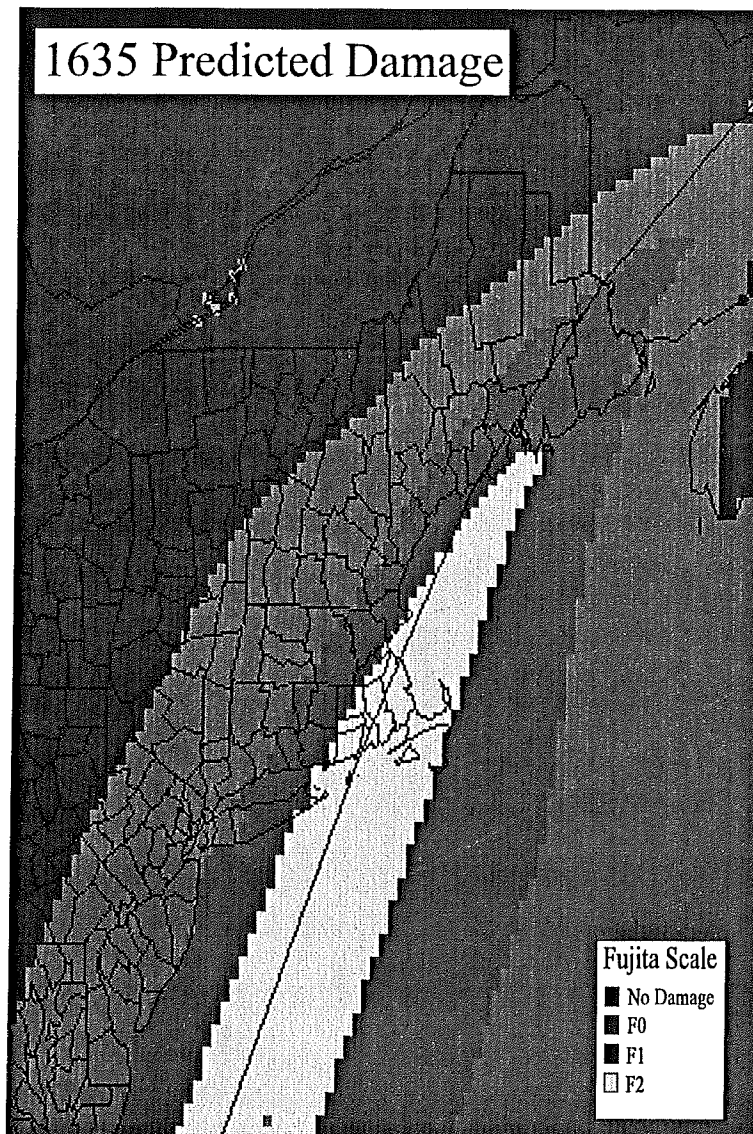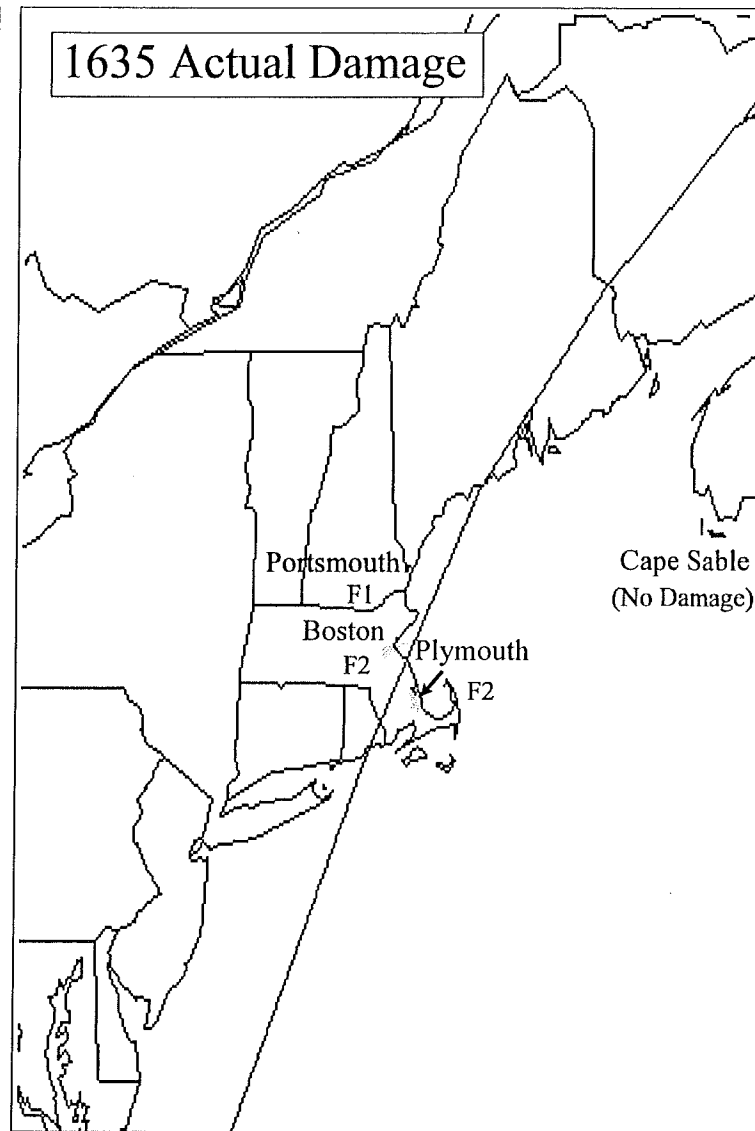Fujita Scale

- ■ No Damage
- ■ F0
- ■ F1
- ☐ F2

Fig 1

Fig 2

The damage sustained by New England in the Hurricane of 1635 as predicted by the Hurrecon model (Fig. 1) and as reported in historical accounts (Fig 2). Both maps use the Fujita Scale, a measure of the severity of damage caused by wind.

M. Feldberg

in order to model the wind speeds and the corresponding damage sustained by New England in 1635.

Written accounts of the 1635 hurricane were collected from various libraries in New England and compiled into a database organized by the location to which the account refers. These accounts, although scarce, contained enough information to create two different damage maps for the area. The first map was of actual reported damage and was created by assigning Fujita scale values (a measure of damage as a result of wind) to the damage in each location for which there was enough information to make such a determination. The second damage map, was predicted by the hurricane model (HURRECON) using wind direction changes and the time and duration of the strongest winds as reported in the historical records. From this information it was determined that the wind speeds closely resembled those of the 1938 hurricane and that the track was almost identical to that of Hurricane Bob, which hit New England in 1991. Using the data from these storms as well as the historical data from 1635, HURRECON produced data used to create GIS maps showing the maximum wind speeds, wind direction and predicted damage in the area, for this storm.

Unlike the reconstructions of modern hurricanes for which there is a significant amount of meteorological information, the input data used to produce the predicted maps were not completely independent of the damage reports. There was, however, enough other information about wind shifts, strength, and timing to run HURRECON and produce a predicted damage map (Fig. 1) suitable for comparison with the actual damage map (Fig. 2). Both the actual damage map and the model outputs of predicted damage and wind speeds suggest that the hurricane of 1635 was similar in severity to those in 1815 and 1938, producing at least F2 damage in areas of New England. The 1635 storm can therefore be concluded to have had similar impacts on the forest ecosystem. Because of the scarcity of such ecologically devastating storms in this area, the determination of the approximate extent of damage for this storm is important in reconstructing the disturbance history of New England.

Influence of Microsite on Tree Seedling Establishment in an Unsalvaged 1938 Hurricane Blowdown Area

Amanda Gardner

The hurricane of 1938 had a major impact on the forested lands of New England. Within the land holdings of the Harvard Forest in Petersham, MA, approximately 70% of the standing timber volume was blown over by this tropical storm (Foster, 1988). The uprooting of the trees by the severe winds created a dramatic hurricane microtopography in this area. This topography encompassed ecologically disparate microsites in which seedlings could establish themselves in the years following the storm. These sites consisted of a pit left where the tree uprooted, a mound created by the dislodged root ball and the soil trapped within it, and the downed bole of the windthrown tree (in sites not subjected to timber salvage).

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This study explored the potential species-specific patterns of seedling establishment in these three microsites fifty-eight years after their formation. A fourth site, the open forest floor, was also evaluated for comparative purposes. Twenty-five square meter quadrats were placed and surveyed on each of the four sites. All tree species present within each quadrat were identified, counted, and measured for height. Information regarding shrub and herbaceous cover, canopy density and composition, extent of the decomposition of the bole, and the depth of the litter in the quadrat was also recorded.

Trends in establishment of certain species on particular sites were revealed. *Betula lenta/allegheniensis* seedlings (exact identification was often difficult due to the age of the seedlings, therefore data for both species were lumped) made up 35% of the total sample. Of these, 61% were emergent seedlings. *Betula* was clearly the most site-stratified species sampled. Trees and seedlings of this species established almost exclusively on the mound and decomposing bole microsites. *Quercus rubra*, encompassing 43% of the sample, established preferentially on the pit and forest floor microsites. Ten other species of tree seedling were identified and recorded but none seemed to show a clear microsite preference. The data are also being evaluated for the potential effects of shrub and herbaceous cover, canopy cover, level of bole decomposition, and litter depth on patterns of tree seedling establishment.

The information gained may provide important knowledge as to successional patterns which arise and persist for many decades on a hurricane-impacted landscape. Although the vast majority of these seedlings will not survive to maturity, their presence as a persistent, regularly replaced understory may give us information that helps to predict patterns of regeneration if another major disturbance were to occur in this area.

A Comparison of Balsam Fir and Red Spruce Needle Temperatures

Jeffrey D. Herrick

Balsam fir and red spruce occur together in the montane zone of many New England mountains. However, red spruce is typically more abundant at lower elevations and balsam fir is more abundant at higher elevations. Observations were made to ascertain if the needle temperatures in the co-occurring species were related to their elevational distributions. Needle temperature is important because it influences physiological growth factors such as photosynthesis. We compared fir and spruce needle temperatures on a site at 970 m in elevation on Mt. Greylock in Northwestern Massachussetts. Temperatures were measured every minute and averaged hourly from June 14 to July 6 on one tree of each species. Six needles on different compass aspects (E, SE, SW, W, NW NE) in the mid-canopy of each tree were sampled. It was found that during mid-day average fir needle temperatures were about 2°C (p=0.001) higher than spruce needles (Fig. 1). The higher needle temperatures in balsam fir may be explained by the morphological characteristics of the shoots (i.e.

Figure 1.

Average red spruce and balsam fir needle - air temperatures
(June 14 - July 6)

J. Herrick
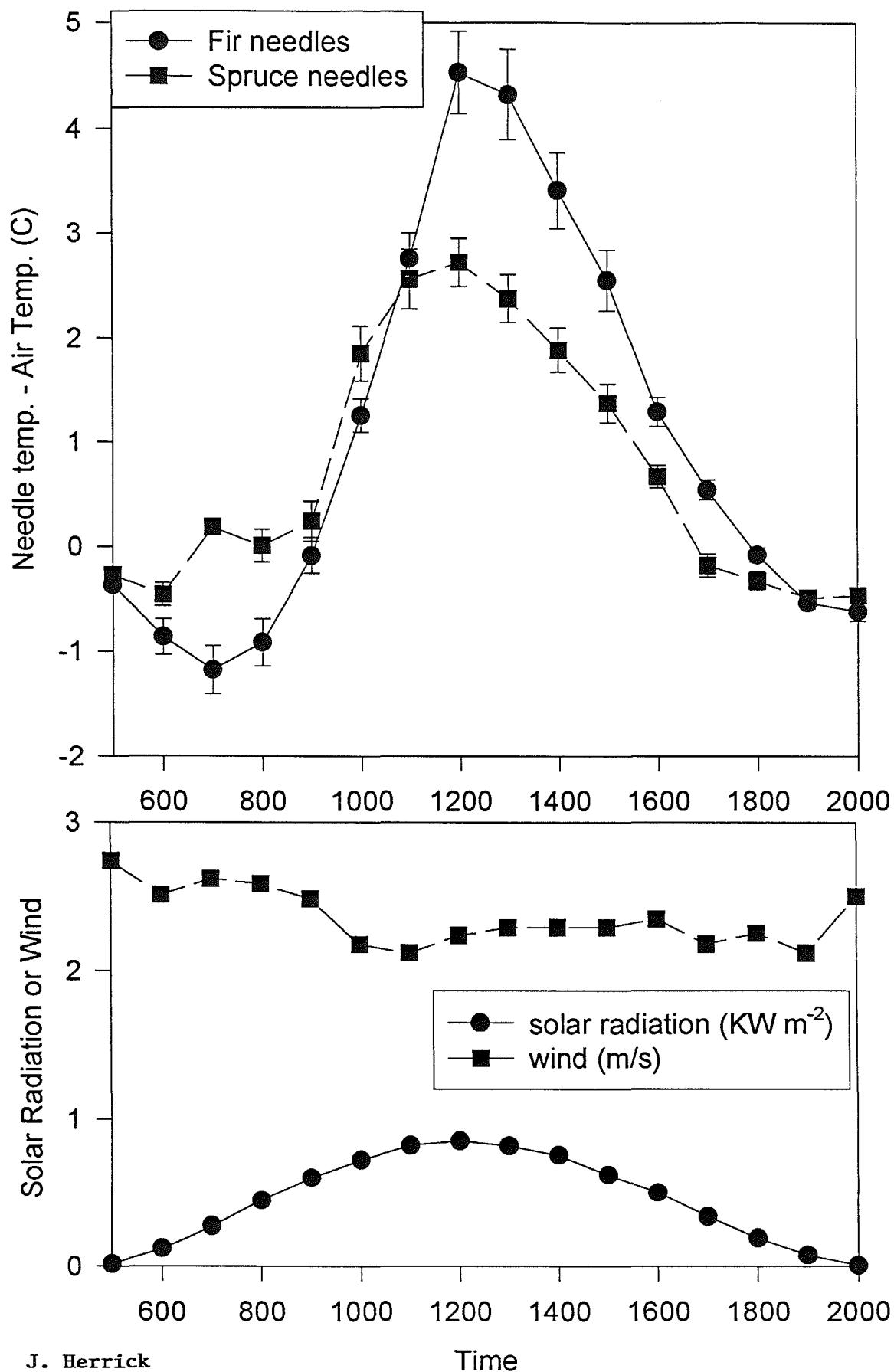
larger needles, and closer clustering of needles). Dense clustering of balsam fir needles could create a more resistant boundary layer around the shoot and make it less likely to be cooled down by wind. Higher needle temperatures in balsam fir may extend its growing season (at higher elevations) by allowing the needles to start photosynthesizing earlier in the spring and stop later in the fall. However, balsam fir may also have a disadvantage at lower elevations because the needles may become "overheated" and photosynthesis could be inhibited. Future studies could examine if balsam fir actually extends its growing season longer than red spruce by measuring seasonal photosynthetic rates in the two species.

Carbon/Nitrogen Analysis of MA and PA Forest Soils

Karin Kryger

Twelve randomly selected plots were examined at the Bousson Experimental Forest, PA, and the Harvard Forest, MA, for carbon and nitrogen content to a depth of 60 cm in increments of 15 cm. The forests are about 700 miles apart and share the same general climatic characteristics. As one would expect, there is little difference in the percent of carbon and nitrogen in the two soils at various depths, with the exception of the top 15 cm. Bousson shows a much higher percent nitrogen and a slightly higher percent carbon in the first 15 cm of soil than does Harvard Forest. As Bousson is a more productive forest, this result is not unusual. It does lead to an interesting set of C/N ratios. While the C/N ratio for the Harvard Forest soil decreases steadily with depth from almost 23 in the forest floor layer to about 16 in the deepest layers, the Bousson C/N ratio in the top layer is only 11, rising and falling with depth to 12 in the deepest layer.

At Harvard Forest we measured soil density in order to additionally calculate the total grams of carbon and nitrogen in the soil. This process yielded some interesting results. Soil density increased dramatically with depth. Because of this, the carbon and nitrogen content was actually lower in the forest floor than in any other level. Plans have been made to gather the same information at Bousson in order to compare the forest soils on an absolute scale of carbon and nitrogen content. The results of this study clearly demonstrate the need to carefully consider seemingly similar areas before making assumptions regarding them. This data is also significantly helpful in understanding and predicting emission of greenhouse gases from forest soils.

Trace Gas Fluxes in Soil Warming Plots After a Small Forest Fire

Anne Lawrence

Global warming is a major environmental concern. The Ecosystems Center (Woods Hole, MA) has developed an experiment at the Harvard Forest to evaluate a hardwood forest's response to a 5°C increase in ambient soil temperature by using a buried heating cable system. In May of 1995, an additional variable was unintentionally added to the experiment when a fire occurred causing ten of the eighteen plots to be burned to varying degrees. The purpose of this experiment was to evaluate the effect of the burn on trace gas fluxes of CO_2 and CH_4 in relation to the previously observed four years of data.

After the burn, plots were designated as slightly or moderately burned. This determination was based on the extent of the charred debris and the damage to the equipment within the plot. If the fire damaged most of the equipment and charred most of the plot, then it was labeled as moderately bured. If the fire barely damaged the equipment and charred only part of the plot, then it was labeled as slightly burned. Gas samples were then taken to evaluate trace gas fluxes. Gas samples were collected using a static chamber technique and analyzed using gas chromatography. In the six burned plots, the chambers served as fire breaks, leaving inside the chamber unburned. Therefore, a second gas chamber was added to make a within plot comparison. Soil temperature was determined by placing a soil thermometer 2.5-5.0 cm deep. Soil moisture was determined by Time Domain Reflectometry.

The current data show that the fire had, if anything, only a short term effect on the experiment, which is no longer apparent. The results showed, as expected, that the CO_2 fluxes increased as the soil temperature increased and CH_4 uptake decreased as the soil moisture increased. The CO_2 and CH_4 fluxes in burned plots exhibited similar responses when compared to results from the first four years of the experiment (Figs. 1 and 2). The greatest CH_4 uptake rate appears to be greater than previously observed, but is not out of the expected range.

A Comparison of Cultivated, Pastured, and Primary Woodland Land-use Histories of a Temperate Humid Forest Using Carbon Nitrogen Ratios

Todd F. Lieske

The C/N of forest soil has been recognized to be a valuable tool in assessing available nitrogen, rate of organic matter decay, total organic matter content, and in the development of soil management techniques. The purpose of this study is to determine if the land-use history of a temperate humid forest has an influence on the C/N of the 0-15 cm mineral soil. This study utilized forest soils that in the past have been primarily woodland and soils that from c. 1733 to c. 1870 have been cultivated or used for pasture.
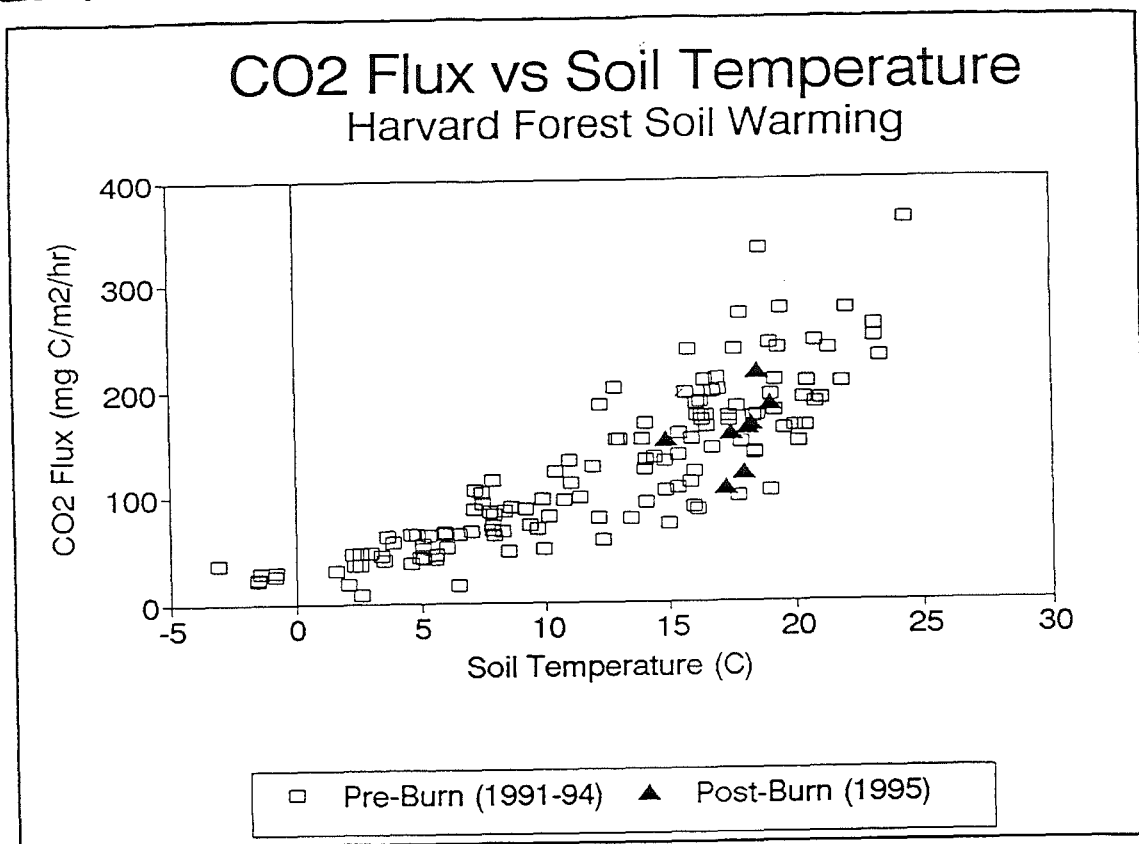
Figure 1.

CO2 Flux vs Soil Temperature
Harvard Forest Soil Warming

□ Pre-Burn (1991-94)   ▲ Post-Burn (1995)

Figure 2.

CH4 Flux vs Soil Moisture Content
Harvard Forest Soil Warming

Approximate "Field Capacity"
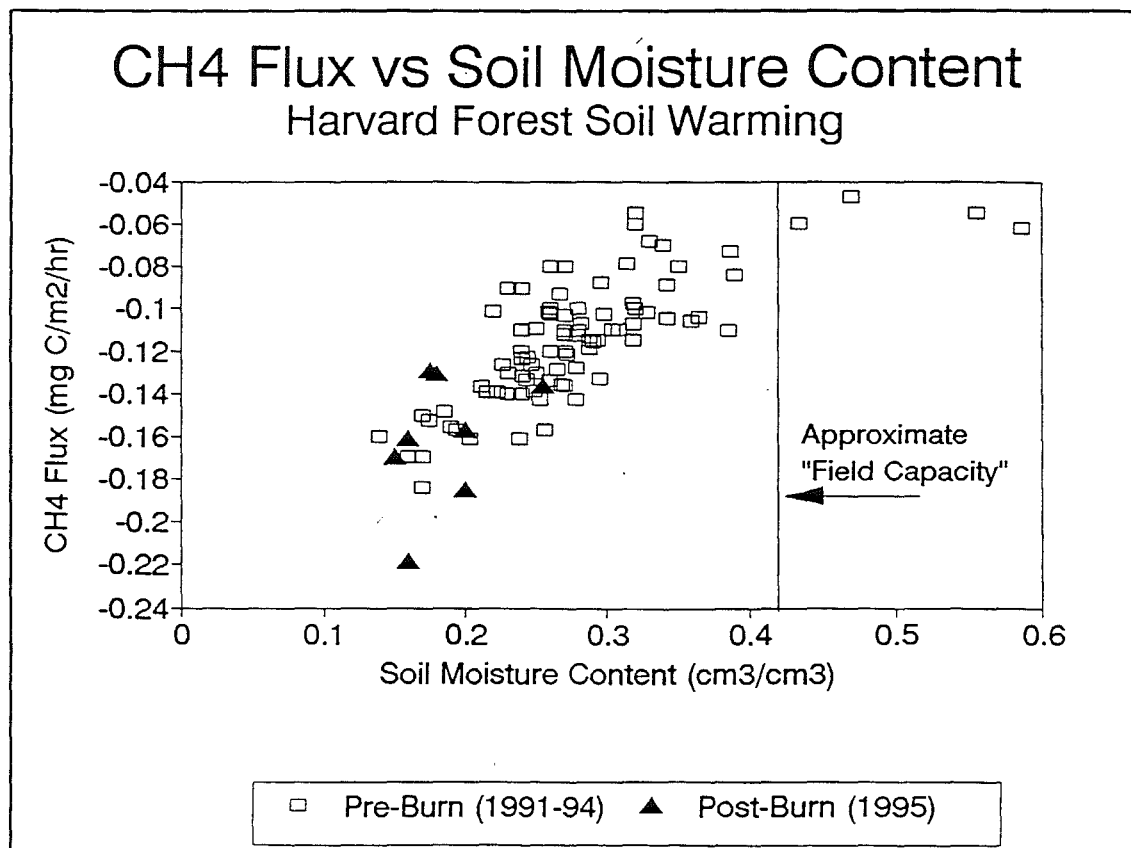
□ Pre-Burn (1991-94)   ▲ Post-Burn (1995)

A. Lawrence

The data obtained showed that the primary woodland sites had a higher C/N (avg. 25/1) then both the improved pasture (avg. 21/1), rough pasture (avg. 22/1) and the cultivated sites (avg. 18/1). The data shows that land-use history does affect the C/N of temperate humid forest 0-15 cm mineral soil and that it is important to take into account land-use history as a variable affecting the C/N ratio.

Figure 1.
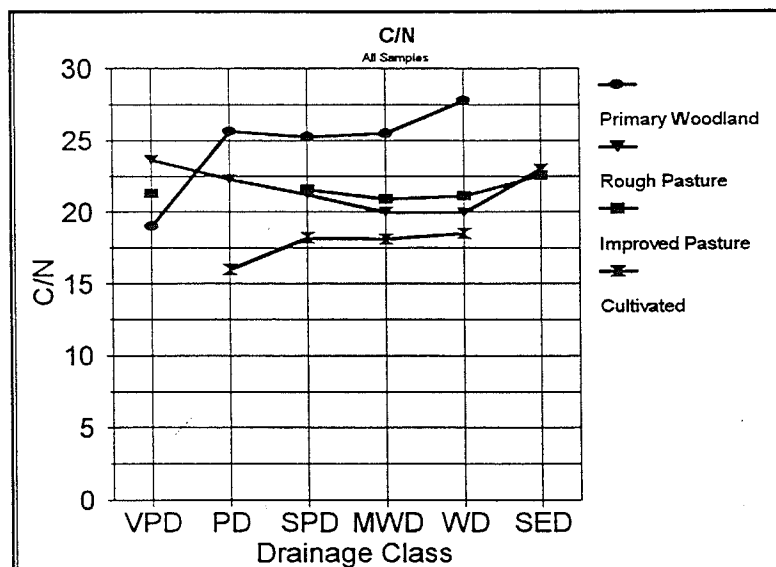
The Effect of Land-use History on the Abundance of Ericoid Mycorrhizal Fungi: a Potential Limit to *Gaultheria procumbens'* Recolonization of Previously Plowed Areas

Satya K. Maliakal

Previous human land-use has tremendously impacted the plant communities of many New England landscapes. On the Montague Sand Plain, although it has been anywhere from 50 to 100 years since agricultural abandonment, pitch pine occurs almost exclusively on previously plowed land, while scrub oak, certain hardwood species, and ericaceous species such as *Vaccinium angustifolium*, *V. vaccilens*, *Gaylusaccia baccata*, and *Gaultheria procumbens* occur almost exclusively on unplowed land, with *Gaylussacia* and *Gaultheria* showing the most restriction (Motzkin *et al.*,1995). We are examining the abundance of ericoid mycorrhizae on *Gaultheria* to determine if differences in amounts of infection

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could limit its recolonization of plowed areas. *Gaultheria* and the other ericaceous species mentioned, are thought to be dependent on ericoid mycorrhizae, especially in a region like the Montague Sand Plain, which has well-drained, sandy soils that are nutrient-poor. There are at least two species of ericoid mycorrhizae, which infect different members of the Ericaceae, but a single species of fungus can potentially inhabit many different plant species within the family (Read, 1984). One hypothesis is that after an area has been plowed, all the potential mycorrhizal host species are eliminated, so their mycorrhizae can no longer persist in the soil. After agricultural abandonment, these plant species may have extreme difficulties re-establishing in these areas. If these plowed areas continue to support a lower abundance of host species that may be less densely aggregated, they may also support a lower amount of mycorrhizal fungi. These fungi may not be able to disperse as easily from one plant to another if they are on average further apart. There may also be differences in soil conditions such as acidity that may differentially affect the mycorrhizal populations. An alternative hypothesis is that on plowed land, mycorrhizae can colonize *Gaultheria* roots in as much abundance as they do on unplowed land.

We used ten sites along plow boundaries, five dominated by scrub oak and five by hardwood, to see if there were any differences between scrub oak and hardwood sites with respect to amount of infection. At each site, ten plants were collected, five from a random distance into the plowed region up to 50 meters, and five from the furthest extent of *Gaultheria* into the unplowed region. For each plant, we collected three age classes of rhizome, used to control for effects of age. We chose an arbitrary section of rhizome in each age class to pick off all the lateral roots from, and measured the length of rhizome, and the number of lateral roots, so eventually we can make estimates of total root length per unit rhizome, and average length of a single lateral root. We then used a series of solutions to clear, bleach, and stain the roots. Samples were arranged on microscope slides, and infection was quantified with a compound microscope by running transect lines across the slides, and counting for each transect, the total number of intersections, the number of intersections with pronounced infection, and because infection will only occur in cortical cells, we separately counted the number of intersections that lacked cortical cells. From these measurements we can make estimates of root length and percent infection.

Preliminary results based on data for two sites do not demonstrate a significant difference between plowed or unplowed areas, or scrub oak vs hardwood sites; however, in both sites, we find a strong trend towards less infection in the youngest age class. We still need to finish quantifying infection for the rest of the sites and estimate total root length per unit rhizome so we can include this data in our analysis. We need to include the distance from the plow boundary and the density of other ericaceous species at the collection spot into our analysis. If we do find differences in amounts of infection, then mycorrhizae could be a potential limitation to *Gaultheria's* recolonization of plowed areas. If there are no differences, then there must be some other reason for *Gaultheria's* restriction, and *Gaultheria's* mycorrhizae are capable of very quick and efficient colonization of *Gaultheria*, even at the furthest extent into the plowed areas.

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Dendroecological Analysis of *Tsuga canadensis* (Hemlock) Stands in Central New England

Fabian D. Menalled

The consequences of different types of human intervention and natural disturbances on the New England forested landscape were assessed by studying dendroecological records, tree recruitment dates, and stand composition and structure. Four 30 m^2 plots were selected to represent primary hemlock stands in a range of different landscape contexts. I hypothesize that modern dissimilarities among hemlock stands are a consequence of differences in their land-use history and long-term disturbance regime. The following questions about the process of stand development were raised:

1. Do differences in land-use history, disturbance dynamics, and landscape traits (e.g., soils, physiography) translate into characteristic dendroecological patterns of suppression and release?

2. Do the tree-ring chronologies of different canopy strata and crown classes provide similar insight on the time series of forest stand growth and dynamic?

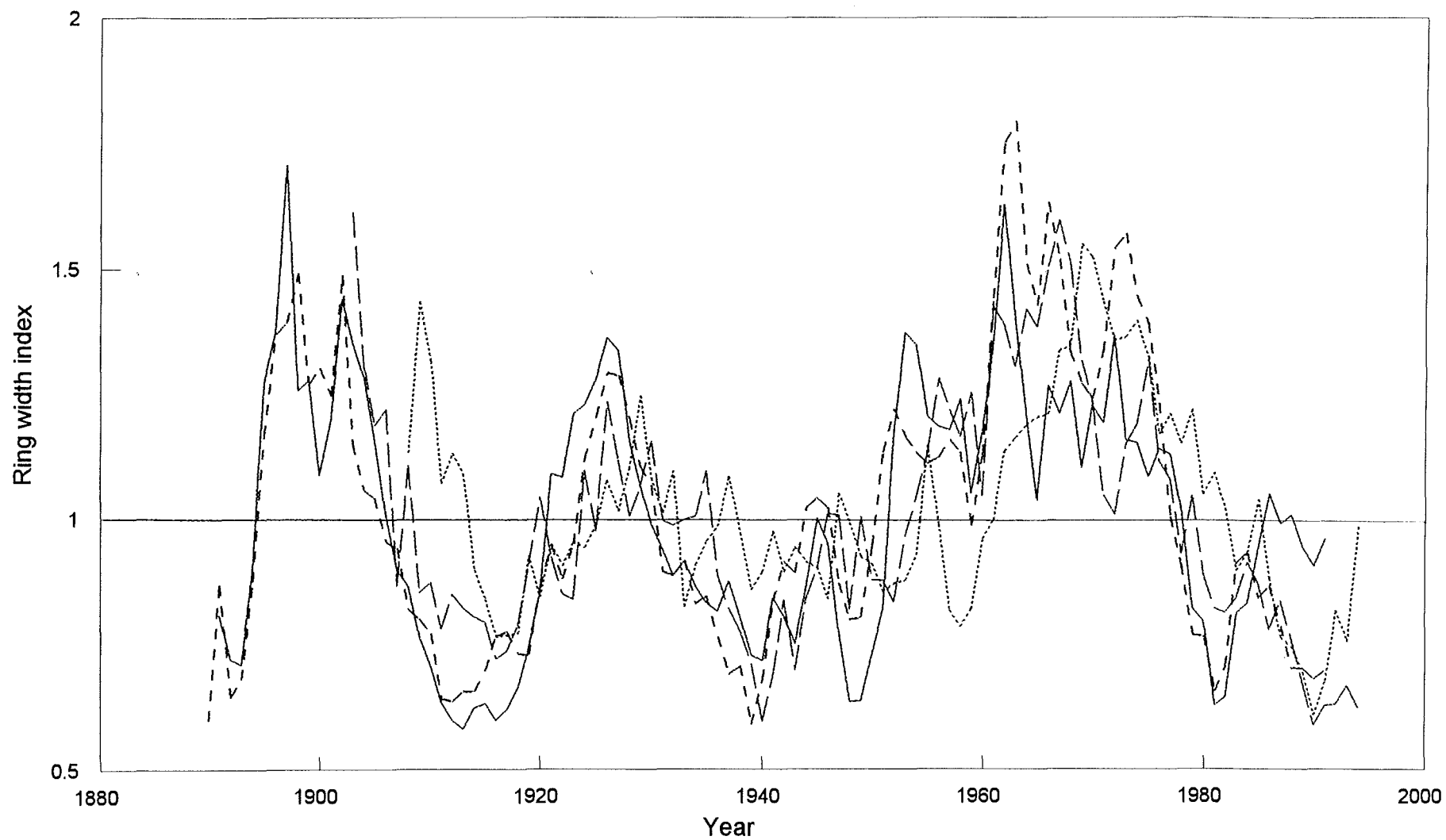3. How do age, canopy position, and stand history influence tree growth?

The species, diameter at breast height (DBH), crown class, and condition (dead or alive) were recorded for all trees (DBH$\geq$ 2.5 cm at a height of 1.30 m) occurring within each plot. Trees were classified as occurring in two strata (upper and lower). Within the upper stratum classification of crowns in four classes (dominant, codominant, intermediate and suppressed) was obtained based on the amount of direct sunlight intercepted. All trees were cored as close to the ground as possible. Cores were dried, mounted and sanded. Tree age and annual growth increments were measured to the nearest 0.01 mm with an incremental measuring device linked with a digital encoder and microcomputer. Trees were grouped into four categories: 1) lower stratum trees, 2) suppressed, 3) intermediate, 4) codominant and dominant trees of the upper stratum. Within each site and category, cores were cross-dated. Individual series were conservatively standardized with a negative exponential curve, a straight line of negative slope, or a horizontal line drawn through the mean. To obtain a ring width index, measured growth values were divided by the expected values obtained in the standardized series.

For Prospect Hill 7, age-diameter relationships of hemlock trees indicated that this stand has a clear canopy stratification with 2 layers, and a continuous recruitment of trees in the lower stratum (Fig. 1). It is a relatively young stand, formed after a clearcut during the late 18th C. Mean ring width index revealed a strong correlation among the four tree categories (Fig. 2) indicating three periods of releases, each followed by a suppression phase. Historically, release's periods can be correlated with logging activities performed in the late 18th C, the chestnut decline which occurred in 1913, and an experimental hardwood thinning performed during the 1960s. These preliminary results will be complemented with those obtained from the

o = lower stratum, - = suppressed -upper stratum-
* = intermediate - upper stratum -, + = codominant and dominat - upper stratum -

FIGURE 1.   Canopy position, crown class, and age-diameter relationships for all cored hemlock trees in Prospect Hill 7.

F. Menalled

Figure 2. Mean ring width index as function of canopy position and crown classes for all cored hemlock trees in Prospect Hill 7.

F. Menalled

other stands, and with fossil pollen data and historical records. The information gathered in this study will help us understand the extent to which the less-disturbed components of New England's forested landscape have been affected by natural disturbances and human activities during the past two centuries.

Effect of Land-Use on Lake Sedimentation rates:
Upland vs Lowland Sites

Jeff Milder

A major challenge of long-term ecological research is finding data on ecosystems of the past. Undisturbed lake sediments provide a long-term stratigraphic history of lake nutrification, terrigenous organic input, terrestrial plant communities, and sedimentation rates. Paleoecological studies of the New England landscape based on such stratigraphic records can provide a picture of long-term ecosystem dynamics and may serve as analogies for regions of the world currently undergoing deforestation or reforestation.

We compared two watersheds from different physiographic regions and with different land use histories in order to determine which types of human land use are most likely to increase sedimentation rates. Lake Pleasant in the Connecticut Valley lowland (Montague) has seen disturbance from logging (late 1700s), agriculture (mid 1800s), and residential development (1900s). Aino Pond in the Central Upland (Ashburnham) has had much less human disturbance, although there has been some logging in the watershed, agriculture and building is minimal compared to other parts of central Massachusetts. We expected that both ponds would show increased sedimentation rates following European settlement, with lake Pleasant showing the most dramatic increase; in addition, we hypothesized that agriculture would cause a larger sedimentation increase than other land uses.

Each lake was cored using a plastic tube 100 cm long and 10 cm in diameter. The core was then subsampled in 2 cm increments and taken to the lab for analysis. Samples were dated using a combination of ^{14}C and ^{210}Pb radiodating methods. Sediment accumulation rate was calculated by measuring the amount of dry sediment per sample and dividing it by the accumulation time for that sample. We also investigated the history of each watershed by consulting town histories and old maps.

For both sites, there was a marked increase in sedimentation rates following European settlement. As expected, the sedimentation rate in Lake Pleasant rose more (1500%) than in Aino Pond (600%). In Lake Pleasant, sedimentation was highest during initial land-clearance, lower during the agricultural and post-agricultural periods, and higher again in recent times. In Aino Pond, sedimentation rates rose steadily from initial settlement to the present, despite minimal current land-use.

Effect of Land-Use on Sedimentation Rates
Relative to Long Term Pre-Settlement Average

J. Milder
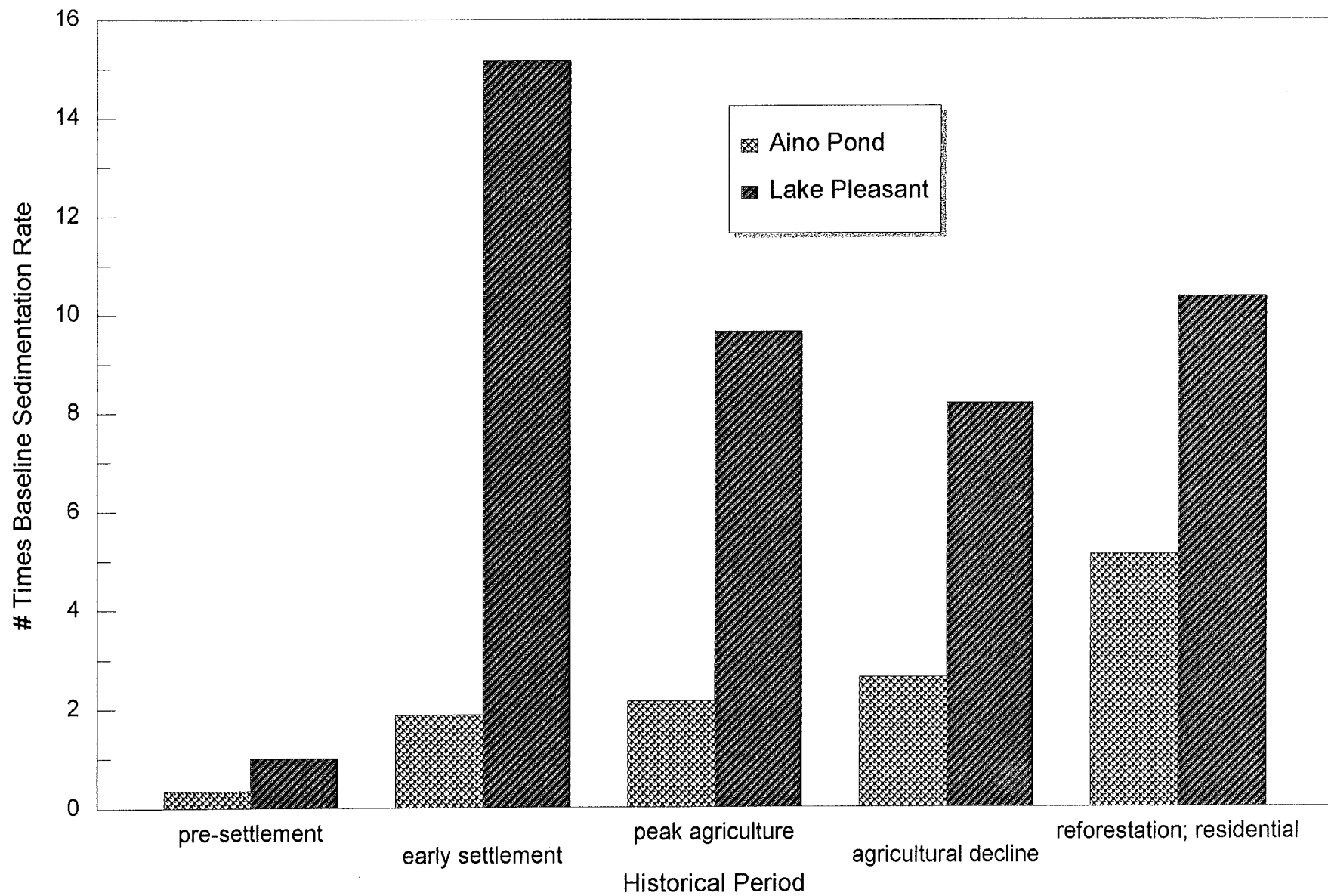
The increase in the sedimentation rates of both lakes since the time of settlement suggests that all forms of post-settlement land-use are more disruptive to watersheds than are disturbances induced by natural processes or native peoples. In both lakes, the highest sedimentation rates occurred during periods of forest cutting, suggesting that initial land clearance may cause even more disturbance than sustained agriculture. Finally, Lake Pleasant's larger sedimentation increase relative to pre-settlement values indicates that sandy, lowland ecosystems may be more susceptible to watershed disturbance than upland settings.

Understory Vegetation Response to Simulated Hurricane Disturbance

Sarah Neelon

Wind disturbance has played an important role in maintaining the structure and composition of forests in New England. Most of the research on the effects of large scale disturbances has focused on trees and saplings and little is known about the effect of wind disturbance on understory vegetation. This study examines the long term effects of a simulated wind disturbance on herbaceous species.

In the fall of 1990, trees in a 160 X 50 m area of the Tom Swamp tract at Harvard Forest were pulled over to simulate a hurricane. A 120 X 50 m control plot was also established. Three transects, each containing 24 plots, were established running east to west in the pulldown. One 24 plot transect was designated in the control. In both areas, vegetation sampling began in the summer of 1990, before the pulldown and plots were re-sampled in 1991, 1992 and 1995. In each 1 meter square circular herb plot, percent cover of all the herbaceous species was estimated. The pulldown transects were designed to represent different light intensities (Lezberg and Foster). There also appear to be differences in light intensity between the east and west ends of the transects due to the concentration of tree crowns in the northwest and boles in the southeast.

Dennstaedtia punctilobula, Aralia nudicaulis, Maianthemum canadense, and *Osmunda claytoniana* dominate the herb layer in both the pulldown and the control. In the pulldown in 1995, all four have higher percent cover than in the control. In 1990, these species were much more even in their distribution (Fig.0 1). In a 6 year study, Peterson and Pickett (1995) looked at an old-growth beech-hemlock forest that was hit by a tornado. Although this is a different forest type from Tom Swamp, they also found that total herbaceous cover was greater in the disturbed area than in the adjoining undisturbed forest.

Despite observations of tufts of *Carex* growing out of mound tops in the pulldown, changes in cover have not been recorded with this sampling technique. After the pulldown, 8.3% of ground area in the pulldown was pit or mound. Plots sampled in this survey were established before the pulldown. After the pulldown, some plots are on mounds or include the edges of pits, but
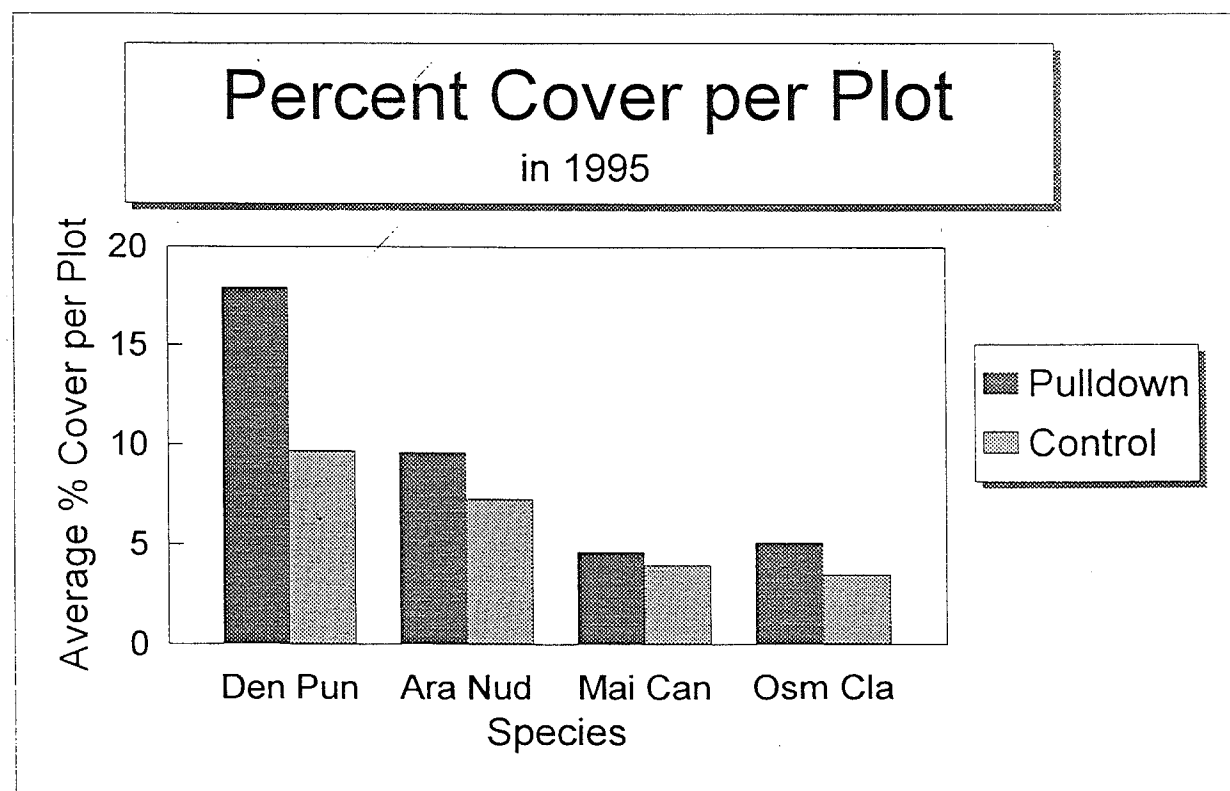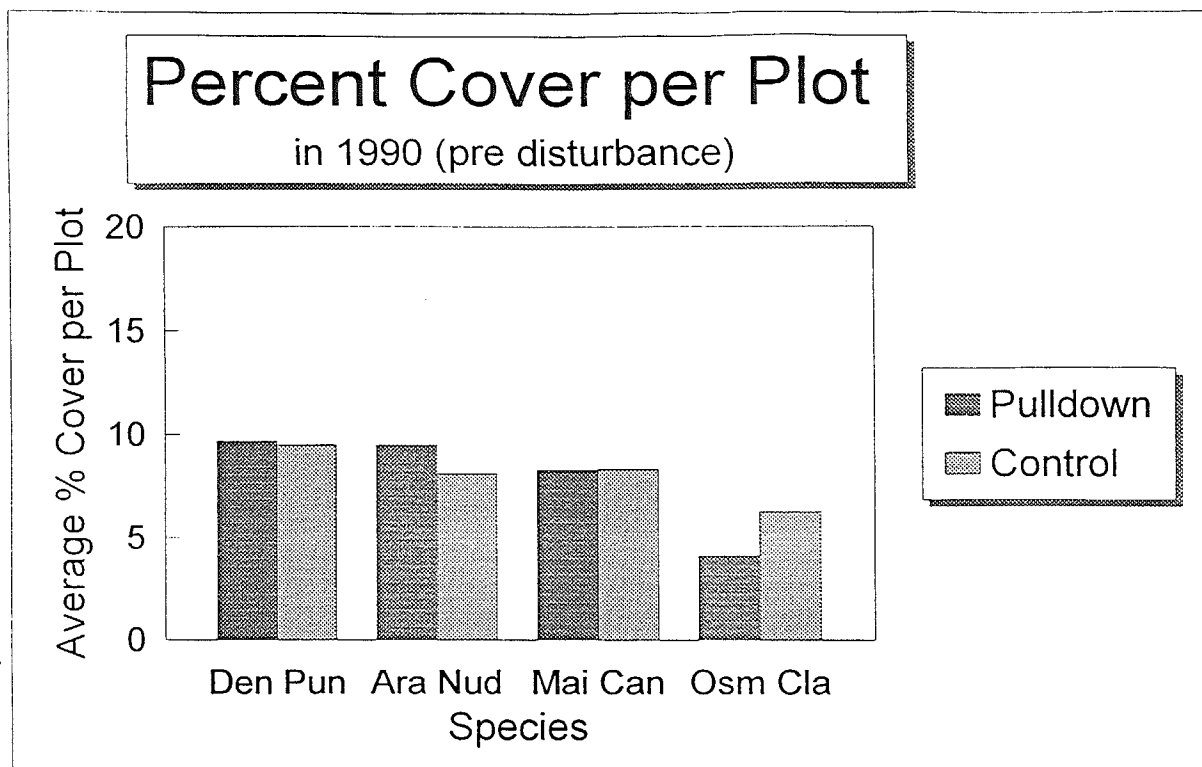
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Figure 1: Percent cover per plot of the four most common species in the pulldown and the control in 1990, before the pulldown and in 1995, five years after the disturbance. *Dennstaedtia punctilobula, Osmunda claytoniana, Aralia nudicaulis,* and *Maianthemum canadense* now have higher percent cover in the pulldown. The ferns have changed more than the herbs.

S. Neelon

none include large mound tops. Pits and mounds have been sampled in a microsite survey that will be important to continue because these areas seem to contain the majority of the sedge diversity.

In the future, the role of the different light intensities in different areas of the pulldown should be explored. This fall, shrubs will be sampled in all the plots in the pulldown and the control. It will be interesting to track how long the increased herb and fern cover persist, and whether or not this increased cover affects the germination and success of seedlings.

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The Effects of Chronic Nitrogen Additions on Understory Plants

Susan Rainey

Increases in wet and dry nitrogen deposition are changing the nitrogen cycle in many northern forests. Though nitrogen is usually a limiting factor, with high rates of deposition these systems could reach nitrogen saturation, where nitrogen is no longer limiting. To study the effects of chronic nitrogen deposition, a red pine plantation at the Harvard Forest has been fertilized with chronic levels of nitrogen. After six years of fertilization, one visible difference between the control, low nitrogen ($50 \text{ kg·ha}^{-1}\text{·yr}^{-1}$), and high nitrogen ($150 \text{ kg·ha}^{-1}\text{·yr}^{-1}$) plots is the number and biomass of groundcover plants. Samples of these plants were harvested from 1 x 1 m (control) or 1 x 2 m (low and high nitrogen) areas in eight subplots of each treatment and assessed for numbers of stems, biomass, and percent nitrogen.

Seven to nine species were found on each of the plots, with *Maianthemum canadense* and *Trientalis borealis* being the most abundant. Numbers of stems per square meter decreased with increasing nitrogen additions (see table). Total biomass of all plants sampled decreased 82% in the low nitrogen plots and 91% in high nitrogen plots, as compared to the control. Average percent nitrogen also increased among species with increasing nitrogen additions.

	Control	Low Nitrogen	High Nitrogen
Average Stems per m^2	250 (42)	67 (19)	30 (5)
Average biomass g/m^2	12.9 (2.6)	4.6 (1.3)	2.3 (0.4)
Average %N	2.3 (0.1)	3.2 (0.1)	3.4 (0.2)
M. candense			
avg. stems per m^2	220 (44)	89 (24)	33 (90)
avg. biomass (g/m^2)	8.9 (1.6)	1.5 (0.8)	0.5 (0.3)
avg. %N	2.5 (0.1)	3.1 (0.1)	3.4 (0.2)
T. borealis			
avg. stems per m^2	8.4 (2.9)	36 (14)	25 (7.8)
avg. biomass (g/m^2)	0.3 (0.1)	0.8 (0.6)	0.5 (0.3)
avg. %N	2.1 (0.1)	2.9 (0.1)	3.4 (0.1)

(numbers in parentheses are standard errors)

Though nitrogen additions would be expected to have positive effects, chronic nitrogen additions are having negative effects on the growth of these understory plants. These negative effects seem to be preceding similar effects in the tree species in these plots. The findings presented here suggest that the species composition, biomass, and nitrogen contents of understory plants may be sensitive indicators of nitrogen saturation in tree species.

Ecosystem Effects of Changing Land-use in the Central Uplands of Massachusetts

Raul A. Romero

The effects of long term changes in land-use on ecosystems in the New England region has been a focus of research at Harvard Forest for several years. The objective of this project is to detect how human disturbances can alter watersheds and their surroundings. Our research is focused on the effects of land-use on sedimentation rate in three ponds in the same physiographic region of central Massachusetts. It is expected that similar land-use histories within different watersheds will cause similar fluctuations in sedimentation rate through time.

We researched historical data and land-use maps for Gardner (which includes Snake Pond and Quag Pond) and Ashburnham (which includes Aino Pond). Lakes of interest were cored with a piston sampler. Lake sediment was divided into intervals of 1 cm to 2 cm. Percent loss on ignition was calculated in order to find the percentage of organic matter and water. Low organic percentage often results from high inorganic influx correlated with an

increase in sedimentation rates. The radionuclide ^{210}Pb was used in order to date sediments younger than 150 years and ^{14}C was utilized to date samples of 350 years and older.

Sedimentation rates increased following European settlement within the Aino Pond watershed. Interestingly, a rise in organic content was seen during the same period followed by a deep drop which continues until the peak of the agriculture in this area. Sedimentation rates gradually increased during the modern period even though the region is not currently appreciably developed. Overall, Aino Pond had a higher sedimentation rate during the modern period than during the European settlement period.

At Snake Pond, the early settlement and agricultural period have higher sedimentation rates than the modern period. A considerable decrease in the sediment organic composition can be seen during the period of 1850-1960 (agricultural period) which correspond to the construction of an airport and housing development in the area.

Sedimentation rates at Quag Pond were highest during initial European settlement. Sedimentation rates dropped during the agricultural period and rose again during the modern period although this watershed is not currently developed.

Different patterns of sedimentation influx were found at our study sites despite the geographic proximity of the selected basins to each other. This suggests that even in broadly similar sites, different land-use histories can result in dissimilar environmental trends. These results reinforce the importance of studying land use as a disturbance agent on ecosystems.

The Effect of Land-Use History on the Demographic Properties of *Gaultheria procumbens*

Elizabeth Zacharias

Land-use history plays an important role in determining the vegetation of a landscape. The Montague Sand Plain in central Massachusetts went through a period of agriculture fifty to one-hundred years ago and a previous study by Motzkin *et al.* (1995) documents that there is a relationship between land-use history and vegetation at Montague. There are forests of scrub oak and hardwood on much of the unplowed land and forests of pitch pine on the previously plowed land. Many species show restriction to either the plowed or the unplowed land. One species that shows extreme restriction is *Gaultheria procumbens* which grows mainly on unplowed land and extends only short distances onto the plowed land. The purpose of the study was to document any demographic differences among *Gaultheria* populations due to land-use history. We studied both vegetative growth and sexual reproduction. Montague was chosen as the study site because the land-use variable could be isolated from other variables. The homogeneity of the site led to some of its land being

plowed based on ownership and not on quality of land. The hypothesis is that the different environment that the plowed land provides is what is limiting reestablishment of *Gaultheria*. Yet, perhaps the different environments that the land-use leads to have no effect on the ability of the plant to grow. Therefore, the alternative hypothesis is that the slow growth pattern of *Gaultheria* is what is limiting its reestablishment.

The two types of study sites chosen for the project were scrub oak and hardwood because these are the dominant vegetation types on the unplowed land. Auguring was done to determine the location of the plow boundary on each of ten sites and ten one meter square quadrats were randomly placed in each site, with five on plowed and five on unplowed. Twenty-five erect shoots in each quadrat were labeled. The data collected from each one were number of leaves, branches, buds, flowers, fruit scars, dead branches and leaves, and new branches and leaves. Also noted was whether the shoot was old or new and if there was any herbivory.

The results show that there is a significant difference in the morphology of the plant populations between plowed and unplowed land. The *Gaultheria* populations on the plowed land produced more branches during the present growing season and had more branches total. The second result is that there is no significant difference in the sexual reproductive ability among the plowed and unplowed populations. Thus, a difference in reproductive ability is not what is limiting *Gaultheria's* reestablishment. In addition, no seedlings of *Gaultheria* were found during the study; the plant seems to travel only by way of rhizomes and does not seem to expand its range by way of seed dispersal and seedling establishment. The third result is that there is no significant difference in the densities of the populations or the number of new stems; limited growth of new stems on plowed land is not limiting *Gaultheria's* reestablishment. Our present results do not support either of the hypotheses. Based on our results, reproductive differences are not the limiting factor of *Gaultheria's* reestablishment on previously plowed land. Results are inconclusive as to whether morphological differences are leading to the slow reestablishment of *Gaultheria*.

1995 HARVARD FOREST SUMMER SEMINAR, DINNER DISCUSSION, FIELD TRIP, AND
WORKSHOP SCHEDULE

June 6 - Tuesday - Research Seminar

   "Current research on nitrogen saturation in New England
    Forests"
   Knute Nadelhoffer, Marine Biological Laboratories

June 13 - Tuesday - Research Seminar

   "Chronic human stress versus catastrophic natural
      disturbance in a forest ecosystem"
   Rich Bowden, Allegheny College

June 20 - Tuesday - Research Seminar

   "Research on the origin of species"
   Paul Wilson, Harvard Forest

June 27 - Tuesday - Research Seminar

   "Tropical tree coexistences: the mycorrhizal connection"
   David P. Janos, University of Miami and Harvard Forest

July 6 - Thursday - Field Trip

   "Field description of Soils"
   Art Allen, Harvard Forest. (Meet outside Torrey Lab)

July 10-11 - Institute of Ecosystem Studies, Millbrook, New York

   Careers Workshop

July 10 - Monday - Research Seminar

   "The relationship between science and policy"
   Robert Boyle, Hudson River Institute

July 10 - Monday - Dinner Discussion

   "Diversity in the scientific community"
   Ann Lewis, Alan Berkowitz, Rich Bowden, Steward Pickett

July 20 - Thursday - Seminar

   "Landscape-level analysis of disturbance in old-growth forests of the
   Bull Run Watershed, Oregon"
   Diana Sinton, Oregon State University

July 25 - Tuesday - Seminar

> "Crown structure and biomass allocation in one-year old trees in
> Costa Rica"
> Fabian Menalled, University of Massachusetts

July 26 - Wednesday - Dinner Discussion

> "Ethics in science"
> Rich Bowden, Allegheny College
> Charles McClaugherty, Mt. Union College
> Tim Sipe, Gustavus Adolphus College

August 8 - Tuesday - Research Seminar

> "The Soil Warming Experiment at Harvard Forest"
> Kathy Newkirk, Ecosystems Center, Marine Biological Laboratory

August 15 - Tuesday - Research Seminar

> "Using paleoecology to reconstruct the effects of land-use on
> estuarine populations"
> Grace Brush, Johns Hopkins University and Harvard Forest

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The Institute of Ecosystem Studies presents:

FORUM ON OPPORTUNITIES IN ECOLOGY

July 11, 1995

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<u>Morning Sessions</u>: Rewards and Motivations in Ecology Careers

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

9:35	Jon Polishook	Staff Microbiologist (*Industry*)
		Merck Research Laboratories, Rahway, NJ
9:48	Allisa Perreault	Science Teacher (*Education*)
		Wappingers Junior High School, Wappingers Falls, NY
10:01	Shabazz Jackson	Municipal Recylcing Specialist (*City Government*)
		City of Beacon, Beacon, NY
10:14	Sara Davison	Executive Director and Vice President (*Applied Ecology*)
		The Nature Conservancy, Cold Spring Harbor, NY
10:27	Mark Gallagher	Senior Scientist (*Consulting*)
		Coastal Environmental Services, Princeton, NJ
10:40	Drayton Grant	Environmental Lawyer (*Law*)
		Rhinebeck, NY
10:53	David Stern	Supervisor of the Pathogen Program (*Environmental Research*)
		Department of Environmental Protection, Valhalla, NY.

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

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

11:25	Dr. Ann Lewis	Assistant Professor of Forestry (*Academia*)
		The University of Massachusetts, Amherst, MA
11:38	Les Line	Freelance Writer (*Science Writing*)
		Amenia, NY
11:51	Dr. Andrea Worthington	Associate Professor of Biology (*Research Abroad*)
		Siena College, Loudonville, NY
12:04	Cal Snyder	Entomologist (*Museums*)
		American Museum of Natural History, New York, NY
12:17	John Mylod	Former Executive Director of Clearwater (*Environmental Activism*)
		Poughkeepsie, NY

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1995 SUMMER PROGRAM COMMITTEE ASSIGNMENTS

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Adrian

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Melissa
Annie
Annabel

Vehicles

Jamie
Solai
Cinnie

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Amanda

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Steven Holmes	Woods Crew	Paul S. Wilson	Research Associate
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Guy D'Oyly Hughes	MFS Candidate	John S. Wisnewski	Woods Crew
David P. Janos	Charles Bullard Fellow	Steven C. Wofsy	Associate

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Middle Row: Jackie Bartee, Solai Buchanan, Cinne Chou, Melissa Feldberg, Adrian Elseroad, Elizabeth Zacharias
Back Row: Annabel Bradford, Karin Kryger, Lonnie Williams, Jeff Milder, Satya Maliakal, Amanda Gardner
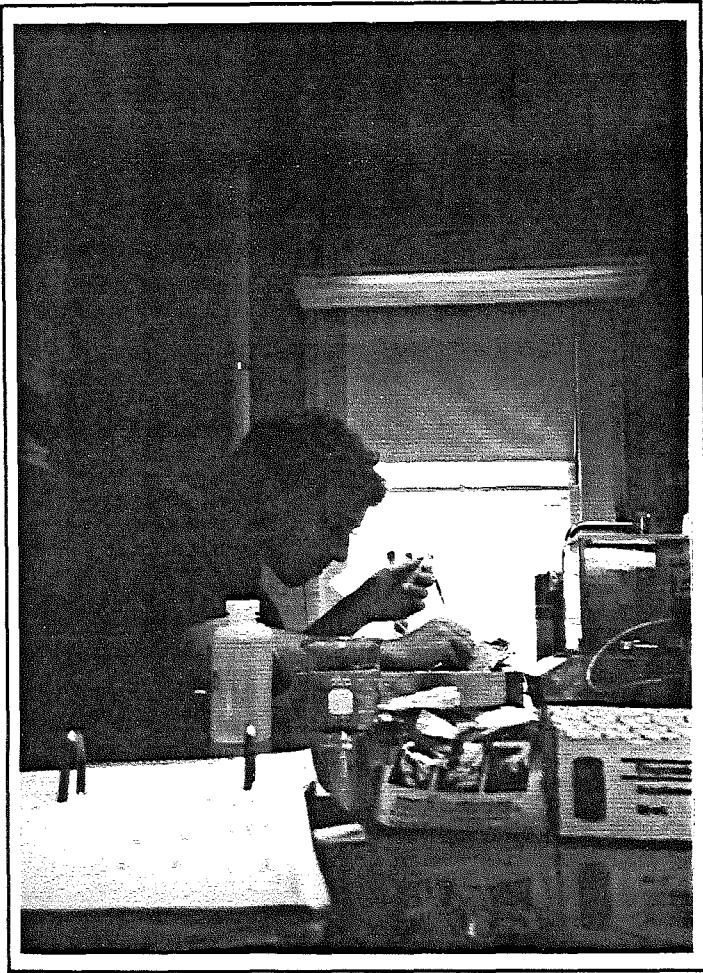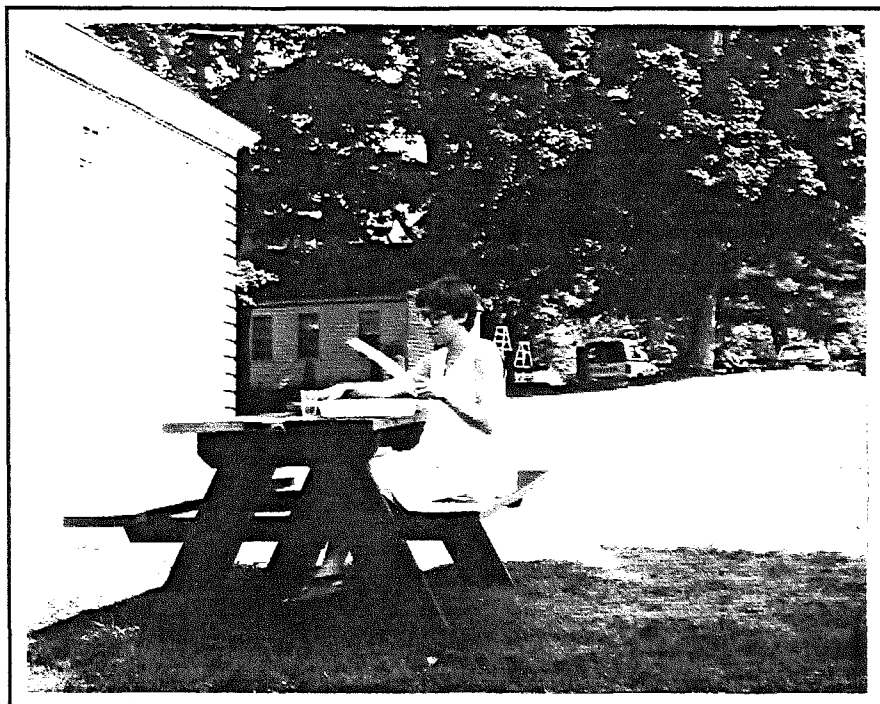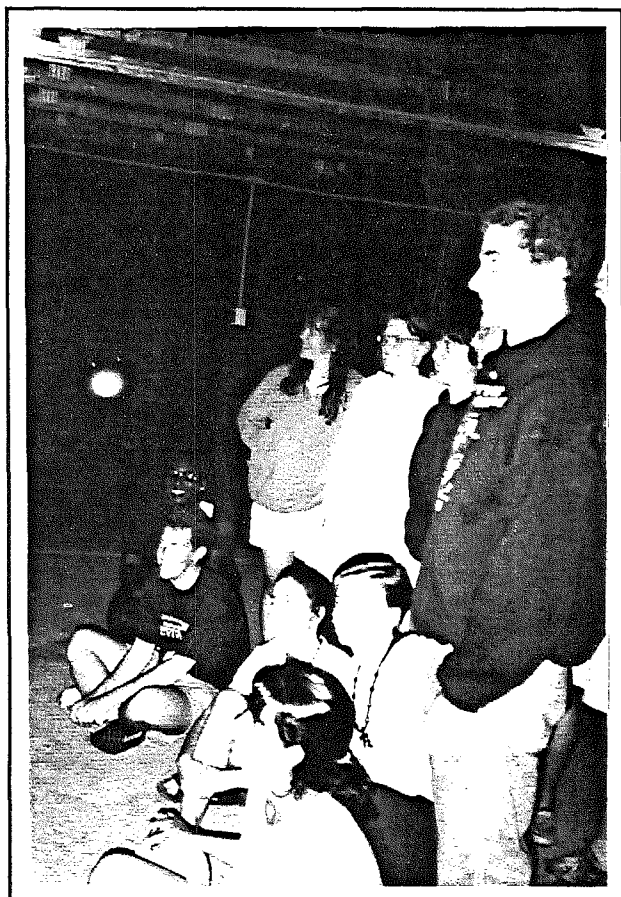
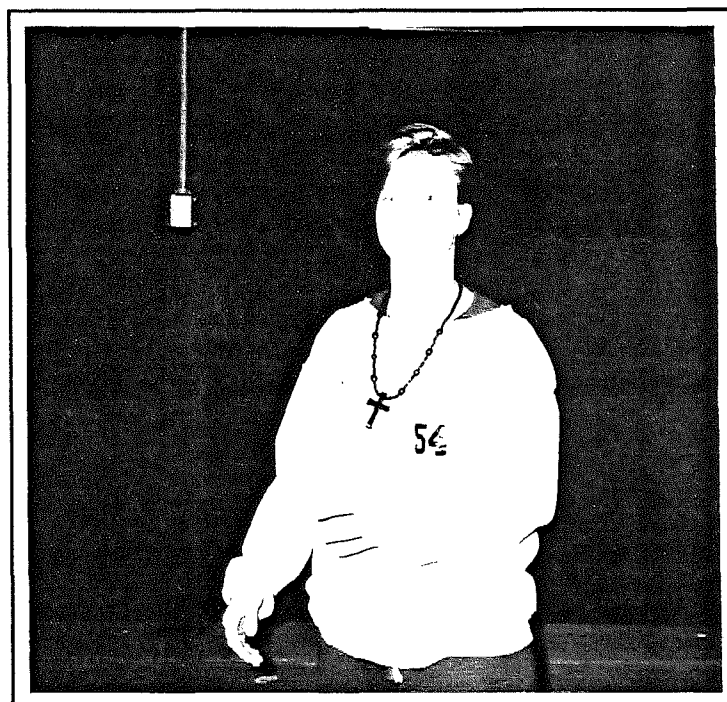Jeff
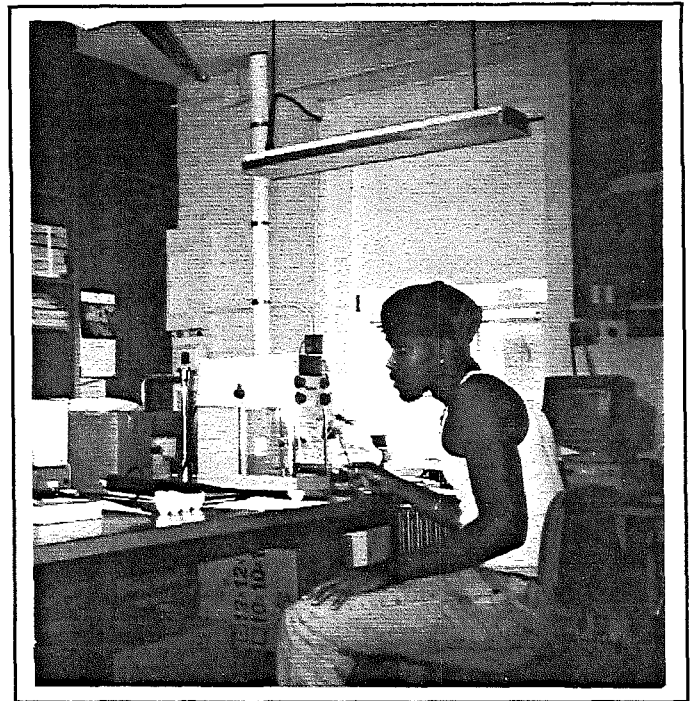
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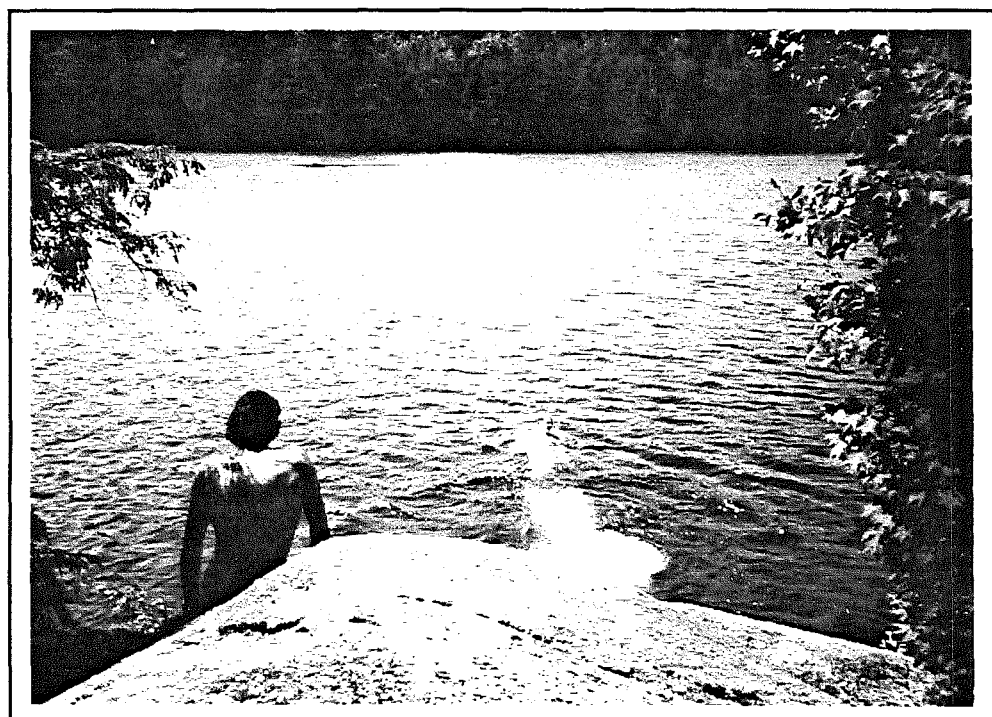
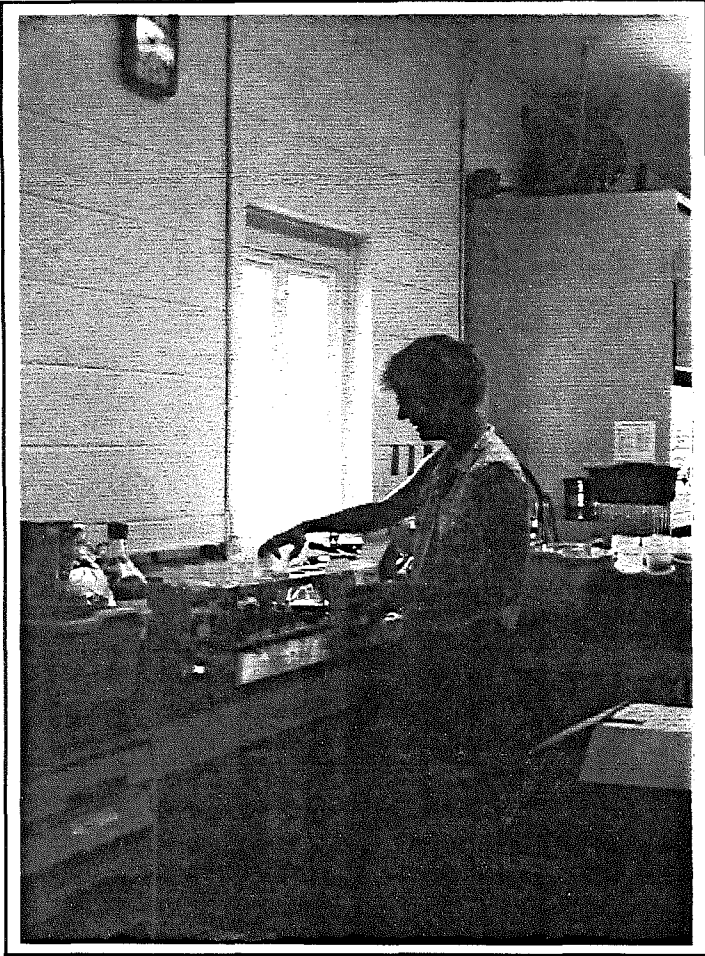

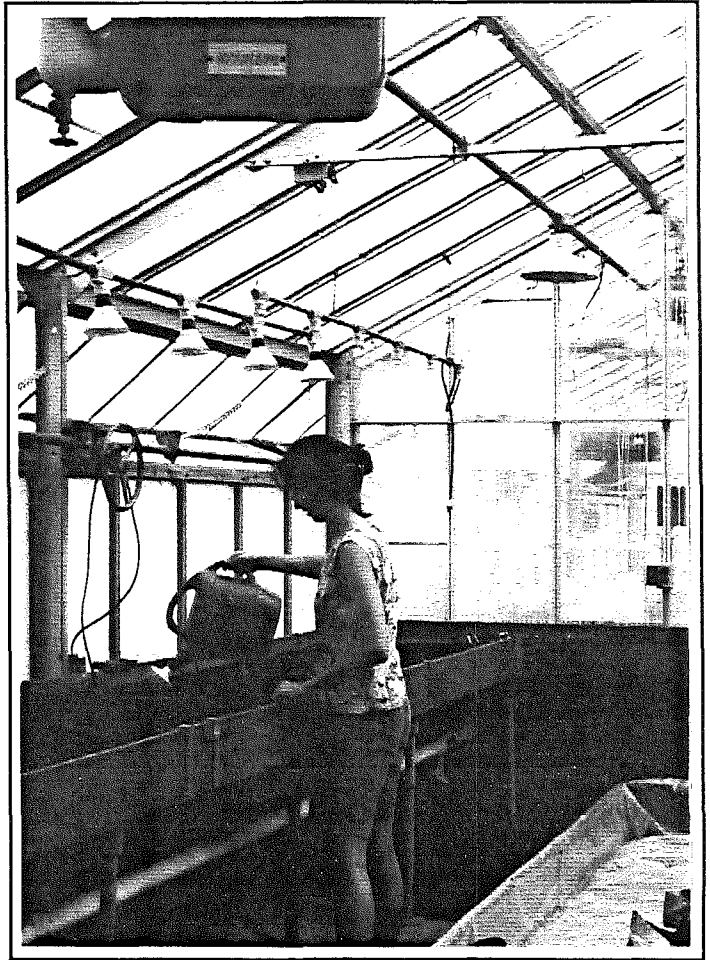?   Jamie
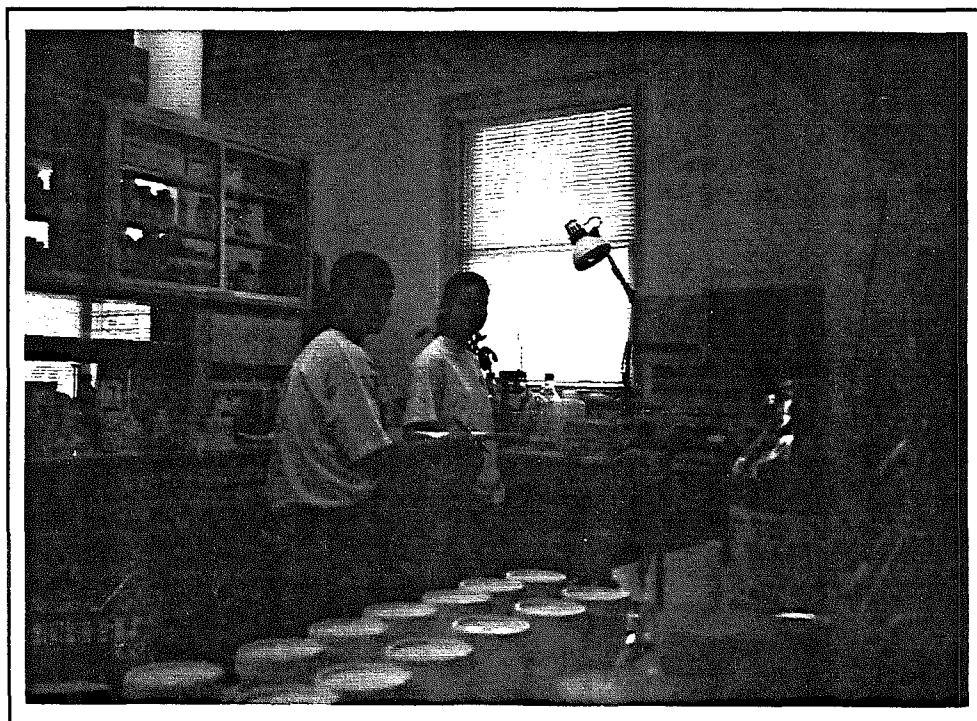
Michelle

Jackie, Solai, Jeff M., Sarah, Susan,
Amanda, Anne, Annabel, Elizabeth, Todd

Annie

Karin

Annabel

Annie, Susan