Vermont Monitoring Cooperative

Annual Report for 1993

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(Editors)

VMC Annual Report Number 3

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Table of Contents

Introduction

Introduction

The purpose of the VMC annual report is to provide a document to all VMC cooperators and interested persons describing preliminary results from studies conducted at Mount Mansfield and Lye Brook Area sites for the year. Participants in the program are invited to submit their findings for the year in a form that is easily understood by others involved in or interested in the program. It is hoped that this process will facilitate exchange of information and ideas and stimulate cooperativeness in expanding our understanding of forest ecosystems.

This document begins with an overview of program highlights for 1993, then proceeds to specific study results. Results are organized by site (Mount Mansfield or Lye Brook Area) and the type of information collected. When looking for results on a specific topic, it is recommended that you review each abstract for information pertinent to the topic and site.

With the addition of the Lye Brook Area site, and personnel changes within the USDA Forest Service, the composition of the VMC Steering Committee was modified in 1993 to include: Terry Hoffman, GMNF Supervisor, Robert Lewis, USDA Forest Service Northeast Forest Experiment Station Director, and Al Schacht, USDA Forest Service Northeastern Area State and Private Forestry Director.

In 1993, the Lye Brook Area Subcommittee began actively developing an operating framework for the southern VMC site. They worked as a multi-disciplinary team to address the initiation of activities at the site. The GMNF has implemented numerous monitoring projects as part of their goal to improve information on Air Quality Related Values of the wilderness area.

Lye Brook Projects include:

* establishment of wet and dry deposition, ozone and meteorology monitoring as part of the EPA CASTNet program
* installation of a nephelometer to monitor air visibility, making the IMPROVE site fully operational
* amphibian inventory and monitoring program
* biological and chemical monitoring of 3 ponds and 2 streams
* lichen community and chemistry survey
* mapping of Ecological Land Types
* continuation of forest health monitoring
* forest pest surveys
* ozone and bioindicator plant studies

Early in 1993, the Commissioner of the Department of Forests, Parks and Recreation officially designated state land within the Browns River, Stevensville Brook and Ranch Brook headwaters for use by the Vermont Monitoring Cooperative toconduct long-term monitoring and research on forest ecosystems. While existing uses of this land for recreation and natural area protection will continue, silvicultural treatments and other activities in the area will incorporate the needs of monitoring and research projects.

Expansion of monitoring and research projects on Mount Mansfield continued in 1993. New projects this year included:

* streamflow and water quality monitoring at Nettle Brook
* snowmelt and run-off chemistry
* foliar nitrogen variability and resorption in sugar maples
* expansion of ecological studies on the Bicknell's Thrush
* genetic variation in Bicknell's Thrush
* winter algal communities in streams
* cold tolerance and bud mortality of high elevation red spruce and balsam fir
* sugar maple photosynthetic responses to the environment
* bedrock geology of the mountain

The VMC is in the early stages of planning the integration of normal silvicultural treatments with forest ecosystem monitoring and research. The overall goal is to determine the ramifications of thinning a stand on the structure, diversity and processes. This will couple resource managers, with their information needs, with researchers to address current issues in ecosystem management and forest health.

Two areas have been selected within the Stevensville Brook drainage to conduct the management project. A FOREX inventory was conducted in one of the areas, with additional inventory information to be done in next year. Specific research and monitoring objectives are being developed by those interested in participating in the project. Additional promotion and planning of the project will be done in the next year to draw in others in coupling specific monitoring, research or management questions to this project.

Data Integration

THE VMC DATA INTEGRATION PROJECT: 1993 PROGRESS REPORT

Ian D. Martin
Tim Scherbatskoy
University of Vermont
School of Natural Resources

COOPERATORS

VT Department of Forests Parks and Recreation, VT Air Pollution Control Division, VT DEC Water Quality Division, Northeastern States for Coordinated Air Use Management, National Atmospheric Deposition Program, National Weather Service, US Forest Service, Lantern Corporation.

ABSTRACT

We at the Vermont Monitoring Cooperative believe that data integration is a fundamental requirement for any study or management plan following an ecological approach to ecosystem management and research. The goal of this work was to improve our ability to integrate and use multi-disciplinary data from ecosystem monitoring and research. We collected and compiled data from multiple studies into a common computer format (Voyager data files) to facilitate temporal, spatial and relational comparability. In 1993, several new data sets were added to the VMC database. These data sets include preliminary ozone data reported by the Northeastern States For Coordinated Air Use Management from the 1993 ozone season, Vermont forest health data from the North American Maple Project and meteorological data from National Weather Service stations in Vermont for the entire period of record through 1990. Two Voyager workbook files have also been prepared to demonstrate the process of data integration by combining multiple data sets into a common data environment. In addition, a final report describing the VMC Data Integration Pilot Project has been prepared and will be available for distribution in Spring 1994.

INTRODUCTION

One of the earliest goals of the Vermont Monitoring Cooperative (VMC) has been to facilitate cooperative research and monitoring of environmental change effects on forested ecosystems. To fulfill this goal, the VMC, with technical assistance from Lantern Corporation, launched the **Data Integration Pilot Project** in 1990. The aim of this effort was to create a highly structured and easily accessible database to: a) provide ready access to disparate data sets, b) allow for comparison and correlation of data across disciplines, and c) facilitate predictive modeling of ecosystem response to environmental change. This database would contain data provided by investigators conducting studies in cooperation with the VMC at VMC research sites (Mount Mansfield and Lye Brook Wilderness) and from existing data sets which contained information relevant to the VMC goals.

The principle objectives for 1993 were to:

1. Continue collecting and formatting data sets for inclusion in the VMC database

2. Prepare several integrated Voyager workbooks to initiate and demonstrate the process of data integration by combining multiple data sets into a common data environment.

3. Prepare and distribute a final printed report describing the Data Integration Pilot Project and the data products created during the project.

METHODS

Data processing was conducted at the University of Vermont School of Natural Resources (SNR). Data were converted into comparable spatial, temporal, and quantitative units and arranged in fixed format ASCII files. The ASCII files were saved to produce an archived database and were used for compilation into Voyager. At SNR, data processing was conducted on a desk top PC with a 486 processor operating at 33 MHz. All data sets were compiled from ASCII to individual Voyager files using the data compiler provided with the Voyager Data Exploration Software. These files were then incorporated into individual workbooks; a workbook is a Voyager workspace used to access individual or multiple data files.

RESULTS

A significant result of the 1993 data integration efforts has been the compilation of a final report entitled ***The Vermont Monitoring Cooperative Data Integration Pilot Project***. This report describes in detail the integrated VMC database including methods, data products, and future plans for the continuation of the VMC's data integration efforts. At the time of this writing the final report is nearing completion and will be available in early spring 1994.

Also in 1993 the following three data sets were processed and added to the VMC database:

1. Vermont Meteorological Data, period of record through 1990 (NWS).

2. NESCAUM Daily Ozone Maximums and Times of Occurrence, Preliminary Data, 1993 Ozone Season (NESCAUM).

3. North American Maple Project, Vermont Data, 1988-92 (VT FPR).

These data sets are now available in Voyager workbook, Spreadsheet and ASCII formats. For more details on these data sets please see the figures on the following pages.

Two integrated Voyager workbooks were also prepared, to initiate and demonstrate the process of data integration by combining multiple data sets into a common data environment. These integrated workbooks represent a preliminary investigation and interpretation of the inter-relationships between independently generated environmental and ecological data sets. They also represent data integration "tools". These integrated workbooks can be exchanged among, and enhanced by the usage of, other data users with an interest in exploring these relationships in additional detail. They are also intended to serve as examples, to encourage similar intercomparisons among other currently accessible or yet to be acquired VMC data sets. The two integrated workbooks are described below (for more information on these and other integrated workbooks see ***The Vermont Monitoring Cooperative Data Integration Pilot Project Final Report***).

1. Contrast of Precipitation Chemistry Measurements Between NADP and VAPMP.

   This workbook contains both NADP and VAPMP data on precipitation chemistry. It provides a comparative look at measurements made by both programs at the Proctor Maple Research Center in Underhill, VT during the same period of record.

2. Comparisons of Monthly Mean Precipitation and Aquatic Chemistry.

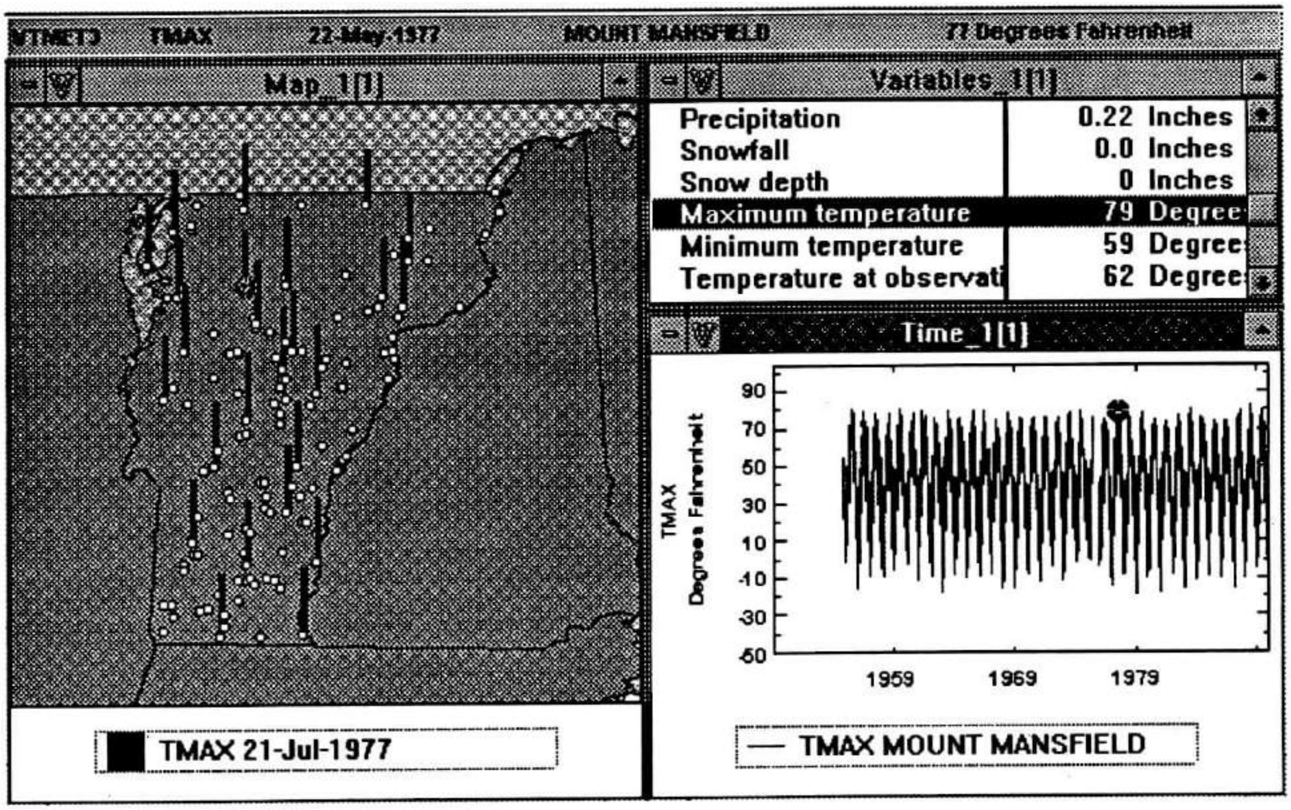
   VAPMP precipitation chemistry data and aquatic chemistry from the Vermont Long-Term Lake Monitoring Program are combined in this workbook. The workbook explores the relationship between lake and precipitation pH in both northern and southern Vermont.

FUTURE PLANS

Future plans for the VMC's data integration efforts are discussed in detail in ***The Vermont Monitoring Cooperative Data Integration Pilot Project Final Report***. In brief, the VMC plans to hire a full time Data Manager, scheduled for Spring 1994. The Data Manager will be responsible for coordinating the VMC's data integration program, updating and expanding the VMC database and distributing VMC data products. Also anticipated are pro-active efforts to expand the participation of VMC cooperators in the data integration project leading to the production of a truly integrated VMC report for 1995.

FUNDING

This project was supported in 1993 by grants from the VT Department of Forests, Parks and Recreation, the VT Department of Environmental Conservation, the Northeastern States for Coordinated Air Use Management, and the US Forest Service (cooperative agreement # USDA 23-758).



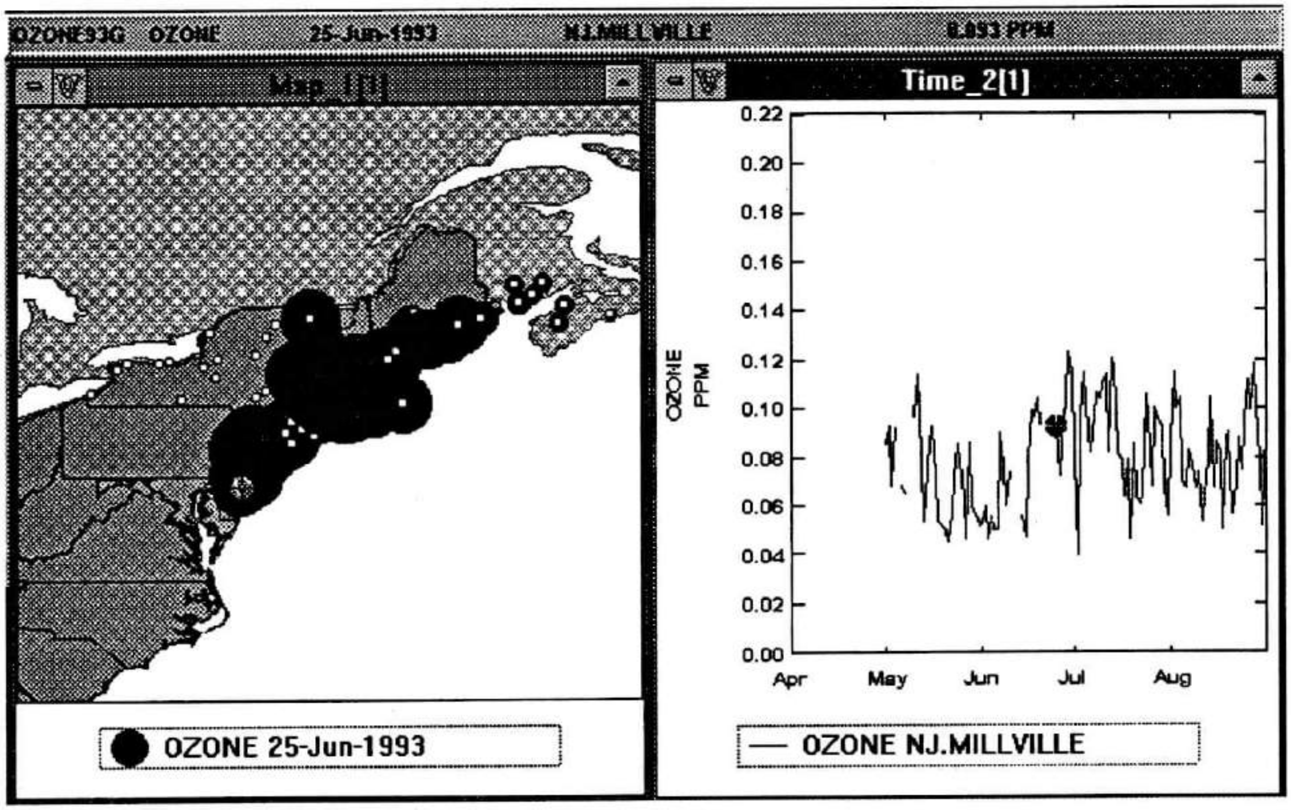
VERMONT METEOROLOGICAL DATA

Contributors: National Weather Service
Compiled: October 10, 1993 by Don Hay, Carl Slenk and Ian Martin

This data set contains daily weather data from all National Weather Service cooperating weather stations in Vermont for their entire period of record. The most recent data available is through December 1990, at which time there were 45 active stations. Due to the large size of this database, it is only available as a Voyager file and workbook, or as an ASCII file of variable (40 Mb) or fixed (90 Mb) length records. The only known problem with these data may be an erroneous extreme value (easy to identify) for at least one station for temperature (e.g., 500 deg F) and precipitation (e.g., 1,000 inches).

Variables: Daily precipitation amount (inches), snowfall (inches), snow-depth (inches), maximum, minimum and time-of-observation temperature (deg. F), and numerous categories of weather conditions (sleet, blowing snow, lightning, dust, etc.).

Workbook names:	VTMET3.WKB
Required files:	VTMET3.VOY, NAM.MAP, US.LAY
Package size:	9.52 Mb
Related files:	VAPMPMO2.VOY, VTPREC.VOY, UNDERDAY.VOY, UNDERHR.VOY, BURLDAY.VOY, BURLINGT.VOY, NEMINMAX.VOY, NEPREC.VOY



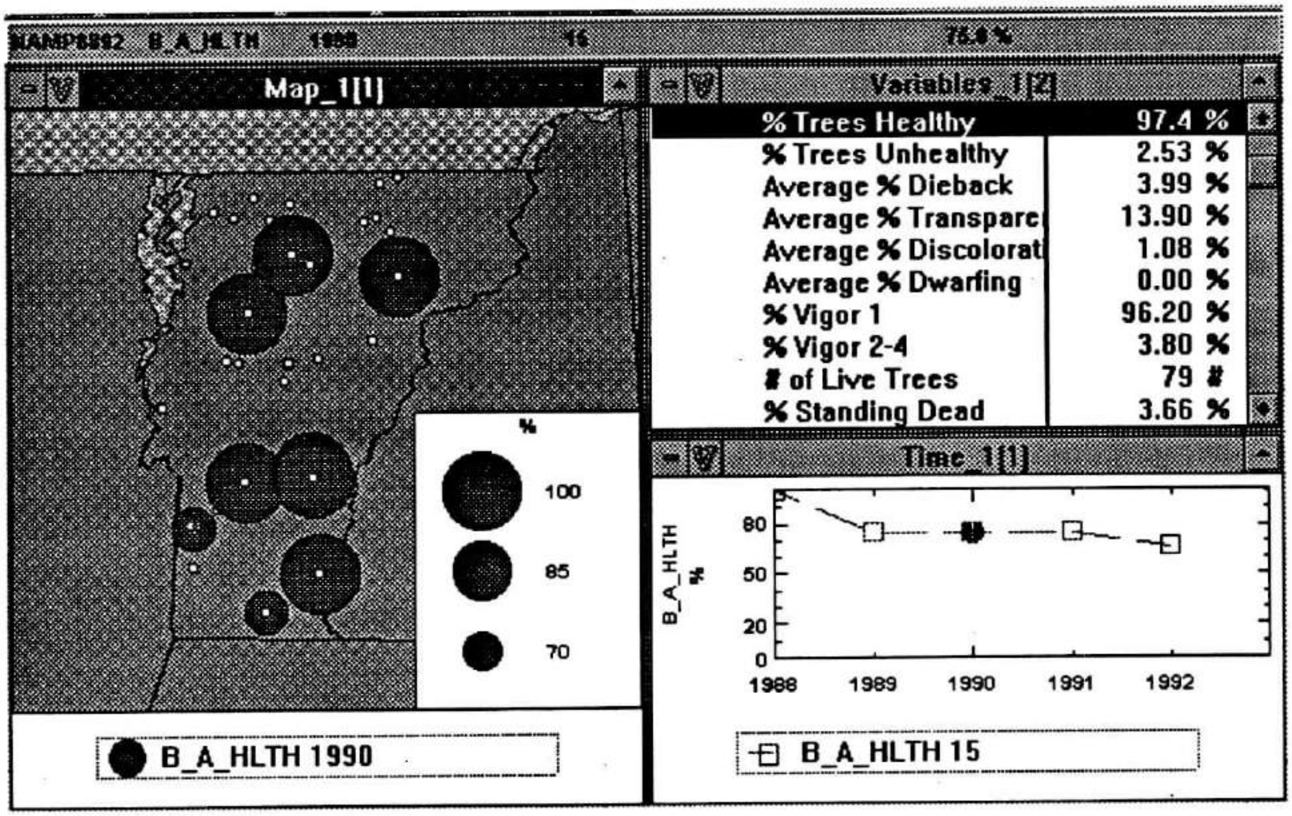
NESCAUM DAILY OZONE MAXIMUMS AND TIMES OF OCCURANCE, 1993. PRELIMINARY DATA

Contributors: Northeastern States for Coordinated Air Use Management
Compiled: December 10, 1993 by Ian Martin

Ozone93j.wkb is the sixth in a series of workbooks constructed for NESCAUM cooperators in 1993. This final edition contains data submited to the NESCAUM ozone network between the dates April 1, 1993 and November 30, 1993. The data covers 93 monitoring stations in CT, ME, MA, New Brunswick (Can), NH, NY, Nova Scotia (Can), RI, and VT. This data set is also available in ASCII (800 kB) or EXCEL files (1.3 MB).

Variables: Daily ozone maximum (ppm), Hour of occurance (hours)

Workbook Name:	OZONE93J.WKB
Required Files:	OZONE93G.VOY, NAM.MAP, US.LAY
Package Size:	163 kB
Related Files:	OZONE92.VOY, OZONE91.VOY, NEOZAGDA.VOY, NEOZMOAG.VOY, NEOZPERC.VOY



NORTH AMERICAN MAPLE PROJECT, VERMONT DATA 1988 - 1992

Contributors: VT Department of Forests Parks and Recreation
Compiled: September 3, 1993 by Ian Martin & Sandy Wilmot

This data represents a summary of data collected in Vermont under the NAMP program. In 1988, 26 plots were established. Additional plots were added in subsequent years so that by 1992, there were a total of 40 plots. Displayed here are data collected on trees greater than or equal to 10 cm. Initially, crown measurements were not collected on non-sugar maple species, but beginning in 1991 these measurements were taken on all hardwood species. Data displayed here have been stratified by both species and crown class, such that for each species, variables are displayed for all trees and for dominant/codominant trees. All sites contain data collected for sugar maples, but not necessarily other tree species. The data set is also available in an ASCII or Lotus file (ASCII 200 kB, Lotus 400 kB).

Variables: % trees healthy, % trees unhealthy, average % dieback, average % transparency, average % discoloration, % vigor 1, % vigor 2-4, # of live trees, % standing dead. % new mortality, % trees cut, average # tapped, average # open tapholes.

Workbook Name: NAMP8892.WKB
Required Files: NAMP8892.VOY, NAM.MAP, US.LAY
Package Size: 125 kB

Mount Mansfield

Atmospheric

Atmospheric Mercury Deposition in the Lake Champlain Basin of Vermont - 1993 -

Tim Scherbatskoy
University of Vermont School of Natural Resources

Cooperators:

University of Vermont: Joanne Cummings, Carl Waite, Cathy Borer.
Proctor Maple Research Center: Sumner Williams, Brian Stowe.
University of Michigan: Jerry Keeler, Janet Burke, Marion Hoyer.
NOAA Air Resources Laboratory: Rick Artz.

Abstract:

A new research program to quantify mercury (Hg) deposition in the Lake Champlain Basin was initiated by the Vermont Monitoring Cooperative (VMC) in cooperation with the Lake Champlain Research Consortium, University of Michigan Air Quality Laboratory, and NOAA (National Oceanic and Atmospheric Administration). Monitoring of Hg in precipitation, vapor and particulate phases began 16 December, 1992 at the VMC air quality site at the Proctor Maple Research Center in Underhill (400 m elevation). Precipitation was collected on a daily/event basis using a wet-only precipitation collector, and vapor and particulate phases were collected in 24-hour air samples twice a week. Samples were shipped to the University of Michigan Air Quality Laboratory (UMAQL) where they were analyzed for total Hg by cold vapor atomic fluorescence spectrometry within 48 hours of collection in the field.

Results indicate that there are significant levels of Hg present at all times in all three phases. Mercury in precipitation ranged from 1.5-26 ng/L, with a volume-weighted mean of 8.3 ng/L for 1993; the highest concentrations occurred during the summer months. Deposition of total Hg in precipitation events averaged 0.07 $\mu g/m^2$ during this period, with total deposition of 9.26 $\mu g/m^2$ for 1993. Vapor phase Hg ranged from 1.2 to 4.2 ng/m^3, with a mean of 2.0 ng/m^3 during this period. Particulate phase Hg ranged from 1 to 43 pg/m^3, with a mean of 11.2 pg/m^3, with the highest concentrations occurring in the winter months.

Mercury in snowmelt-fed stream water was also measured in Harvey Brook, a small stream near the deposition monitoring site. Stream water concentrations were measured twice daily during snowmelt from 26-31 March, and ranged from 1.9 to 12.6 ng/L with concentrations during afternoon high flow being 2-4 times greater than during morning lower flow.

Introduction:

There is widespread concern that atmospheric sources of mercury may be responsible for increasing mercury burdens in Lake Champlain. This has been shown to be the case for many remote lakes in the Great Lakes region (Fitzgerald *et al.* 1991), but there are no data for the Lake Champlain Basin. Currently there is a Vermont State Heath Advisory against the consumption of Walleye from Lake Champlain due to mercury contamination. In addition, recent research supported by the VT Water Resources Research and Lake Studies Center has identified elevated levels of mercury and other metals in sediments in the lake. Little information exists on levels or behavior of mercury in forested ecosystems, but atmospheric and forest scientists are becoming increasingly concerned about the impacts of long distance transport of hazardous air pollutants including mercury into northern Vermont. The Lake Champlain Basin is characterized by a large (18:1) ratio of watershed to lake surface area, so capture and processing of atmospheric pollutants by forest systems is particularly important to understand in this region. Furthermore, as mercury is a potent toxin to many organisms, its presence and behavior in forest soils, plants or waters is potentially of great concern. This program to monitor atmospheric mercury was established to address information needs of several groups: aquatic, terrestrial and atmospheric.

Objectives:

The goals of the mercury monitoring and research program include: (1) characterizing mercury deposition in precipitation, aerosol and vapor phases, (2) studying mercury transport and processing in a forested watershed (including snowmelt, stream chemistry and hydrology, and forest throughfall), and (3) supporting larger Lake Champlain issues (meso-scale modeling of pollutant deposition, trace metal toxicology, sediment accumulation, etc.).

Specific objectives for 1993 included: (1) monitoring mercury concentration in every precipitation event and twice-weekly vapor and particulate phase samples, and (2) measuring mercury concentration in a snow-melt fed stream in early spring.

Methods:

Precipitation samples were collected in a MIC-B (MIC Co., Richmond Hill, Ontario) wet-only precipitation collector located at the air quality monitoring station at the Proctor Maple Research Center (400 m elevation). This collector contains a large Teflon coated funnel for trace metal sampling, and was co-located with the other precipitation monitoring equipment (e.g., NADP. AIRMoN, see Cummings and Scherbatskoy, this volume) at this site. Samples were collected on a daily/event basis (samples were collected every morning that there was precipitation) and shipped by overnight courier to the University of Michigan Air Quality Laboratory (UMAQL) for analysis within 48 hours.

Vapor and particulate samples were collected every Wednesday and every sixth day as 24-hour air samples on gold-coated sand vapor traps and glass-fiber particulate filters, respectively; these were shipped on the day of collection to UMAQL for analysis.

During five days of peak snowmelt in early spring (26-31 March), stream water samples were collected twice daily from Harvey Brook, a small stream near the air quality monitoring site. Samples were collected in the early morning and late afternoon using the same type of sample bottles and analytical procedures as for precipitation.

All samples were analyzed for total elemental mercury by cold vapor atomic fluorescence spectrometry (CVAFS). Ultra-clean sampling, handling and storage techniques were used throughout all procedures. In the field, this entailed wearing particle-free gloves to handle sample bottles and filter packs, and triple bagging all samples. Analysis and sample bottle preparation at UMAQL was conducted in a Class 100 clean lab. Twenty percent of the samples were analytical blanks for quality assurance purposes. Analytical accuracy was within 5% of known standards and precision error was less than 8%. No Hg speciation was performed, so all data represent total Hg measurements.

Results:

Atmospheric Deposition.

Mercury concentrations in the three principle phases (precipitation, vapor and particulate) are summarized in Figure 1. For the year, volume-weighted average precipitation Hg concentration was

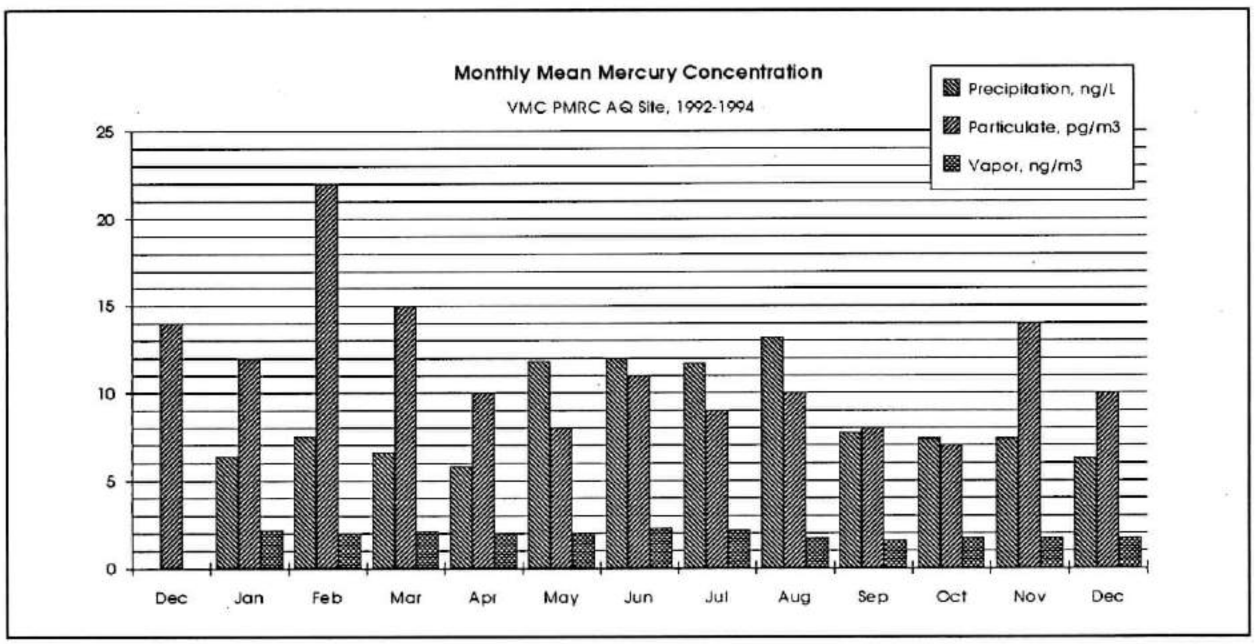


Figure 1: Average monthly mercury concentrations in precipitation, particulate and vapor phases in December 1992 and all of 1993.

8.3 ng/L, with the highest concentrations occurring in the summer months; vapor phase Hg was relatively constant throughout the year, averaging 2.0 ng/m^3. Particulate Hg concentration was greatest in the winter months, and averaged 11.2 pg/m^3 for the year. These data are comparable in magnitude and trend to values for northern Michigan, where other sites in the network are operated (Burke et al 1994, Hoyer *et al.* 1994). Mercury deposition in precipitation was also greatest in the summer months, due to high concentration and high precipitation amount. Total annual Hg deposition was 9.26 $\mu g/m^2$, distributed as shown in Figure 2.

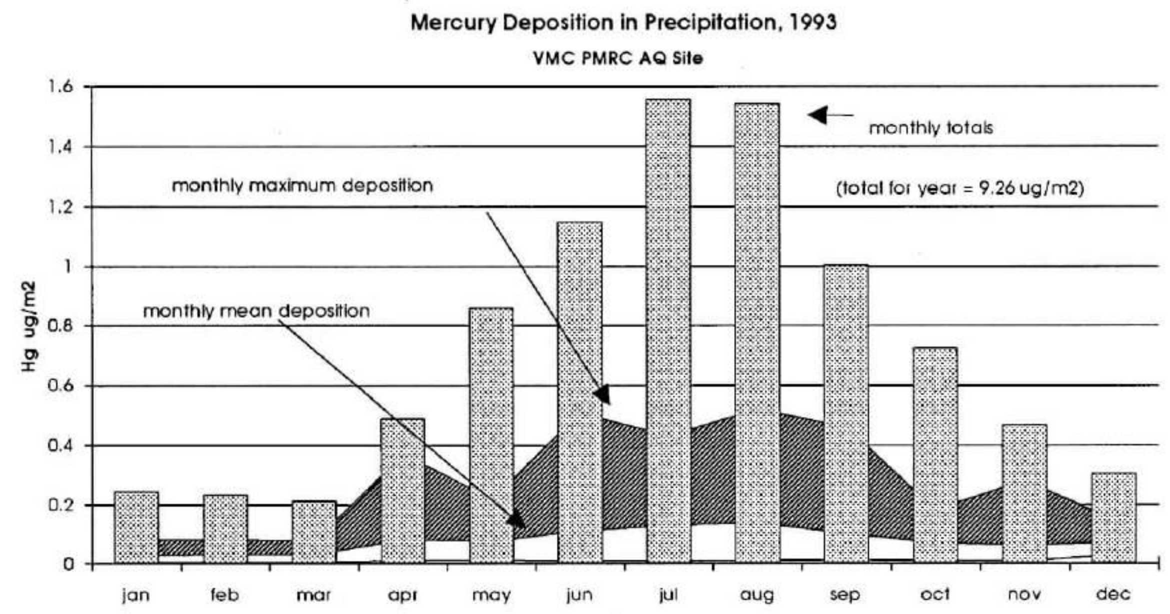


Figure 2: Mercury deposition in precipitation, showing monthly totals as bars, and maximum and minimum deposition for each month in 1993.

Surface Water Chemistry.

Stream water Hg concentrations during snowmelt fluctuated diurnally, being higher in the afternoon samples when stream flow rate was greater (Figure 3). No attempt was made to quantify the flow rate, but observations at the time of collection indicated substantially greater flow during the warm afternoons and lower flow during the cold mornings. Air temperature was above freezing during all of this period, ranging between 2 and 16 °C. Stream water Hg concentrations varied during this period between 2 and 12 ng/L, with an average of 6.1 ng/L. During this period, NO_3 concentrations increased slightly (mean of 1.8 mg/L) and SO_4 concentrations declined slightly (mean of 5.9 mg/L).

Discussion:

Atmospheric Hg vapor concentrations varied little during the year, and were comparable to measured vapor concentrations in rural Michigan, the Great Lakes region and New York, about 2 ng/m^3 (Burke *et al.* 1994). Particulate Hg, however, was considerably greater in the winter months (~15 pg/m^3) than in the summer months (~9 pg/m^3), suggesting possible wintertime increases in

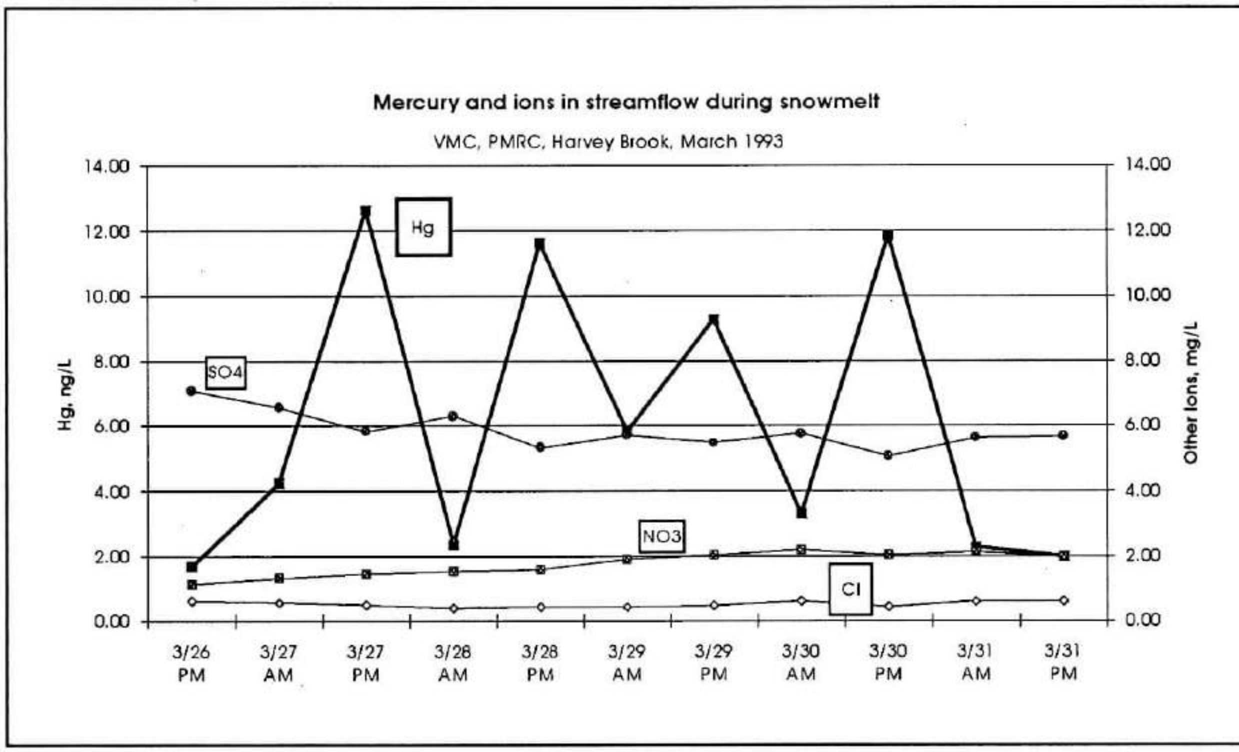


Figure 3: Twice-daily measurements of stream water during five days of spring snow-melt for total Hg, SO_4, NO_3 and Cl.

sources. A similar trend toward higher concentrations in winter was also seen for Hg particulate in Michigan (Burke *et al.* 1994). Other trace metals - notably As and Se, usually associated with coal combustion emission signatures - have also been observed to increase in winter aerosol concentrations at PMRC and in Michigan.

Precipitation Hg concentrations were significantly greater in the summer months (~11 ng/L) than in the winter months (~5 ng/L), but without additional data it is difficult to determine if this is a normal trend related to temperature and source emission patterns. Nonetheless, precipitation Hg deposition was also considerably greater in the summer months, due to the combined effects of higher concentration and higher amounts of precipitation than in the winter. During the summer months, more than 1 $\mu g/m^2$ Hg per month was deposited, compared to about 0.2 $\mu g/m^2$ Hg per month during the winter. The total deposition for the entire year, 9.26 $\mu g/m^2$ Hg, was comparable to that of rural sites in Michigan (range 6.2 - 9.9 $\mu g/m^2$, Burke *et al.* 1994).

Typical total Hg concentrations tend to be around 0.5-2 ng/L in many waters (Porcella *et al.* 1991), and appear to be in the 2 ng/L range during low flow for the stream sampled in this study. In the afternoon stream samples, however, Hg concentrations were 2 to 4 times greater than during base flow, increasing to as much as 12 ng/L. These increases appeared to be associated with diurnal increases in stream flow rate. Because Hg complexes strongly with organic matter, this increase could be partly due to increased suspension of Hg-bearing organic matter during increased flow. Increased Hg concentrations could also be caused by afternoon snowmelt adding higher concentrations of Hg to the stream. Without detailed information on snowpack chemistry, it is difficult to resolve this question. In either case, this would result in significantly increased flux of Hg to downstream communities during these periods. We have not actually estimated Hg fluxes in the stream system because of the lack of flow data.

Although the variation in stream SO_4 concentration appears small, there was a pronounced negative correlation (r=-0.61) between SO_4 and Hg during snowmelt (Figure 3). This was probably caused by a flow-related dilution of stream SO_4 (rather than an interaction between Hg and SO_4), but because this pattern was not apparent for NO_3 or Cl, it could suggest a chemical relationship between SO_4 and Hg.

At this time, no information is available about the forms of Hg in precipitation or stream samples, although it is assumed that only 2-10% of the Hg in precipitation is in the methyl form, the remainder being inorganic (Bloom and Watras 1989). In Adirondack lakes typical total Hg concentrations range from 0.8 to 5.3 ng/L, with about 10% being methyl Hg (Driscoll *et al.* 1994). There are no comparable Hg data available for uncontaminated streams. Although methyl Hg concentrations are usually relatively low in waters, it is this form that is highly toxic and accumulates in animal tissues. These levels in lake water yielded from 0.2 to 1.2 μg/g Hg in tissues of yellow perch, depending on fish age (the US FDA action level for Hg is 1 μg/g). Concentrations of total Hg in Harvey Brook during our snowmelt sampling period were many times greater than the Adirondack lakes, suggesting possibilities for significant accumulation and toxic effects on stream biota. More information on the form of Hg (inorganic, methylated, particulate, etc.) and on stream water chemistry (pH, DOC, etc.) is needed to assess the likelihood of these effects, but these data indicate the need for further study of Hg concentrations in snowmelt and stream waters.

Future Plans:

In 1994 we will continue monitoring precipitation, vapor and particulate phase atmospheric mercury, although we anticipate reducing the vapor and particulate sampling to weekly. In addition, we will conduct regular sampling of stream water for mercury and major ions at the new continuously gauged weir on Nettle Brook in the Stevensville Brook watershed. This work will also include intensive studies of mercury chemistry during spring snow-melt. Associated with this will be analysis of mercury in accumulated snowpack and snowpack melt water. We will also conduct limited synoptic sampling at several sites in the Lamoille River drainage system. Finally, we hope to obtain funding to conduct an intensive study of mercury chemistry in forest throughfall. These studies are designed to continue our basic monitoring of atmospheric mercury deposition and to build toward understanding the processes controlling mercury deposition, transport, transformation and accumulation in the watersheds and streams of the Lake Champlain Basin.

Regional Context:

This work was designed primarily to provide information about Hg deposition patterns, transport and transformation processes in the Lake Champlain Basin. The precipitation, vapor and aerosol monitoring are coordinated with ongoing mercury monitoring in the Great Lakes Region operated by UMAQL (Hoyer *et al.* 1994). Data from this study are used in regional analyses of mercury transport and deposition patterns in northeastern North America, and in meso-scale analysis of hazardous air pollutant deposition in the Lake Champlain Basin being conducted by the NOAA

Air Resources Laboratory. As part of the effort to assess toxics deposition in the Great Waters of the US, this work provides valuable data on Hg deposition and ecological processing in this region. In addition, these data represent an important baseline database, and support research on mercury patterns and toxicology in Lake Champlain by scientists in the Lake Champlain Research Consortium.

Acknowledgements:

Primary financial support for this work was from the NOAA Air Resources Lab (contract # USDC-40EANR-3000923) under the Lake Champlain Special Designation Act of 1990. Additional support was provided by the VT Air Pollution Control Division. We also wish to acknowledge the assistance and support of the Proctor Maple Research Center, where much of this work was conducted.

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Driscoll, C.T., C. Yan, C.L. Schofield, R. Munson, J. Holsapple. 1994. The mercury cycle and fish in Adirondack lakes. Environ. Sci. Technol. 28:136A-143A.

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Porcella, D.B., C.J. Watras, N.S. Bloom. 1991. Mercury species in lake water. Proceedings of the annual NADP conference, 8-10 October, 1991, Philadelphia.

Vermont Acid Precipitation Monitoring Program -

Data Summary Report 1980-1993 for Underhill and Mt.Mansfield

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Vermont Department of Environmental Conservation

COOPERATORS:

UVM Proctor Maple Research Center (Sumner Williams and Joanne Cummings), WCAX-TV Mt.Mansfield Transmitter Station (Michael Rainey)

ABSTRACT:

The VMC monitoring stations located at Underhill and Mt.Mansfield are included in the Vermont Acid Precipitation Monitoring Program (VAPMP). The majority of bulk precipitation in Vermont is unquestionably acidic. Forty-one percent of all events occurs between the pH of 4.20 - 4.60. Ninety-four percent of all precipitation events have a pH less than 5.60, the theoretical pH of unpolluted rain. Both Mt. Mansfield and Underhill have frequent low monthly volume-weighted means compared to the other VAPMP sites. Both Underhill and Mt.Mansfield with a few exceptions, have lower volume-weighted pH means in the summer than in the winter. Mt.Mansfield and Underhill, in addition to one additional site located in Morrisville were selected for the purpose of examining spatial variations. Mt.Mansfield, located at the highest elevation can be characterized as the lowest pH site followed by Underhill.

INTRODUCTION:

The Department of Environmental Conservation (DEC) has been monitoring precipitation via the Vermont Acid Precipitation Monitoring Program (VAPMP) since 1980. The program was initiated to assess the impact of acid precipitation and to assess the 1970 Clean Air Act which mandated improvements in air quality. The pH of bulk precipitation is collected by dedicated volunteers at six sites located throughout Vermont (Mt.Mansfield, Underhill, Morrisville, Concord, St.Johnsbury and South Lincoln). Formally, five additional sites located in Swanton, Canaan, Woodstock, Manchester and West Dover were also monitoring for the VAPMP program. This report is a summary of a previous report for all the VAPMP sites from 1980-1991. The goals of the VAPMP report were to: 1) describe the pH range of bulk precipitation in Vermont 2) evaluate seasonal trends in bulk precipitation pH; and 3) to evaluate spatial differences in pH in relation to elevation and site location. Observations regarding trends and variations have been made predominately without rigorous statistical testing to confirm their significance.

METHODS:

Precipitation is collected in bulk collectors on an event basis with the pH and precipitation amount measured for each event. The pH is determined by a Cole Parmer digital pH meter model 5987 and a Cole Parmer combination electrode with a calomel reference. The U.S. Weather Service provides weather information.

Rainfall is intercepted by a funnel with a polyethylene screen (1241 micron mesh) at its vortex and passes through a length of tygon tubing until it reaches and is collected in a one gallon polyethylene jug. The entire apparatus is housed in a wooden box, one foot in width and four feet in height. Snow is collected in a five-gallon polyethylene bucket and brought indoors to completely melt before the pH is measured.

The collectors are located in flat open area, away from roads, point sources, heavily urbanized and/or agricultural areas, trees and overhead wires.

All monitors are trained by the DEC and the monitor's techniques are observed bi-annually. There has been a low turnover of monitors, which has contributed to consistency in the data collection.

The pH meters are calibrated with buffers 4.00 and 7.00 prior to each use. To ensure that the electrodes are working properly, the monitors are supplied with a check sample of pH 4.70+/-0.10 at 25°C. The pH meters are professionally calibrated yearly and the electrodes are replaced when they show signs of slow response or failure. The pH and amount of precipitation are recorded on monthly report sheets along with comments about duration of event, type of precipitation, time and date of analysis, use of pH check sample and presence of visible contaminants in the sample. The bulk collector jugs and snow buckets are rinsed with distilled water three times after each precipitation event.

RESULTS:

Frequency of Distribution

The highest frequency of precipitation pH occurrence falls between 4.20-4.60. Ninety- four percent of all precipitation events from July 1980 to December 1991 are less than pH 5.60. Eighty-four percent of all precipitation events are between 3.00-5.00.

Mt. Mansfield recorded substantially lower annual volume-weighted pH's in 1980,1981,1991 and 1992 (Table 1). In comparison with the other VAPMP sites, Mt Mansfield and Underhill have frequent low monthly volume-weighted means (Table 2).

Seasonal Variation

Summer volume-weighted means tend to be slightly lower than the winter volume-weighted means (Table 3). There does not appear to be a clear trend indicating that the summer means are consistently lower than winter means.

Spatial Variation

Mt.Mansfield, Underhill and Morrisville are located in too close a proximity to one another to determine any real spatial or elevational variation. However, Mt.Mansfield compared to these sites can be characterized as the lowest pH site.

DISCUSSION

The majority of bulk precipitation in Vermont is unquestionably acidic. Ninety-four percent of all precipitation events from 1980 to 1991 have a pH less than 5.60. The highest frequency of distribution observed was between the range of pH 4.20 and 4.40.

Mt. Mansfield recorded very low annual volume-weighted means in 1980,1981,1991 and 1992. It appears that there has been a slight decrease in the annual volume-weighted means starting in 1991 (Table 1).

Mt. Mansfield and Underhill have frequent low mean monthly pH's compared to the other VAPMP sites. There are two other sites located in West Dover and Canaan with slightly lower mean monthly pH's. However, most observed differences were not statistically significant ($p. < .05$) (Table 2).

In general, a lower pH is expected in the summertime due to increases in sunlight, temperature, humidity and photochemical oxidants which enhance the chemical transformation of sulfur dioxide (SO2) into sulfuric acid (H2SO4) (Allan and Mueller, 1985; Bowersox and Stensland, 1985).

Although the summer volume-weighted means tend to be slightly lower than the winter volume weighted means, there does not appear to be a clear trend indicating that the summer means are consistently lower than the winter means. In fact beginning in 1989 through 1993 it appears that the summer means are higher than the winter means. This pattern is

Table 1. Annual Volume-Weighted Mean pH for 2 Continuously Operating Sites

SITE	1980		1981		1982		1983		1984		1985		1986		1987		1988		1989		1990	
	Precip.	pH	Precip.	pH	Precip.	pH	Precip.	pH	Precip.	pH	Precip.	pH	Precip.	pH	Precip.	pH	Precip.	pH	Precip.	pH	Precip.	pH
Mt. Mansfield	26.06*	3.86	76.54	4.09	37.52	4.28	54.45	4.41	48.99	4.30	61.42	4.35	67.23	4.43	52.93	4.42	41.26	4.49	68.49	4.26	75.48	4.28
Underhill	Station Not Operating		Station Not Operating		Station Not Operating		35.39*	4.37	40.37	4.29	37.68	4.27	39.59	4.36	41.58	4.32	38.31	4.32	56.11	4.34	62.35	4.46

Table 1. (Continued)

SITE	1991		1992		1993	
	Precip.	pH	Precip.	pH	Precip.	pH
Mt. Mansfield	55.30	4.14	41.01	4.03	62.24	4.25
Underhill	35.88	4.41	32.31	4.46	35.68	4.29

Table 2. Monthly Volume-Weighted pH of Bulk Precipitation at 2 Continuous Sites for the Years 1984-1993.

SITE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Mt. Mansfield	4.27	4.26	4.36	4.42	4.38	4.41	4.37	4.24	4.31	4.26	4.43	4.30
Underhill	4.31	4.25	4.44	4.33	4.35	4.39	4.45	4.33	4.43	4.37	4.44	4.31

Table 3. Seasonal Volume-Weighted pH 1981-1993

Site	1981		1982		1983		1984		1985		1986		1987		1988		1989		1990		1991		1992		1993	
	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S
Mt. Mansfield	4.32	4.00	4.37	4.25	4.45	4.40	4.21	4.21	4.20	4.24	4.52	4.39	4.53	4.42	4.38	4.51	4.36	4.29	4.22	4.24	4.32	4.29	3.69	4.60	4.24	4.31
Underhill	ND	ND	ND	ND	ND	4.25	4.44	4.14	4.30	4.25	4.37	4.32	4.40	4.36	4.12	4.23	4.12	4.50	4.35	4.53	4.44	4.50	4.33	4.62	4.25	4.25

W = winter; S = summer; ND = no data

suggestive of possible changes in the seasonal distribution of precipitation pH occurring during the latter part of the 1980's. Although no conclusive data exists supporting the change in summer and winter pH, climatic changes could affect the pH. For example, in the past couple of years there may have been more rain than snow events than normal in the winter months, which would possibly have an effect on the recorded winter pH values.

There are several spatial relationships that have been hypothesized in regards to precipitation and pH in Vermont. 1) There is a decrease in pH with increasing elevation mainly due to acidic fog; 2) A lower pH is expected to occur in precipitation at sites west of the Green Mountains as a result of storm fronts moving west to east over the Green Mountains and depositing more acidic and concentrated pollutants as they rise and pass over the mountains (Scott,1987). Mt. Mansfield, Underhill and two other sites were chosen to evaluate the relationship between elevation and pH, and to compare the pH east and west of the Green Mountains. The sites located on Mt.Mansfield and in Underhill have similar mean monthly volume-weighted pH values, annual volume-weighted pH values, and seasonal volume-weighted pH values. Mt. Mansfield has a noticeably lower minimum annual volume-weighted pH than the other north central sites, possible due to the higher volumes of precipitation and the regularity with which the site is bathed in acidic fog.

FUTURE PLANS

Continued monitoring by the VAPMP and its dedicated volunteers will provide important information in evaluating the effects and uncertainties of the relationship between the Clean Air Act regulatory implementation and precipitation quality.

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MEASUREMENT OF ENVIRONMENTAL AND POLLUTANT GRADIENTS IN THE FOREST CANOPY

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Cooperators:

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ABSTRACT

From January to December 1993 meteorology data including temperature, relative humidity, wind speed and direction, and surface wetness were collected at five elevations (0.5, 7.5, 12, 16, and 24 m above the ground) and total solar irradiance, photosynthetically active radiation, and ultraviolet-B radiation were collected at 22 m only on the VMC research tower at the Proctor Maple Research Center (PMRC) in Underhill, VT . Ozone (O_3) concentrations were also monitored and recorded at each of these same five elevations. Examination of the O_3 data for 1993 revealed a similar pattern to that observed in 1992. Ozone concentrations generally increase with height, but the largest differences occurred between 0.5 m (just above the soil) and all other elevations with O_3 levels being lowest at 0.5 m. On average over the entire sampling season (late May-mid November), O_3 concentrations were 21% lower at 0.5 than at 24 m. This reduction in O_3 concentration just above the forest floor may result from inadequate mixing of air due to a boundry layer effect and lower air velocities at this level or the physical or chemical destruction of O_3. When number of hours of O_3 exposure at certain threshhold concentrations during June, July, and August were tabulated, it was found that the entire canopy (7.5, 12, and 16 m) was exposed to more than 300 hrs. at 60 ppb, a concentration that may cause injury to sensitive plants, and to at least 17 hrs. at 100 ppb or greater. Ozone concentration data for 1993 collected at the VT State air quality site (an open site typical of many official O_3 monitoring stations) at PMRC correlated well with data recorded at all five elevations on the VMC research tower, but compared most closely to the 7.5 m level.

INTRODUCTION

Collection of meteorological and ozone (O_3) data from five elevations on the VMC research tower located at the Proctor Maple Research Center (PMRC) in Underhill, VT continued throughout 1993. In addition to the temperature, relative humidity, wind speed and direction, surface wetness, total solar irradance, photosynthetically active radiation (PAR), and O_3 data collections begun in 1992, a broad-band ultraviolet-B (UV-B) pyranometer (Yankee Environmental Systems) was purchased and installed at 22 meters on the research tower in July 1993. The UV-B project will be discussed in a separate report.

Objectives

The goal of this research is to improve our knowledge of variation in canopy-atmosphere interactions within the forest canopy using the 22 m research tower, located in a mature hardwood stand, at the PMRC. At heights of 0.5, 7.5, 12, 16, and 24 m above the ground (from ground-level to above the canopy) we are:

1. monitoring ambient environmental conditions (meteorology and O_3) beneath, within, and above a northern hardwood forest canopy. Meteorological variables continuously measured and recorded as 15 minute means at all 5 heights include: temperature, relative humidity, wind speed and direction, and surface wetness. Variables continuously measured (recorded as 15 min. means) above the canopy (22 m) include: total solar irradiance (400-1100 nm), PAR (400-700 nm), and UV-B (290-320 nm).

2. quantifying canopy structure and canopy-light relationships by measuring leaf area distribution (leaf area index, LAI) and PAR.

3. testing the hypothesis that within-canopy O_3 concentration is a function of meteorology and canopy structure.

4. determining the relationship between O_3 concentrations measured in a typical open air quality site and those observed at different elevations in a forest canopy.

METHODS

Throughout 1993 meteorological variables including ambient temperature, relative humidity, windspeed and direction, and leaf surface wetness were continuously collected at five elevations alone a vertical gradient on the VMC research tower. Elevations sampled include: 0.5 meters (just above the soil surface), 7.5 meters (below the main canopy), 12 meters (within the canopy), 16 meters (top of the canopy), and 24 meters (ambient). Ozone concentrations in parts per billion (ppb) at each of these five elevations were also recorded from 25 May to 17 November. Total solar irradiance, PAR, and UV-B (starting on 25 July) data were collected only at the 22 meter level. All data were stored as 15 min averages by a Campbell Scientific 21X datalogger or directly to a computer. For further details about instrumentation, please see the 1992 VMC Annual Report.

An initial attempt was made examine the relationship between O_3 concentrations measured in open areas (most official ozone montoring sites are located in open sites) and those to which different portions of an adjacient forest canopy are exposed. To do this 1993 O_3 data from the VT State air quality site located at the PMRC were obtained from the AIRS network through the efforts of Rich Poirot. The VT State air quality site O_3 data were then correlated with those from the five heights on the research tower and also examined graphically.

In addition to O_3 and meteorological data collected on the research tower, LAI measurements using the LI-2000 (LICOR, Lincoln, NE) were continued in 1993. On 17 August measurements were taken at 0.5, 7.5, 12, and 16 m heights at an approx. 45^o angle from each corner of the tower and 0.5 m outside the structure of the tower. Despite some evidence of damage by pear thrips, LAI values in 1993 were very similar to those in 1992. Little progress was made in 1993 toward analysis of hemispherical photographs, Sunfleck Ceptometer (Decagon Devices, Pullman, WA) PAR attenuation data, or sight-obstruction data collected in 1992. We will continue to pursue the use of these variables in quantifying canopy structure.

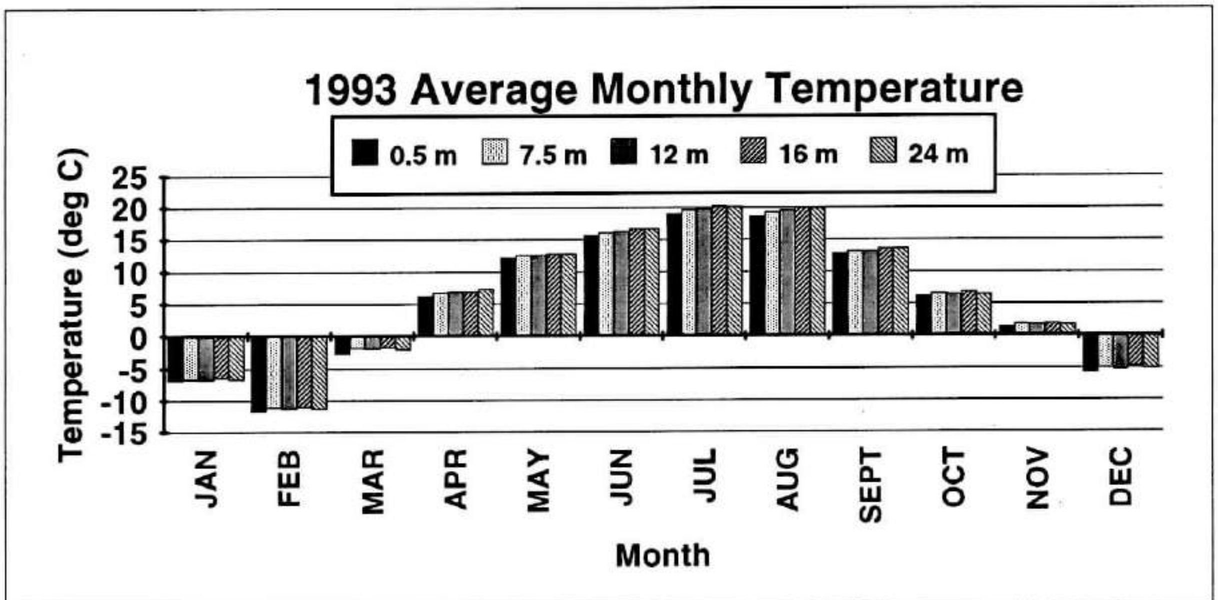
RESULTS

Meteorology. Meteorological data were collected from January to December 1993 at all five elevations on the research tower. The data are summarized in monthly files as 15 min., hourly, and daily averages and are available to VMC cooperators or other researchers in Microsoft Excel, Lotus 123, or ASCII formats. Figure 1 shows examples of some of the data summarized on a monthly basis to look at overall annual trends.

Ozone. Examination of O_3 concentrations during 1993 at all five elevations on the research tower revealed a similar pattern to 1992. Ozone concentrations generally increased with height and concentrations near the forest floor (0.5 m) were significantly lower than those at any other height during much of the sampling season (late May-mid November; Fig. 2). Concentrations of O_3 measured at the top of the reseach tower were significantly higher than those recorded at 12, 7.5, or 0.5 m, but not differerent from those at 16 m. No significant differences in O_3 concentration were found among the 7.5, 12, and 16 m levels. The largest differences in O_3 concentration that occurred between the 0.5 and 24 m heights exceeded 30 ppb. When averaged over the entire season, O_3 concentrations measured near the forest floor (0.5 m) were 21% lower than those recorded at the top of the tower.

We also looked at the total number of hours during June, July, and August that O_3 concentrations exceeded different thresholds (Fig. 3). For example, at 60 ppb, a concentration which may cause injury to certain sensitive plants, we found that while the forest floor was exposed for only 77 hours, all portions of the forest canopy (7.5, 12, and 16 m) received in excess of 300 hours, and the top of the tower saw over 400 hours of

Figure 1. Average and minimum monthly temperature, monthly surface wetness, and average monthly wind speed at five elevations (0.5, 7.5, 12, 16, and 24 m above the ground) along a vertical gradient and maximum monthly photosynthetically active radiation (PAR; 22 m only) on the VMC Research Tower at the Proctor Maple Research Center in Underhill, VT.



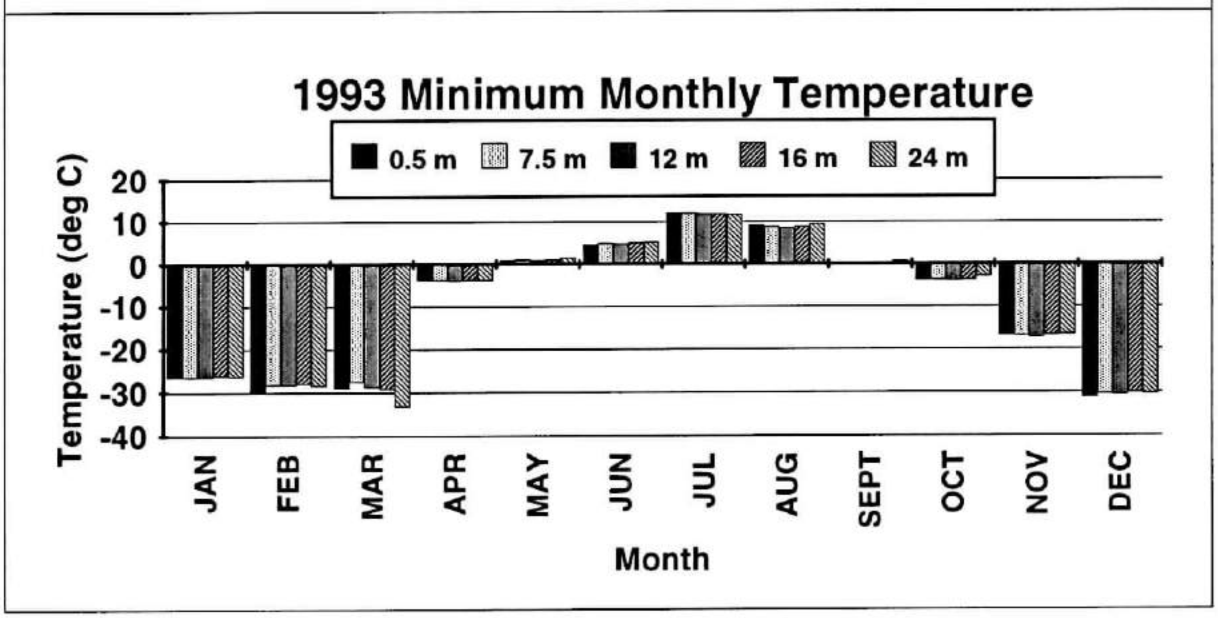
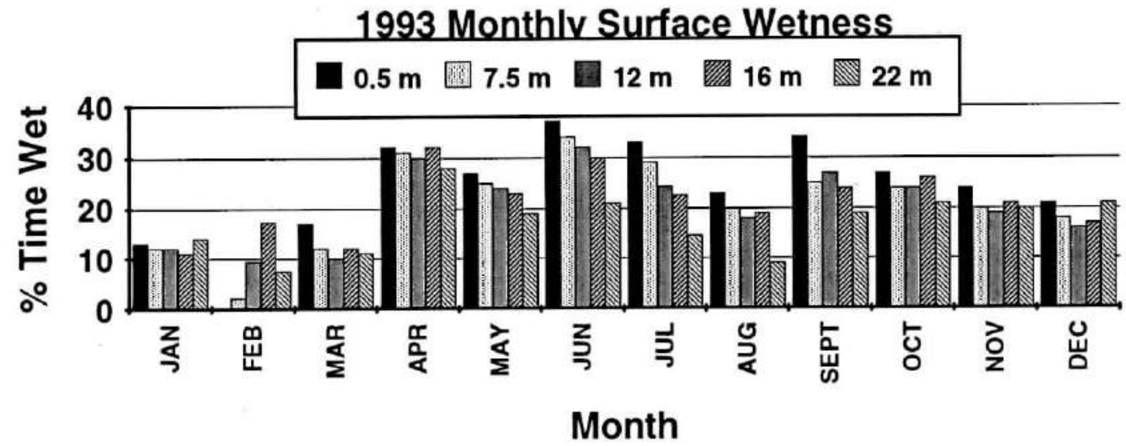
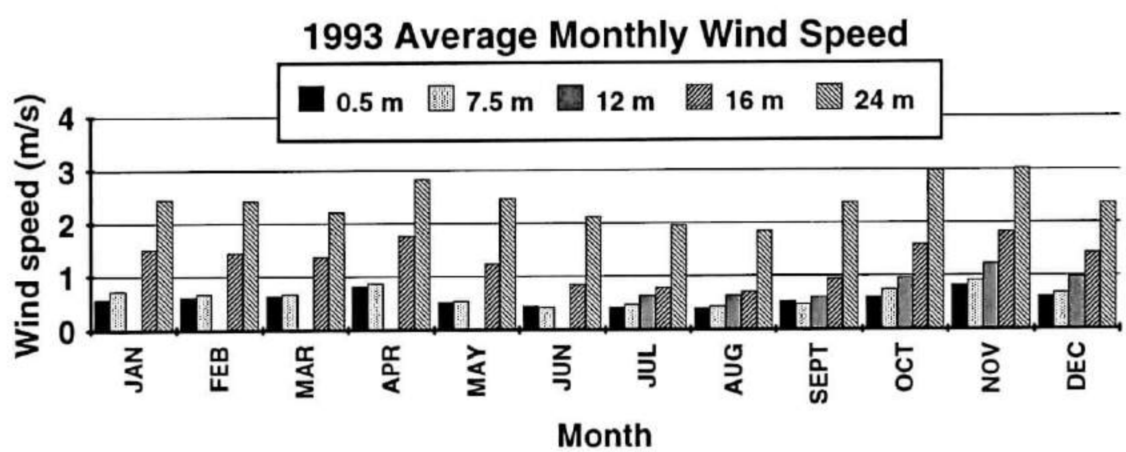
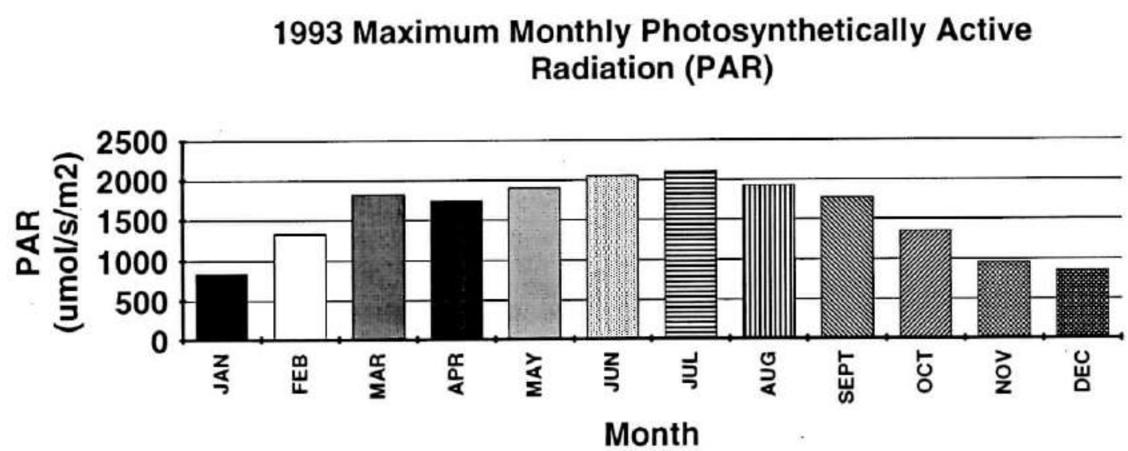


Figure 1. continued

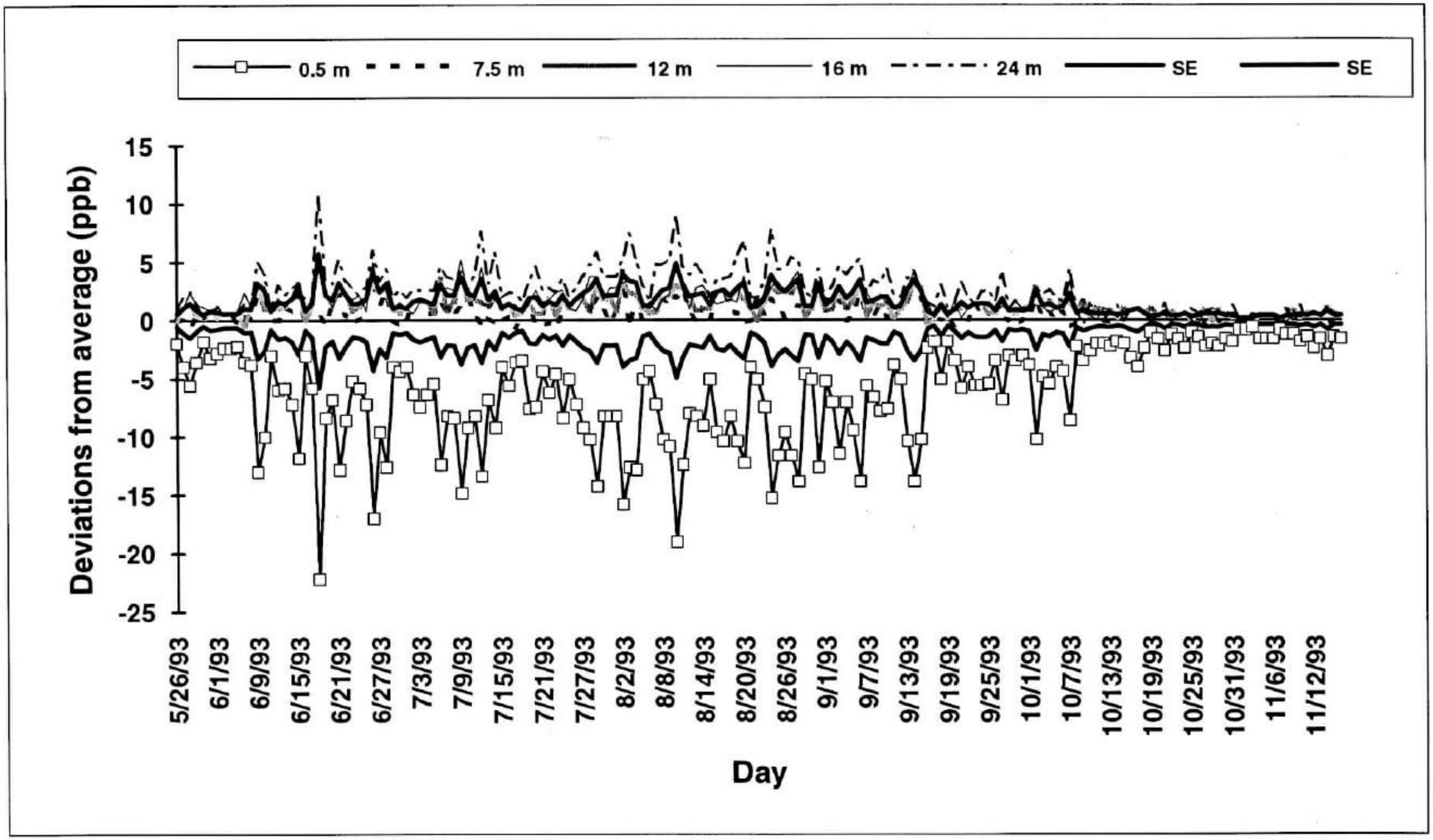






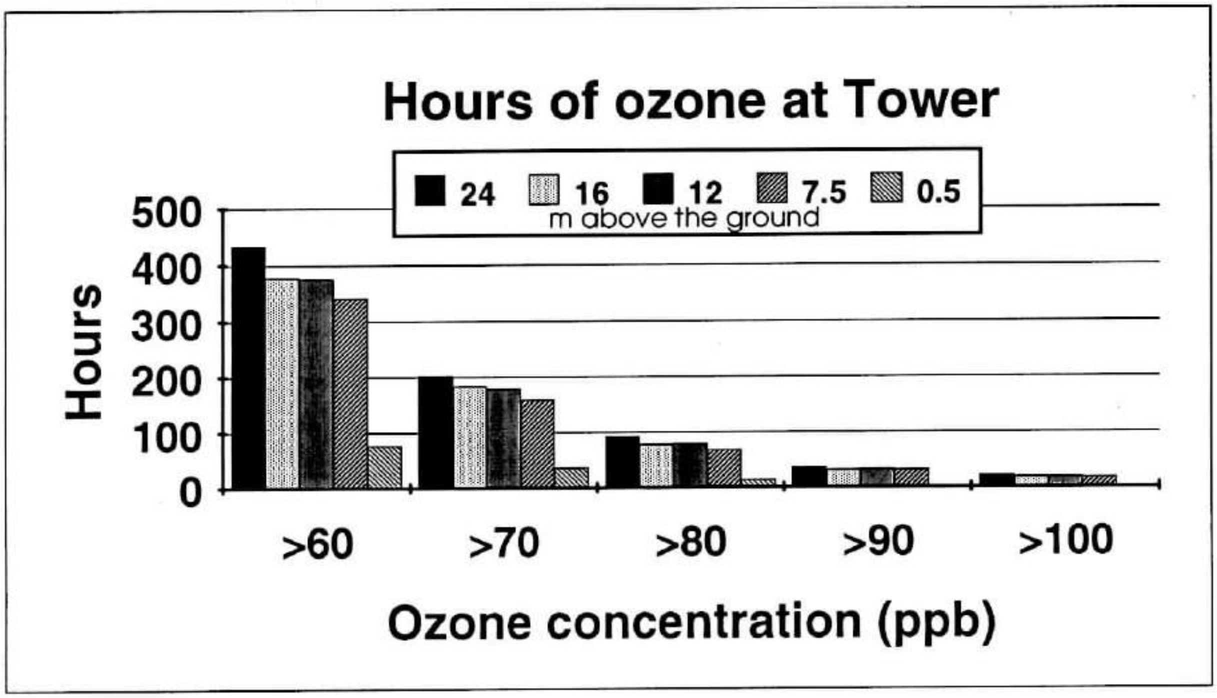
Note: No wind speed data were collected at 12 m from January through June.

Figure 2. Variation in 7-hour-average (9am-4pm) ozone concentration with height for 1993 measured at five elevations (0.5, 7.5, 12, 16, and 24 m above the ground) along a vertical gradient on the VMC Research Tower at the Proctor Maple Research Center in Underhill, VT and expressed as deviations from average ozone concentration for all five levels.



Note: A field site audit in September 1993 revealed that ozone concentrations recorded at the research tower were 7% higher on average than actual values. SE=standard error. The area inside the SE lines represents 2 SE's (+1 and -1 SE).

Figure 3. Number of hours during June, July, and August 1993 that maximum hourly ozone concentrations exceeded certain threshholds at five elevations (0.5, 7.5, 12, 16, and 24 m above the ground) along a vertical gradient on the VMC Research Tower at the Proctor Maple Research Center in Underhill, VT.



exposure at this concentration during the afore mentioned period. At 24 m, concentrations of O_3 of 100 ppb or greater were observed for 21 hours during these same three months and all portions of the canopy were exposed to this relatively high concentration for at least 17 hours.

A comparison of O_3 data from the VT State air quality site and the five heights on the research tower, from late May to the end of October, revealed that the VT State air quality data correlated well with all elevations on the tower, but corresponded most favorably ($r = 0.95$, 3492 df.) with data from the 7.5 m level. The 7.5 m height also coincides most closely to the relative height above the ground of the O_3 intake at the VT State air quality site. In mid-July and mid-October short periods (about 8 hrs. or less) of extremely low O_3 concentrations (<10 ppb) were noted at both the VT State air quality site and the VMC research tower. During these low O_3 episodes, measurements recorded at 0.5 m on the tower were identical in timing and very similar in magnitude to those noted at the VT State air quality site.

DISCUSSION

The patterns of significantly lower O_3 concentrations just above the forest floor (0.5 m) and generally increasing O_3 concentration with elevation on the tower, observed in 1992 and 93, are interesting. Ozone concentrations have been shown to increase with elevation, but this phenomenon has usually been observed along elevational gradients on mountains where monitoring stations are separated by several hundred or even thousands of meters in elevation (Lefohn, 1992). In many cases apparent increases in O_3 concentration associated with increasing elevation disappeared following corrections for differences in barometric pressure.

There are at least three plausible explanations for these lower O_3 concentrations near the soil surface. The first is lack of adequate air mixing near the forest floor due to a boundary layer effect and lower wind speeds. Both maximum and average wind speeds near the forest floor are substantially lower than at other heights on the tower. It is certainly possible that thorough mixing of air near the forest floor does not occur during the growing season. A second way that lower concentrations of O_3 might occur near the ground could be through either a physical or chemical break-down of O_3. The physical breakdown can occur simply through O_3 coming in direct contact with objects such as leaf surfaces, bark, or soil. Chemical break-down of O_3 in urban areas occurs in the presence of nitrogen oxides (NO_x) and is usually noted during evening hours. In rural areas, which may have lower levels of NO_x, a net loss of O_3 may result when ozone reacts with olefinic hydrocarbons such as propylene and isoprene (Chameides & Lodge, 1992). Low concentrations of NO_x, which allow O_3 to react with these olefinic hydrocarbons, can be important mechanisms for controlling O_3 photochemistry in low-NO_x environments (Chameides & Lodge, 1992). Finally, soil micro-organisms such as anaerobic bacteria may produce NO_x which reacts with O_3 resulting in chemical breakdown also known as "ozone scavenging". At the present time, we do not have equipment to measure concentrations of NO_x or olefinic hydrocarbons so their relative concentrations near the soil surface and possible role in reducing O_3 concentration at this level cannot be evaluated.

FUTURE PLANS

As in the past, this data will continue to be available upon request to VMC cooperators and other researchers. Collection of meteorology and O_3 data at the VMC research tower will continue through December 1994. At some point in the future, as funding permits, we hope to obtain wind instruments to measure wind speed and direction in three dimentions and calculate O_3 deposition at several heights using eddy correlation techniques.

FUNDING SOURCES

Support for this project comes from the UVM Research Advisory Council, the VMC, the U.S. Forest Service Northeastern Forest Experiment Station (cooperative agreement #23-758), the UVM School of Natural Resources (SNR), and the SNR McIntire-Stennis program.

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METEOROLOGICAL AND DEPOSITION CHEMISTRY MONITORING

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ABSTRACT:

Continuous monitoring of meteorology and wet and dry deposition chemistry has been conducted at the VMC Mansfield site. This work is a fundamental component of the monitoring and research activities there, providing basic information on the physical and chemical environment. Several projects are underway, including (a) basic meteorology at four locations, (b) four precipitation chemistry monitoring programs, and (c) a dry deposition monitoring program. Continuous hourly meteorology data from PMRC (400 m elevation) are available from 1988 to present, and daily temperature and precipitation data from the summit of Mt. Mansfield (1205 m) are available from 1954 to present. In addition, meteorology is monitored within the forest at the canopy research tower and the Nettle Brook gauging station; these are discussed elsewhere in the Annual Report. The National Atmospheric Deposition Program, operating at PMRC since 1984, provides weekly analysis of major ions in precipitation, while the Atmospheric Integrated Research Monitoring Network (AIRMoN), established in January 1993, provides similar data on a daily basis. In addition, atmospheric mercury monitoring in precipitation, gaseous and aerosol phases was established in 1993, and the Vermont Acid Precipitation Monitoring Program provides daily precipitation pH since 1980 (Mount Mansfield summit) and 1983 (PMRC); these projects are also discussed elsewhere in the Annual Report. Finally the Dry Deposition Inferential Measurement system, started mid year in 1992, provides weekly data on dry deposition of nitrogen (HNO_3 vapor) and sulfur (SO_2) compounds.

The main objective of the monitoring activities discussed here is to provide continuous environmental data to VMC cooperators and others. Little detailed assessment of patterns or trends in the data from these projects has been performed at this time, but the data are available from the VMC in various forms, including as Voyager files. (see report on Data Integration). Included in this report are representative data tables, graphs and Voyager views of the data. Also discussed here are plans for the future of these projects.

OBJECTIVES:
Continuous monitoring of meteorological variables and the chemistry of precipitation and dry deposition at several locations at the VMC Mansfield site.

METHODS:
Several monitoring stations and programs were operated at the VMC Mansfield site in Underhill in 1993:

1. Basic meteorology (continuous temperature, dew point, wind speed and direction, standard deviation of wind direction, and precipitation amount) is monitored at the air quality monitoring station at the VMC Mansfield site at the Proctor Maple Research Center (PMRC) at 400 m. elevation. This station has remote (modem) access and has been in continuous operation since June 1988. Data are updated continuously and are stored electronically and as hard copy. Data are available from the VMC as spreadsheets (Lotus, Excel), and in Voyager format. Station supervision is by Tim Scherbatskoy and operated by Joanne Cummings and Carl Waite. Additional meteorological data were collected at the forest canopy research tower and in the Stevensville Brook watershed; these are described in other reports.

2. The National Weather Service (NWS) under NOAA supervises a second weather station at the WCAX-TV transmitter station near the nose of Mt. Mansfield (1205 m), one of 45 NWS cooperative weather stations currently operating in Vermont. This station has monitored temperature (daily minimum, maximum and temperature at time of observation) and precipitation amount (daily rainfall, snowfall and snow depth on the ground) since 1954. Data are collected and stored by the National Climatic Data Center. The VMC does not directly support this station, but has access to the data for this station and all others in Vermont through the NWS. Data are now available from the VMC in Voyager format for the period 1954-1992, as part of the Vermont Coop Network meteorological database.

3. NADP/NTN (National Atmospheric Deposition Program/National Trends Network) maintains a site at the air quality monitoring station at PMRC (400m) for the weekly collection of precipitation for chemical analysis. Precipitation amount, pH and conductivity are measured locally, and the sample is then shipped to the NADP Central Analytical Laboratory in Illinois for analysis of pH, conductivity, Ca, K, Mg, Na, NH_4, NO_3, Cl, SO_4 and PO_4. This station has been operational since 1984, and is part of a national network of over 200 stations including one other in Vermont at Bennington. Data are available from the VMC in Voyager format or in other forms from the NADP Central Analytical Laboratory. The site supervisor is Tim Scherbatskoy, and the site operator is Joanne Cummings with cooperation from Sumner Williams at PMRC.

4. DDIM (Dry Deposition Inferential Measurement) program was started in August 1992 at the forest canopy research tower at the PMRC. This monitoring program uses filterpack technology to collect continuous weekly samples of dry deposition of sulfur (SO_2) and nitrogen (HNO_3 vapor), and also continuous meteorology including temperature, relative humidity, wind speed and direction, surface wetness and precipitation amount. The goal of this program is to measure atmospheric concentrations of these species and model their deposition rates. This station is one of 10 stations in the NOAA network in the eastern US; the data collected are comparable to other dry deposition monitoring programs in the US operated by the EPA. This equipment is located above the forest canopy at 22 m. on the forest research tower. Station operation is by Joanne Cummings with supervision by Tim Scherbatskoy. Filterpack and data analysis are conducted by NOAA, with data returned to the VMC quarterly.

5. AIRMoN (Atmospheric Integrated Research Monitoring Network) is an event based precipitation monitoring program established at the end of 1992 to provide high-resolution data on precipitation chemistry to support regional modeling efforts. There are 7 sites in the network, located in the northeastern US. Except for being an event based sampling program, it follows the protocol and measures the variables of the NADP/NTN described in (4) above; the sampler is located at the Air Quality site at PMRC (400 m). Station operation is by Joanne Cummings with supervision by Tim Scherbatskoy. The AIRMoN station was installed in December, 1992.

SIGNIFICANT FINDINGS:

No major analyses of trends and relationships in these projects have been completed at this time. The principle goal of these projects is to provide a high-quality, long-term database on meteorological and chemical deposition for use by VMC cooperators and others. Data are maintained as up-to-date as possible, and are generally available from the VMC in various forms. A major effort is underway to also make these data available as Voyager files (see the Data Integration Project). In addition, periodic reports are made available by the major sponsor of each program (e.g., NADP annual statistical summaries). Overviews, representative data, and/or data summaries are presented in the pages that follow.

1. Basic meteorology

Consolidation of the historic and current basic meteorology data from the VMC Mansfield site is completed, and consists of annual daily and hourly data for all variables. In addition, in 1993 routine quality assurance, maintenance and calibration programs were instituted. Monthly data summaries are produced routinely. These data are available in ASCII text files, spreadsheets, and Voyager workbooks. Table 1 consists of partial spreadsheets exhibiting the monthly means, maximums and minimum 1993 values for meteorological data at the Proctor Maple Research Lab.
Figure 1 displays graphic representation of temperature and precipitation data for 1993 at the PMRC.

Table 1: Basic Meteorology at PMRC; monthly mean, maximum and minimum values for 1993.

	MBP	MWD	SWD	MWS	XWS	XTMP	NTMP	MTMP	MTMP2	GDD	MDP	MRH	TRAIN
	mb	deg	deg	m/s	m/s	deg C	deg C	deg C	deg C	deg C	deg C	%	mm
JANUARY													
MEAN	956	209	33.43	1.96	3.42	-2.92	-11.59	-7.05	-7.14	0.60	-12.28	64.43	
MAX	973	307	53.40	3.90	6.20	11.70	1.40	5.80	5.80	5.80	1.60	78.10	15.00
MIN	935	124	23.40	0.90	1.40	-14.60	-26.40	-22.00	-20.50	0.00	-28.30	45.10	0.00
SUM										18.6			51.3
FEBRUARY													
MEAN	950	215	30.98	2.07	3.85	-6.90	-16.14	-11.55	-11.51	0.00	-18.02	56.70	
MAX	965	338	50.40	3.30	8.40	-1.20	-3.90	-3.00	-2.60	0.00	-7.90	78.30	15.50
MIN	929	110	21.80	1.30	2.40	-21.90	-28.40	-26.00	-25.10	0.00	-32.60	38.50	0.00
SUM										0			36.4
MARCH													
MEAN	948	207	33.24	1.95	3.31	1.70	-6.31	-2.10	-2.31	2.08	-10.21	53.33	
MAX	968	317	58.10	4.90	6.70	17.30	9.30	12.90	13.30	12.90	0.70	77.00	13.50
MIN	925	122	18.90	1.00	1.70	-14.40	-23.10	-18.20	-18.70	0.00	-26.30	26.00	0.00
SUM										64.4			43.9
APRIL													
MEAN	949	213	33.83	2.15	3.50	10.26	2.49	6.26	6.38	6.50	-2.73	55.62	
MAX	963	341	52.60	4.60	6.10	20.70	15.10	17.50	17.80	17.50	7.50	84.50	18.00
MIN	935	130	23.90	0.80	1.90	-1.00	-3.90	-3.00	-2.50	0.00	-10.3	22.9	0.00
SUM										195			109.5
MAY													
MEAN	950	201	33.61	2.02	3.54	16.30	8.40	12.31	12.35	12.31	3.14	55.39	
MAX	963	287	49.20	3.90	5.30	24.80	16.10	19.70	19.60	19.70	10.10	79.90	20.30
MIN	938	131	23.50	0.90	1.50	8.70	2.60	6.20	6.40	6.20	-3.10	31.50	0.00
SUM										418.4			91.1
JUNE													
MEAN	948	185	38.26	1.71	3.10	19.79	11.98	15.76	15.89	15.76	8.04	61.78	
MAX	956	291	52.80	2.90	5.20	27.90	17.30	22.30	22.60	22.30	14.90	79.40	16.80
MIN	939	123	29.10	1.00	1.80	10.60	5.10	8.40	8.50	8.40	0.50	37.60	0.00
SUM										472.9			97.8

1993 WEATHER DATA SUMMARY FOR PMRC AQ SITE - MONTHLY MEAN, MAXIMUM AND MINIMUM VALUES

	MBP mb	MWD deg	SWD deg	MWS m/s	XWS m/s	XTMP deg C	NTMP deg C	MTMP deg C	MTMP2 deg C	GDD deg C	MDP deg C	MRH %	TRAIN mm
	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
JULY													
MEAN	945	185	37.57	1.55	2.93	23.15	15.94	19.31	19.54	19.31	11.99	63.67	
MAX	954	300	55.60	2.50	4.90	29.80	22.90	25.70	25.70	25.70	17.30	77.70	33.00
MIN	936	126	28.30	1.10	1.80	13.70	11.60	12.70	12.90	12.70	7.40	47.70	0.00
SUM										598.5			127.2
AUGUST													
MEAN	959	158	36.98	1.40	2.49	22.90	15.17	18.72	19.04	18.72	12.63	69.35	
MAX	966	250	54.30	2.00	3.80	28.20	19.80	23.70	23.60	23.70	16.80	82.60	40.90
MIN	951	123	25.30	1.00	1.70	15.20	8.10	11.80	11.90	11.80	3.80	55.80	0.00
SUM										580.4			146.4
SEPTEMBER													
MEAN	957	181	39.63	1.65	2.85	16.31	8.73	12.51	12.52	12.51	7.36	71.89	
MAX	968	276	58.70	2.40	5.10	25.20	19.20	21.90	22.20	21.90	17.40	86.40	23.40
MIN	943	125	27.60	1.10	1.50	7.30	-0.60	2.30	3.30	2.40	-3.30	56.90	0.00
SUM										375.3			119
OCTOBER													
MEAN	955	195	32.60	2.21	3.61	9.57	2.30	5.88	5.93	6.00	-0.55	63.83	
MAX	968	306	46.60	4.00	6.10	19.90	10.30	14.20	15.10	14.20	8.00	87.00	19.80
MIN	942	121	22.20	1.20	1.80	0.90	-4.20	-1.20	-1.00	0.10	-7.20	46 10	0.00
SUM										186.1			101.4
NOVEMBER													
MEAN	961	201	30.42	2.25	3.75	4.91	-2.33	1.26	1.30	2.75	-5.15	63.32	
MAX	974	344	41.40	5.20	7.20	13.70	8.20	10.30	10.80	10.30	7.00	90.20	28.40
MIN	941	138	23.00	1.10	1.70	-7.10	-17.40	-11.90	-12.20	0.00	-21.90	19.30	0.00
SUM										82.5			83.8
DECEMBER													
MEAN	957	204	32.08	1.79	3.19	-2.26	-9.05	-5.62	-5.67	0.50	-10.52	67.83	
MAX	981	346	50.40	3.70	7.70	6.30	2.20	4.10	4.20	4.10	-0.40	94.30	25.40
MIN	937	141	20.00	0.90	1.50	-16.50	-30.40	-23.20	-23.50	0.00	-30.90	36.20	0.00
SUM										15.6			58.9

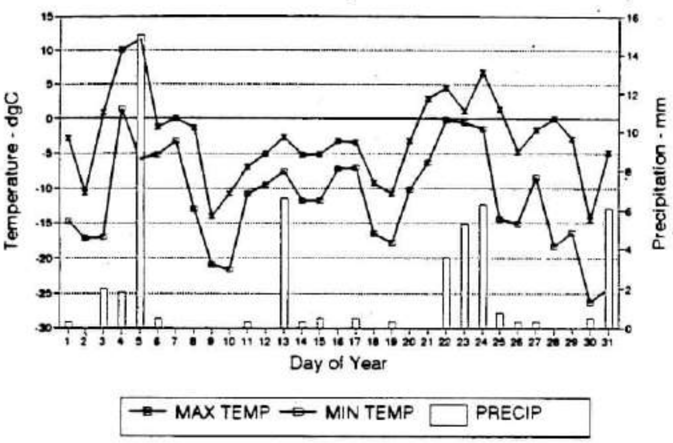
LEGEND

MBP = mean barometric pressure
MWD = mean wind direction
SWD = standard wind deviation
MWS = mean wind speed
XWS = maximum wind speed
XTEMP = maximum temperature
NTEMP = minimum temperature

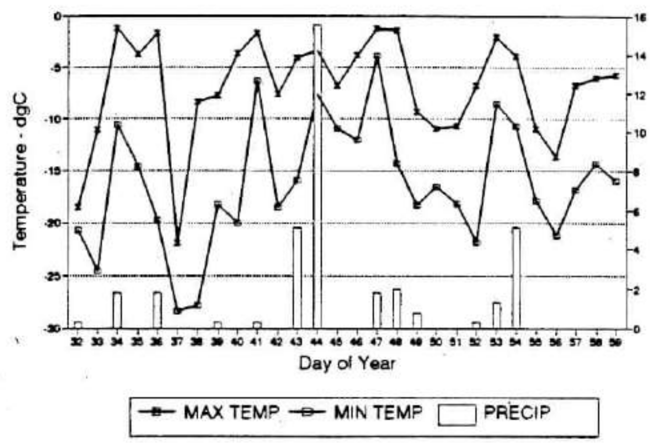
MTEMP = mean temperature (all values for day averaged)
MTEMP2 = mean temperature (max and min temp averaged)
GDD = growing degree day
MDP = mean dew point
MRH = mean relative humidity
TRAIN = total rain

Figure 1: PMRC Monthly temperature and precipitation data for 1993

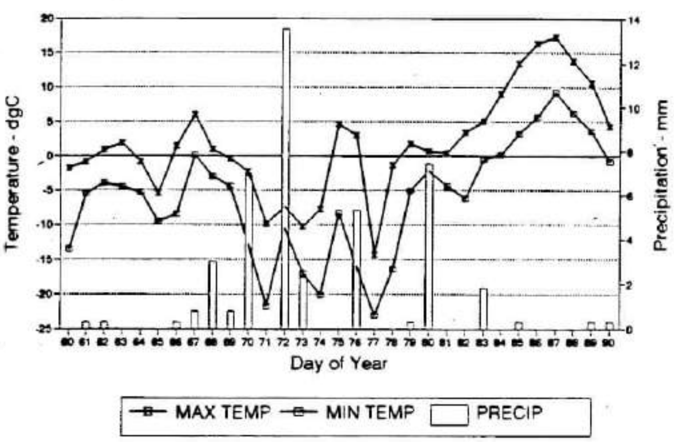
MEAN DAILY TEMPERATURE & PRECIPITATION
PMRC - JANUARY 1993



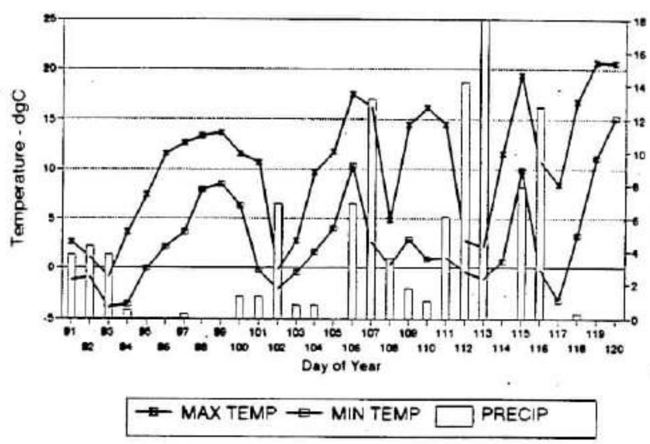
MEAN DAILY TEMPERATURE & PRECIPITATION
PMRC - FEBRUARY 1993



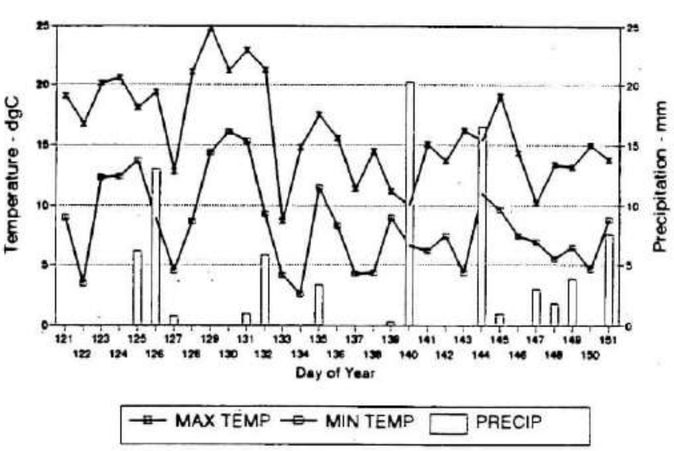
MEAN DAILY TEMPERATURE & PRECIPITATION
PMRC - MARCH 1993



MEAN DAILY TEMPERATURE & PRECIPITATION
PMRC - APRIL 1993



MEAN DAILY TEMPERATURE & PRECIPITATION
PMRC - MAY 1993



MEAN DAILY TEMPERATURE & PRECIPITATION
PMRC - JUNE 1993

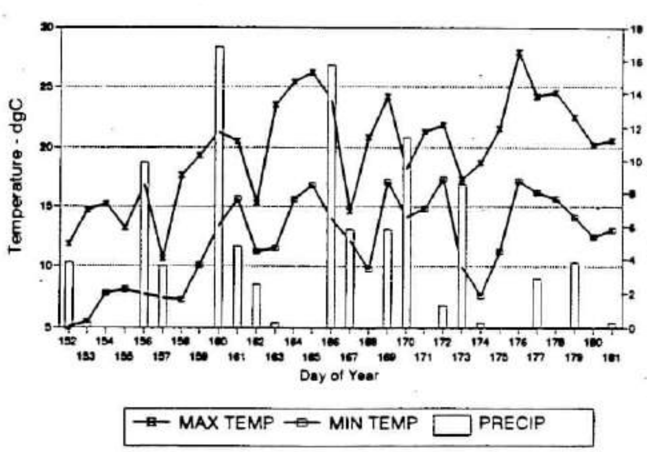
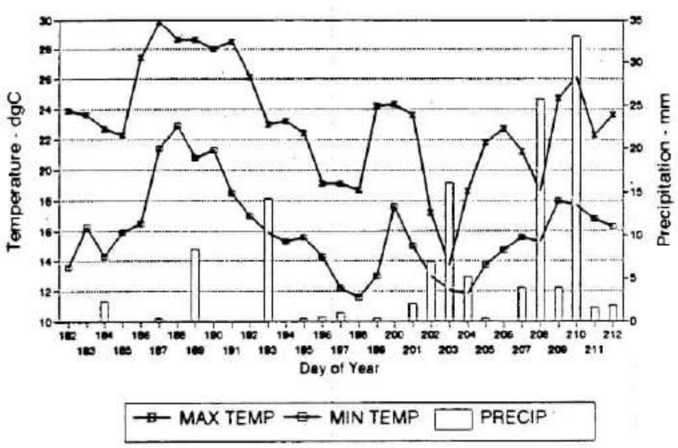
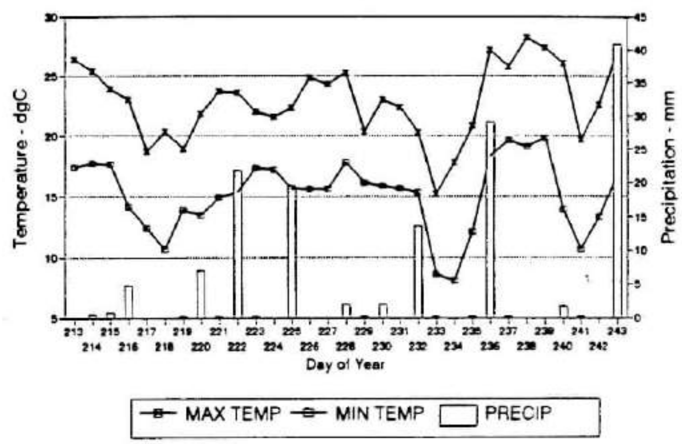


Figure 1: PMRC Monthly temperature and precipitation data for 1993

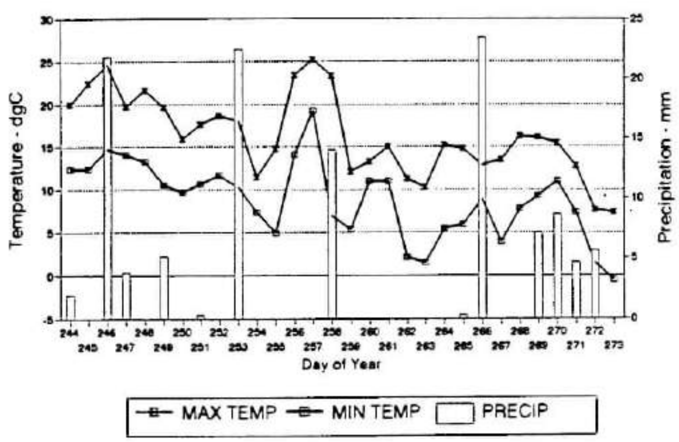
MEAN DAILY TEMPERATURE & PRECIPITATION
PMRC - JULY 1993



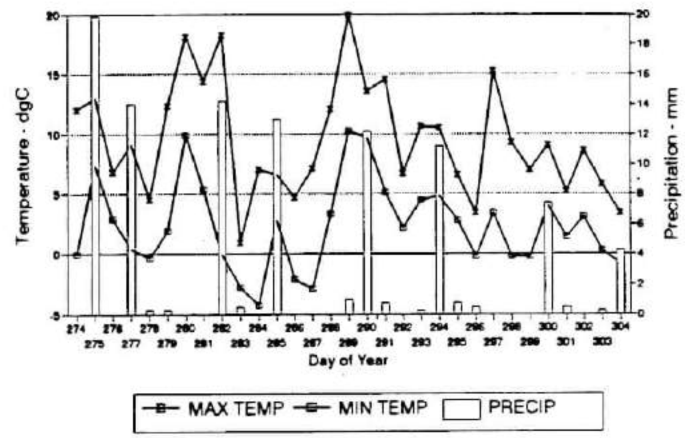
MEAN DAILY TEMPERATURE & PRECIPITATION
PMRC - AUGUST 1993



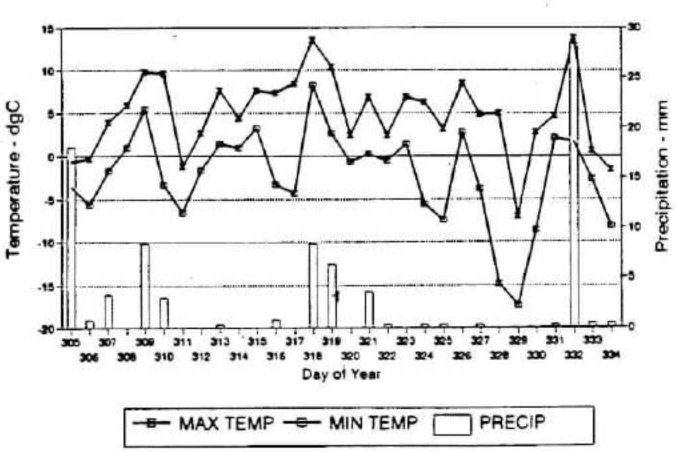
MEAN DAILY TEMPERATURE & PRECIPITATION
PMRC - SEPTEMBER 1993



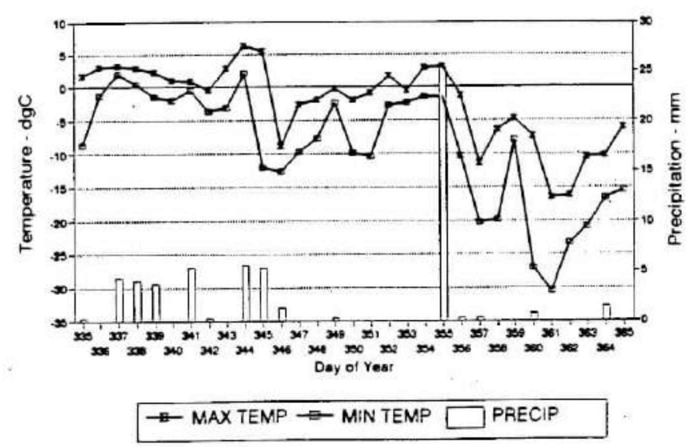
MEAN DAILY TEMPERATURE & PRECIPITATION
PMRC - OCTOBER 1993



MEAN DAILY TEMPERATURE & PRECIPITATION
PMRC - NOVEMBER 1993



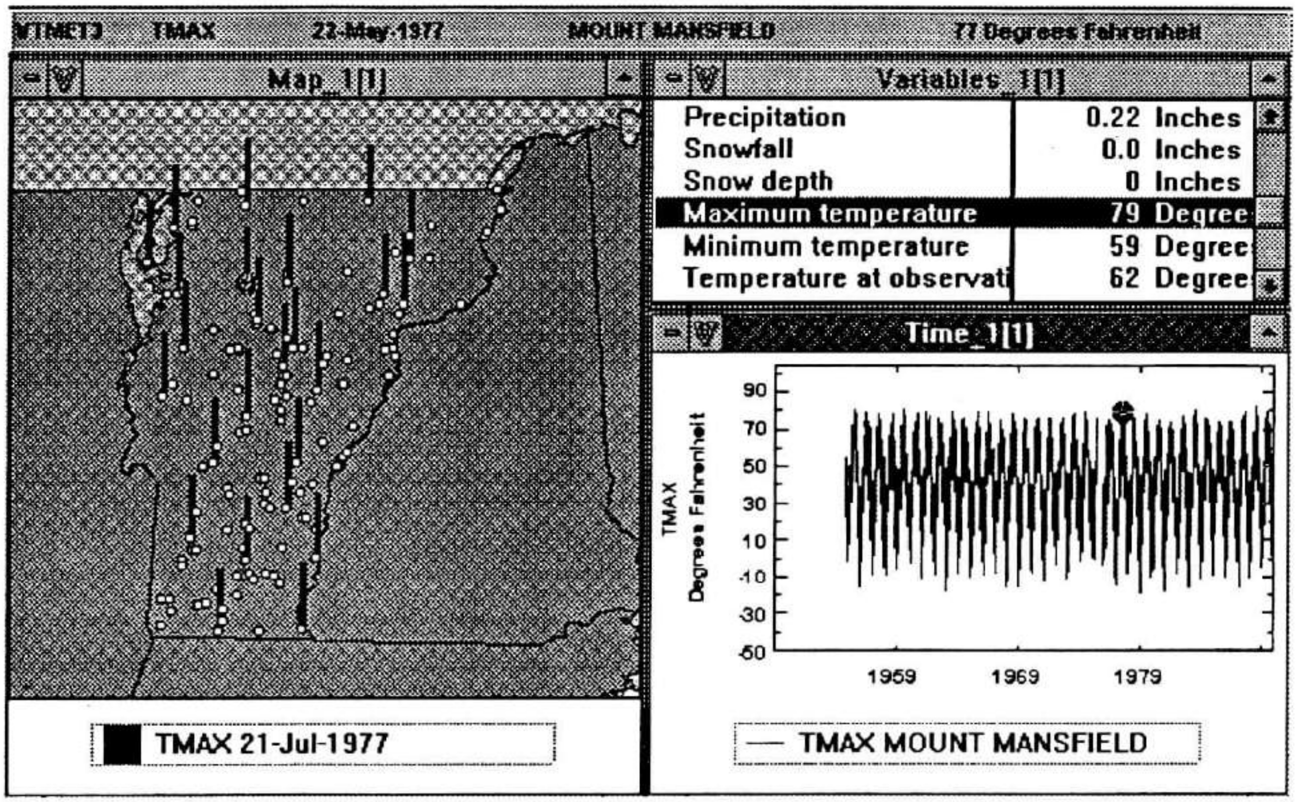
MEAN DAILY TEMPERATURE & PRECIPITATION
PMRC -DECEMBER 1993



2. National Weather Service data

Due to the time lag in obtaining data from the National Climatic Data Center, the 1993 data from the Mt. Mansfield weather station will not be available until May 1994. Current data is complete through 1992. Representative data, as a Voyager view, are shown in Figure 2.

Figure 2: NWS Cooperating stations in Vermont: Voyager view showing the Vermont map view and a time view for the Mt. Mansfield summit weather station.



VERMONT METEOROLOGICAL DATA

Contributors: National Weather Service
Compiled: October 10, 1993 by Don Hay, Carl Slenk and Ian Martin

This data set contains daily weather data from all National Weather Service cooperating weather stations in Vermont for their entire period of record. The most recent data available is through December 1990, at which time there were 45 active stations. Due to the large size of this database, it is only available as a Voyager file and workbook, or as an ASCII file of variable (40 Mb) or fixed (90 Mb) length records. The only known problem with these data may be an erroneous extreme value (easy to identify) for at least one station for temperature (e.g., 500 deg F) and precipitation (e.g., 1,000 inches).

Variables: Daily precipitation amount (inches), snowfall (inches), snow-depth (inches), maximum, minimum and time-of-observation temperature (deg. F), and numerous categories of weather conditions (sleet, blowing snow, lightning, dust, etc.).

3. National Atmospheric Deposition/National Trends Network

Data from the NADP station are available for each 2-month period, and as a semi-annual summary from the site supervisor; data is also available for the entire network as an annual and seasonal data summary from NADP; the last annual data summary is for 1992. Representative data, as shown in the semi-annual report, are contained in Table 2, and as a Voyager view in Figure 3.

Table 2: NADP/NTN Semi-annual summary statistics - 1/93 to 6/93

NADP/NTN PRECIPITATION CHEMISTRY — January - June 1993

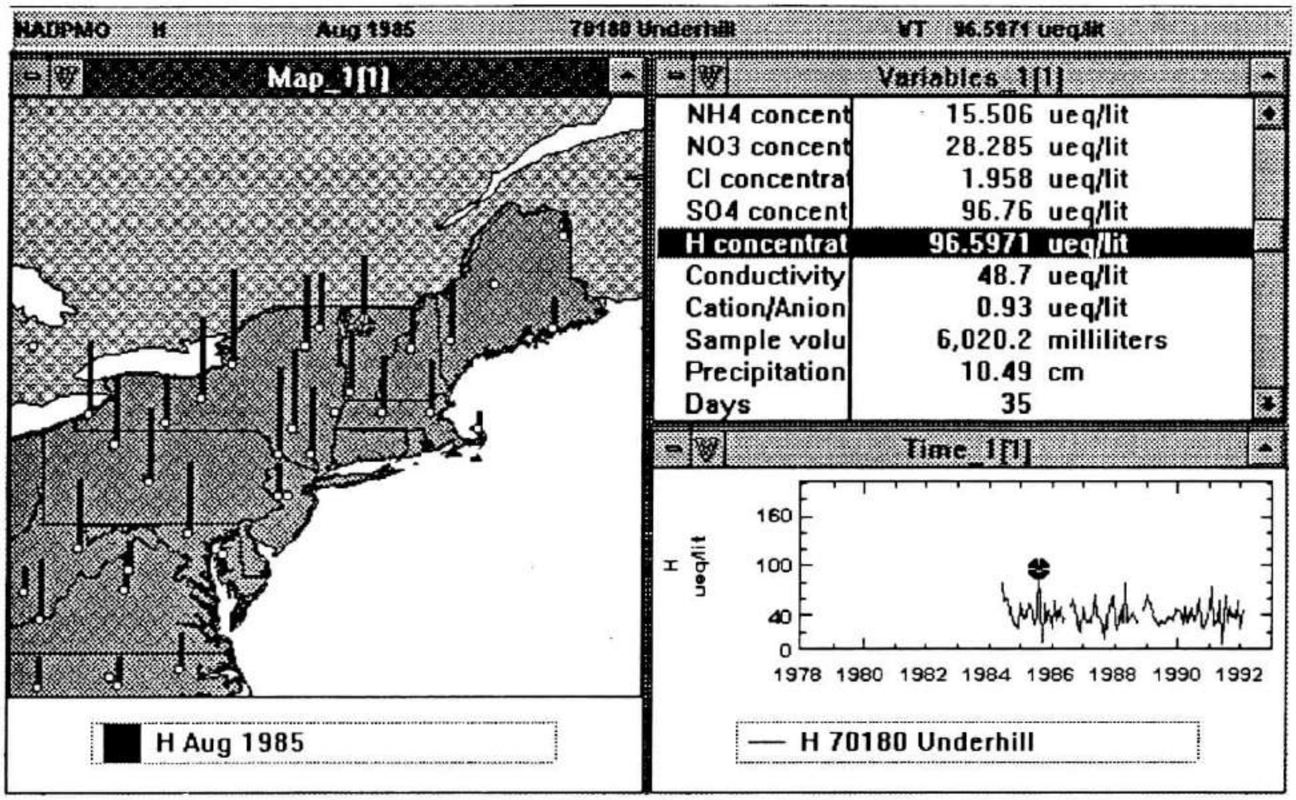
Site: Underhill — Site No. 470180 — CAL Code VT99
Operation: SAES-University of Vermont/USGS — Funding USGS — Printed Jan 31, 1994

Date On modayr	Date Off modayr	Days	pH Lab	pH Field	pH FV	pH Check	Conductivity Lab (uS/cm)	Conductivity Field (uS/cm)	Conductivity FV	Conductivity Check (uS/cm)	Collector Vol L	Collector Depth cm	Rain gage cm	Sub ppt cm	Coll Eff	Lab type	Lab qa	Notes	Time On GMT	Time Off GMT	Obs	Summary Periods yrmo	Summary Periods yrq
122992	010593	7	4.44	4.38	i	4.32	19.1	19.0	f	15.0	1.707	2.51	3.50	3.50	0.72	w			1346	1345	jcc	9301	931
010593	011293	7	4.79	4.69	f	4.29	8.9	6.0	f	19.0	0.361	0.53	0.48	0.48	1.10	w			1346	1400	jcc	9301	931
011293	011993	7	4.51	4.45	p	4.31	14.1	15.0	p	19.0	0.549	0.81	1.32	1.32	0.61	w			1405	1340	jcc	9301	931
011993	012693	7	4.38	4.31	p	4.30	20.8	19.0	p	21.0	1.000	1.47	1.68	1.68	0.88	w			1345	1355	jcc	9301	931
012693	020293	7	4.67	4.57	p	4.31	11.3	10.0	p	20.0	0.637	0.94	1.42	1.42	0.66	w			1355	1400	jcc	9301	931
020293	020993	7	4.29	4.18	p	4.29	37.4	41.0	p	20.0	0.176	0.26	0.76	0.76	0.34	w			1400	1400	jcc	9302	931
020993	021693	7	5.25	5.08	p	4.30	3.2	3.2	p	24.0	1.356	2.00	2.64	2.64	0.76	w			1400	1405	jcc	9302	931
021693	022393	7	4.04	4.02	p	4.29	41.4	50.0	p	21.0	0.493	0.73	1.58	1.58	0.46	w			1405	1410	jcc	9302	931
022393	030293	7	4.10	4.09	p	4.31	38.9	37.0	p	19.0	0.122	0.18	0.28	0.28	0.64	w			1410	1400	jcc	9302	931
030293	030993	7	3.91	3.86	p	4.28	60.6	66.0	p	21.0	0.188	0.28	0.48	0.48	0.57	w			1400	1405	jcc	9303	932
030993	031693	7	4.12	4.08	p	4.29	36.8	41.0	p	21.0	0.226	0.33	3.86	3.86	0.09	w			1405	1405	jcc	9303	932
031693	032393	7	4.29	4.25	p	4.29	23.5	28.0	p	21.0	0.555	0.82	1.32	1.32	0.62	w			1405	1355	jcc	9303	932
032393	033093	7	4.65	4.36	p	4.29	14.3	20.0	p	21.0	0.072	0.11	0.15	0.15	0.70	w			1355	1400	jcc	9303	932
033093	040693	7	4.51	4.45	p	4.28	15.3	16.0	p	21.0	0.630	0.93	1.50	1.50	0.62	w			1400	1300	jcc	9304	932
040693	041393	7	4.94	4.72	p	4.27	8.1	9.0	p	21.0	0.270	0.40	0.79	0.79	0.50	w			1300	1600	jcc	9304	932
041393	042093	7	4.39	4.34	p	4.28	21.7	21.0	p	21.0	1.672	2.46	2.51	2.51	0.98	w			1600	1310	jcc	9304	932
042093	042793	7	4.36	4.30	p	4.29	23.8	26.0	p	21.0	3.838	5.65	--	5.65	--	w			1310	1300	jcc	9304	932
042793	050493	7	--	--	-	--	--	--	-	--	0.	0.	0.	0.	--	da	f	ns	1300	1300	jcc	9304	932
050493	051193	7	4.49	4.47	p	4.29	18.2	18.0	p	20.0	1.265	1.86	1.85	1.85	1.00	w			1300	1315	jcc	9305	932
051193	051893	7	--	--	f	4.28	--	--	f	21.0	0.679	1.00	0.94	0.94	1.07	w	c	ns	1315	1315	jcc	9305	932
051893	052593	7	4.39	4.29	p	4.29	20.5	23.0	p	20.0	2.486	3.66	3.63	3.63	1.01	w			1315	1315	jcc	9305	932
052593	060193	7	4.42	4.31	p	4.28	23.8	22.0	p	20.0	1.194	1.76	1.85	1.85	0.95	w			1315	1305	jcc	9305	932
060193	060893	7	4.71	4.62	p	4.29	9.2	9.0	p	21.9	0.915	1.35	1.45	1.45	0.93	w			1305	1325	jcc	9306	933
060893	061593	7	4.49	4.52	p	4.27	18.9	18.0	p	21.0	1.568	2.31	2.39	2.39	0.97	w			1325	1310	jcc	9306	933
061593	062293	7	--	--	f	4.28	--	--	f	21.0	2.658	3.91	4.04	4.04	0.97	w	c	ns	1310	1325	jcc	9306	933
062293	062993	7	4.16	4.14	p	4.29	35.8	39.0	p	21.0	0.886	1.31	1.27	1.27	1.03	w			1325	1315	jcc	9306	933

Date On	Date Off	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	NH4 (mg/L)	NO3 (mg/L)	Cl (mg/L)	SO4 (mg/L)	PO4 (mg/L)	H (lab) (mg/L)	Cation (ueq/L)	Anion (ueq/L)	Ratio c/a
122992	010593	0.02	0.013	0.004	0.097	0.09	1.23	0.15	1.46	<0.020	3.63e-2	47.69	54.48	0.88
010593	011293	0.08	0.010	<0.003	0.025	0.10	0.92	0.04	0.81	<0.020	1.62e-2	27.70	32.84	0.84
011293	011993	0.03	0.004	<0.003	0.020	0.05	1.94	0.05	0.46	<0.020	3.09e-2	36.41	42.28	0.86
011993	012693	0.01	0.006	0.010	0.028	0.12	2.32	0.05	1.05	0.020	4.17e-2	50.81	60.70	0.84
012693	020293	0.04	0.008	0.004	0.025	0.09	1.67	0.08	0.28	<0.020	2.14e-2	30.21	35.03	0.86
020293	020993	0.14	0.024	0.020	0.186	0.70	5.91	0.31	1.64	<0.020	5.13e-2	107.66	138.23	0.78
020993	021693	0.01	0.005	<0.003	0.018	<0.02	0.26	0.06	0.21	<0.020	5.62e-3	7.91	10.26	0.77
021693	022393	0.03	0.004	0.005	0.042	0.13	5.15	0.10	1.17	<0.020	9.12e-2	102.19	110.26	0.93
022393	030293	0.03	0.009	0.009	0.058	0.20	4.35	0.14	1.34	<0.020	7.94e-2	95.51	102.03	0.94
030293	030993	0.07	0.017	0.018	0.081	0.64	6.46	0.13	3.71	<0.020	1.23e-1	167.38	185.15	0.90
030993	031693	0.13	0.022	0.019	0.109	0.26	4.38	0.15	1.68	<0.020	7.59e-2	103.80	109.88	0.94
031693	032393	0.02	0.006	0.004	0.041	0.08	2.82	0.11	0.74	<0.020	5.13e-2	59.10	64.00	0.92
032393	033093	0.08	0.014	0.006	0.037	0.11	1.02	0.11	1.45	<0.020	2.24e-2	35.39	49.76	0.71
033093	040693	0.02	0.008	0.005	0.054	0.20	1.10	0.08	1.24	<0.020	3.09e-2	46.12	45.83	1.01
040693	041393	0.05	0.027	0.024	0.144	0.07	0.81	0.25	0.62	<0.020	1.15e-2	26.96	33.03	0.82
041393	042093	0.11	0.027	0.016	0.108	0.30	1.76	0.17	1.91	<0.020	4.07e-2	70.19	72.97	0.96
042093	042793	0.13	0.026	0.013	0.078	0.31	1.57	0.11	2.15	<0.020	4.37e-2	73.19	73.21	1.00
042793	050493	--	--	--	--	--	--	--	--	--	--	--	--	--
050493	051193	0.10	0.023	0.018	0.088	0.32	1.40	0.16	1.64	<0.020	3.24e-2	61.27	61.26	1.00
051193	051893	--	--	--	--	--	--	--	--	--	--	--	--	--
051893	052593	0.05	0.009	0.007	0.012	0.22	1.04	0.04	2.09	<0.020	4.07e-2	56.87	61.44	0.93
052593	060193	0.12	0.022	0.040	0.016	0.38	1.72	0.06	2.24	<0.020	3.80e-2	68.60	76.10	0.90
060193	060893	0.03	0.007	0.019	0.013	0.04	0.72	0.04	0.67	<0.020	1.95e-2	24.84	26.70	0.93
060893	061593	0.10	0.017	0.024	0.035	0.37	1.13	0.07	2.05	<0.020	3.24e-2	61.40	62.90	0.98
061593	062293	--	--	--	--	--	--	--	--	--	--	--	--	--
062293	062993	0.12	0.018	0.028	0.041	0.54	1.67	0.09	3.86	<0.020	6.92e-2	109.09	109.88	0.99

-- Indicates missing data

Figure 3: NADP program data: Voyager view showing map view for the eastern United States and a time view of data for the VMC station in Underhill.



NADP PRECIPITATION CHEMISTRY AVERAGES

Contributors: National Atmospheric Deposition Program / National Trends Network
Compiled: September 11, 1992 by Lantern Corp.

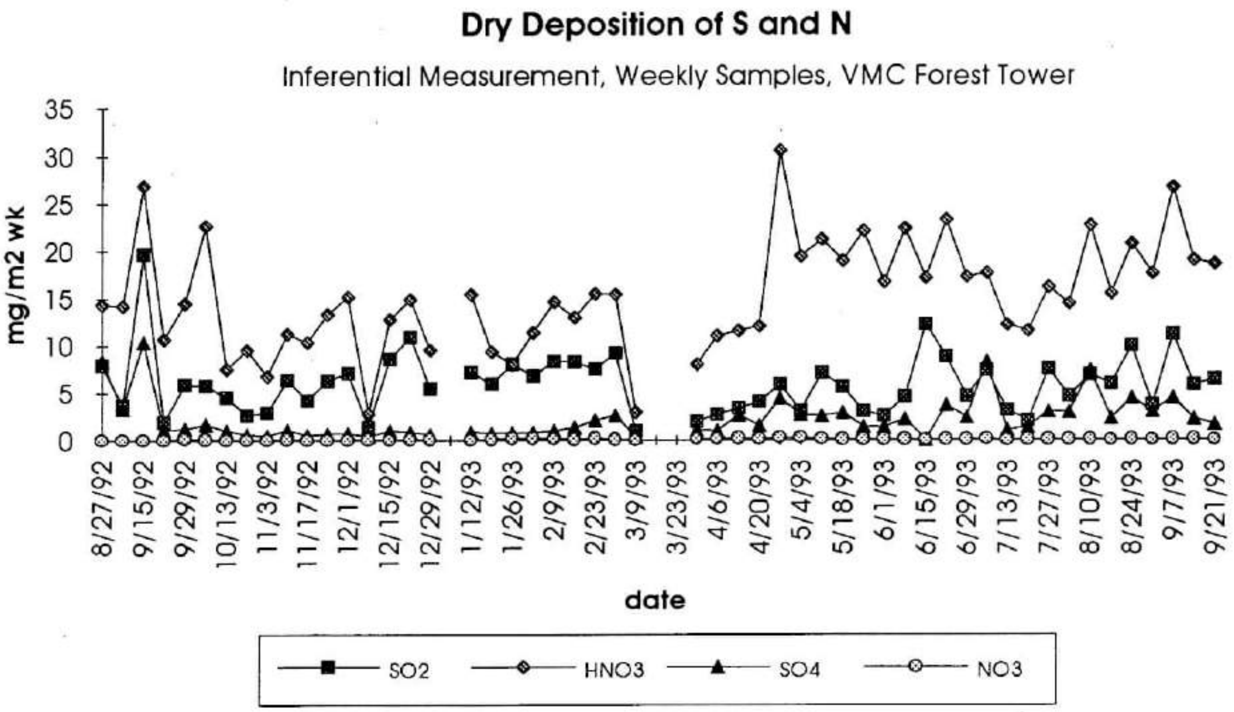
This data set contains monthly averaged data from all U.S. NADP/NTN stations (206 sites in 47 states) from July 1978 through February 1992. There may be in the data at least one erroneous very extreme (easy to identify as erroneous) value for some variables; there are no other known problems.

Variables: Ca, Mg, K, Na, NH4, NO3, Cl, SO4, H, conductivity, cation/anion ratio, volume, precip amount, # days, # valid samples, date on, date off, and data completeness.

4. Dry Deposition Inferential Measurement System

All meteorological data (on tape) and filter packs are sent to NOAA-ATDD weekly. Data are generally returned to the VMC quarterly, although this was slow in occurring in 1993. Quality assurance checks of monitoring equipment on the tower are made weekly, and an annual site audit is done by NOAA-ATDD staff. Missing meteorological data (due to equipment malfunction) can be supplied from the VMC meteorological measurements also taken at the tip of the tower. A summary of the modeled deposition flux data is currently available and presented in Figure 4.

Figure 4: DDIM station dry deposition data in graphic form



5. Atmospheric Inferential Research Monitoring Network

Data reports are now being generated for this project and are available through the NADP/AIRMoN network. Table 3 displays a portion of this summary for 1993.

Table 3: AIRMoN program data: representative data for a portion of 1993 (May - June)

PRELIMINARY PRINTOUT NADP/AIRMoN CENTRAL ANALYTICAL LABORATORY - ILLINOIS STATE WATER SURVEY
DATE: 03/18/94

SAMPLE ID	LAB TYPE	DATE ON	TIME ON	DATE OFF	TIME OFF	CA	MG	K	NA	NH4	NO3	CL	SO4	PO4	FIELD COND. (MICROMHOS/CM)	LAB COND. (MICROMHOS/CM)	FIELD PH	LAB PH
						CONCENTRATIONS(MICROEQUIVALENTS/LITER)												
AA0658L	VT99 W	051993	1005	052093	0930	.50	.08	.10	.13	3.3	10.5	.8	15.6	.00	10.0	10.6	4.58	4.62
AA0659L	VT99 W	052093	0930	052193	0915	.65	.33	.10	.17	12.8	11.5	.6	29.4	.00	14.0	14.8	4.50	4.51
AA0660L	VT99 W	052193	0915	052593	0925	3.69	1.32	.28	.26	16.1	23.2	1.7	62.1	.00	35.0	32.4	4.20	4.15
AA0672L	VT99 W	052593	0925	052893	0905	17.32	4.36	1.07	1.04	33.8	36.3	2.0	53.9	.00	26.0	25.1	4.37	4.42
AA0673L	VT99 W	052893	0905	052993	0910	6.29	1.40	1.30	2.17	61.0	63.1	4.5	98.1	.00	54.0	54.3	4.05	4.01
AA0674L	VT99 W	052993	0910	053093	0915	10.98	3.87	2.40	1.48	24.9	9.2	2.5	14.8	.00	7.0	6.7	5.30	5.80
AA0675L	VT99 W	053093	0915	060193	0920	2.05	.66	1.02	.39	6.7	13.9	1.1	24.8	.00	19.0	19.2	4.42	4.42
AA0688L	VT99 W	060193	0920	060293	0920	1.90	.58	.77	.91	8.3	4.2	1.4	18.7	.00	6.0	8.4	4.80	4.81
AA0689L	VT99 W	060293	0920	060693	0915	1.05	.25	.59	.52	4.4	13.2	1.1	14.2	.00	10.0	11.5	4.55	4.61

FUNDING:

1. Basic meteorology: The weather station is maintained with funds from the VMC base budget, the University of Vermont, and the VT Dept. of Environmental Conservation (DEC); this amounts to approximately $2,500 for utilities, maintenance and data management. During its first two years this station was funded and operated by EPRI as part of the Operational Evaluation Network.

2. National Weather Service: Data collection and station operations are supported by the NOAA National Weather Service and WCAX-TV. VMC activity and funding was used for initial acquisition of the data (approximately $600) and data processing (approximately $1,500). Involvement of University students seeking research experience has reduced costs of data management. Access to future updates of the data is anticipated to be provided at no charge by the Vermont State Climatologist.

3. NADP/NTN: The overall program is funded by several federal agencies; operation of the VMC station is supported by the US Geological Survey ($3,700). Chemical analysis and data management are supported by the USGS, at a cost of about $5,000 per year.

4. DDIM: The overall program as well as the VMC station at the forest research tower is supported by the National Oceanic and Atmospheric Administration (NOAA). Site operations and logistical support cost about $1,000 per year; data management, sampling equipment and chemical analysis are paid for by NOAA at a cost of $10,000 per year.

5. AIRMoN: This program is also supported by NOAA. Annual costs for analysis and coordination for the VMC station in the network are about $22,000 for operation, plus $4,000 for local field technical and logistical support.

FUTURE PLANS:

All of these stations will continue to operate in 1994. Updates for the Mt. Mansfield weather station (as well as all other National Weather Service Vermont stations) will be obtained in May of 1994.

The State of Vermont Air Pollution Control Division will be adding a station at the Proctor Maple Research Center. The PMRC field station will continue operation for at least one year as a calibration for the APCD station, and while we work out plans for data acquisition through APCD.

The VMC will purchase NOAA data from the summit station on Mt. Mansfield to update our data (1991 - 1993). Tim Scherbatskoy will acquire and format the data. This will become part of the complete VT meteorological database containing data for all cooperative NWS stations, through 1993, formatted for Voyager.

The VMC Data Manager (new position, starting in June 1994), will receive processed data from all VMC meteorologicaL stations to reformat for VMC and individuals user's needs.

SOIL TEMPERATURE GRADIENTS IN A NORTHERN HARDWOOD FOREST

Carl Waite and Tim Scherbatskoy
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Cooperators:

Deane Wang and Joanne Cummings, UVM School of Natural Resources

ABSTRACT

Soil temperature is an important factor affecting establishment, growth and productivity, and survival of forest trees. In winter, soil temperature influences the degree of cold hardiness in roots of woody plants, regulates the supply of available moisture, and affects insect populations and other soil-dwelling organisms. A study was initiated in January 1993 to continuously monitor soil temperature in a northern hardwood forest stand located at the Proctor Maple Research Center in Underhill, VT. Averaging thermocouples were installed 2 cm above and 5, 15, and 30 cm below the soil surface in two sets of paired, 1 m^2 plots. The initial treatments applied to these plots were designed to examine the effects of snow cover on soil temperature within a hardwood forest. Snow was allowed to accumulate naturally on one plot in each pair, but was removed from the second plot after each snowfall. Soil temperatures increased with increasing soil depth during fall and winter and decreased with increasing depth in spring and summer. In 1993, late March and mid September represented the transition from soil temperatures warmer than ambient air temperature to those cooler than ambient air and *vice versa*, respectively. Generally, soil temperatures in snow-free plot were more responsive to ambient air temperature than those in snow-covered plots, and were consistently 1 to 5^0 C lower than those measured at corresponding depths in snow plots. Only at 30 cm below the soil surface in snow plots was soil temperature consistently above freezing during most of the winter.

INTRODUCTION

In January 1993 a study was initiated to continuously monitor soil temperatures at several depths within a northern hardwood forest. This monitoring will provide basic data on soil temperature gradients within the forest and address questions about the frequency of freezing in the forest soil rooting zone. Soil thermocouples were installed within the upper rooting zone in two sets of paired, 1 m^2 plots located near the VMC canopy research tower at the Proctor Maple Research Center in Underhill, VT. The paired-plot approach allowed treatment of one plot in each pair while maintaining the second plot as a control. Over time, this instrumentation will allow us to add soil temperature information under a variety of environmental conditions to the ever-increasing database being generated at the tower site.

The first treatments applied to these plots were designed to look at the effects of snow cover on soil temperatures during winter and early spring. Snow was allowed to accumulate naturally on one plot in each pair while the other plot was kept free of snow throughout winter.

Objectives

The overall goals of this project are to increase our understanding of soil temperature dynamics within the upper rooting zone of a northern hardwood forest and to examine the effects of snow cover on forest soil temperatures. Specific goals are to:

1. continuously monitor soil temperature at several depths within the upper rooting zone of a northern hardwood forest,

2. examine the effects of snow cover on soil temperature at various depths within the upper rooting zone of a northern hardwood forest, and

3. relate meteorological variables such as ambient temperature, total irradiance, and wind speed to soil temperature.

METHODS

On 15 January 1993 four-point, averaging thermocouples were installed 2 cm above and 5, 15 and 30 cm below the soil surface (2, -5, -15, and -30 cm) in each of the four plots (two sets of paired plots). Subsurface thermocouples were installed by excavating a small pit with a smooth vertical face and inserting the four ends of each thermocouple set horizontally into the face of the soil approximately 10 cm apart at each depth and 7 cm deep into the soil face. Thermocouples were patterned after commercially available ones sold by Campbell Scientific Inc. (CSI), but were made by us from bulk teflon-coated 22 gauge copper-constantan thermocouple wire. The actual thermocouple junctions were waterproofed by applying clear heat shrink tubing over which several coats of clear commercial plasti-dip were applied. Thermocouples were calibrated and referenced to

National Institute of Standards and Technology (NIST) traceable thermometers prior to installation, with individual temperature corrections developed for each thermocouple. Plots were randomly designated as snow-covered (snow) or snow-free treatments. Data from one set of plots were recorded as 15 min averages to the CSI 21X datalogger located at the VMC research tower. Because of a shortage of available channels on the datalogger, data from the second set of plots were recorded directly to a computer, also as 15 min averages, by means of an analog to digital converter (ADC "blue box") and a Turbo Pascal program.

Thermocouples were installed in mid January immediately following the first significant snow fall of the 1992-93 winter season (approx. 16 cm). Both snow and snow-free plots were cleared of snow during the installation process and no attempt was made to put snow back over the snow plots. It took two weeks for the natural snow cover to again accumulate on the snow plots and, for this reason, we have chosen not to discuss the January 1993 data.

Average snow depths on all plots were measured and recorded and snow was cleared from snow-free plots after each snowfall. On most occasions, a broom was sufficient to remove snow from snow-free plots.

RESULTS

Soil temperatures, as expected, generally increased with depth during fall and winter and decreased with depth in spring and summer. In 1993 soil temperatures at all three subsurface depths came into equilibrium with air temperature near the soil surface in late March and again in mid September (Fig. 1). These times represent the transition from soil temperatures warmer than ambient air in fall and winter to those cooler than ambient air in spring and summer and back to warmer than ambient air. Seasonal soil temperatures increased sharply from March to May, then continued to increase at a slower rate until mid August. Soil temperatures then began to decrease in response to the decrease in ambient air temperatures, more rapidly during September through mid October and then more slowly from mid October on into early winter. Average monthly soil temperatures fluctuated by 13^{o} C from February until August at -30 cm and 17^{o} C at -5 cm.

During the period of continuous snow cover (early February to early April) soil temperatures in snow-free plots were generally more responsive to ambient air temperature than those in snow plots (Fig. 2). This was particularly true at -5 cm and was less apparent as depth increased. Absolute temperatures on snow-free plots were 1 to 5^{o} C lower than those at corresponding depths in snow plots. By mid February snow had accumulated to a depth of 30 cm on snow plots and that depth or greater was maintained for the balance of winter. From mid February until snow melt subsurface soil temperatures in snow plots remained at or above -1^{o} C and soil surface temperatures (2 cm) did not drop below -2.5^{o} C. During this same period subsurface soil temperatures in snow-free plots ranged from -0.3 to -6^{o} C while surface temperatures varied closely with ambient air temperature.

Figure 1. Average monthly soil temperature measured 2 cm above and 5, 15, and 30 cm below the soil surface in a northern hardwood forest stand at the Proctor Maple Research Center in Underhill, VT.

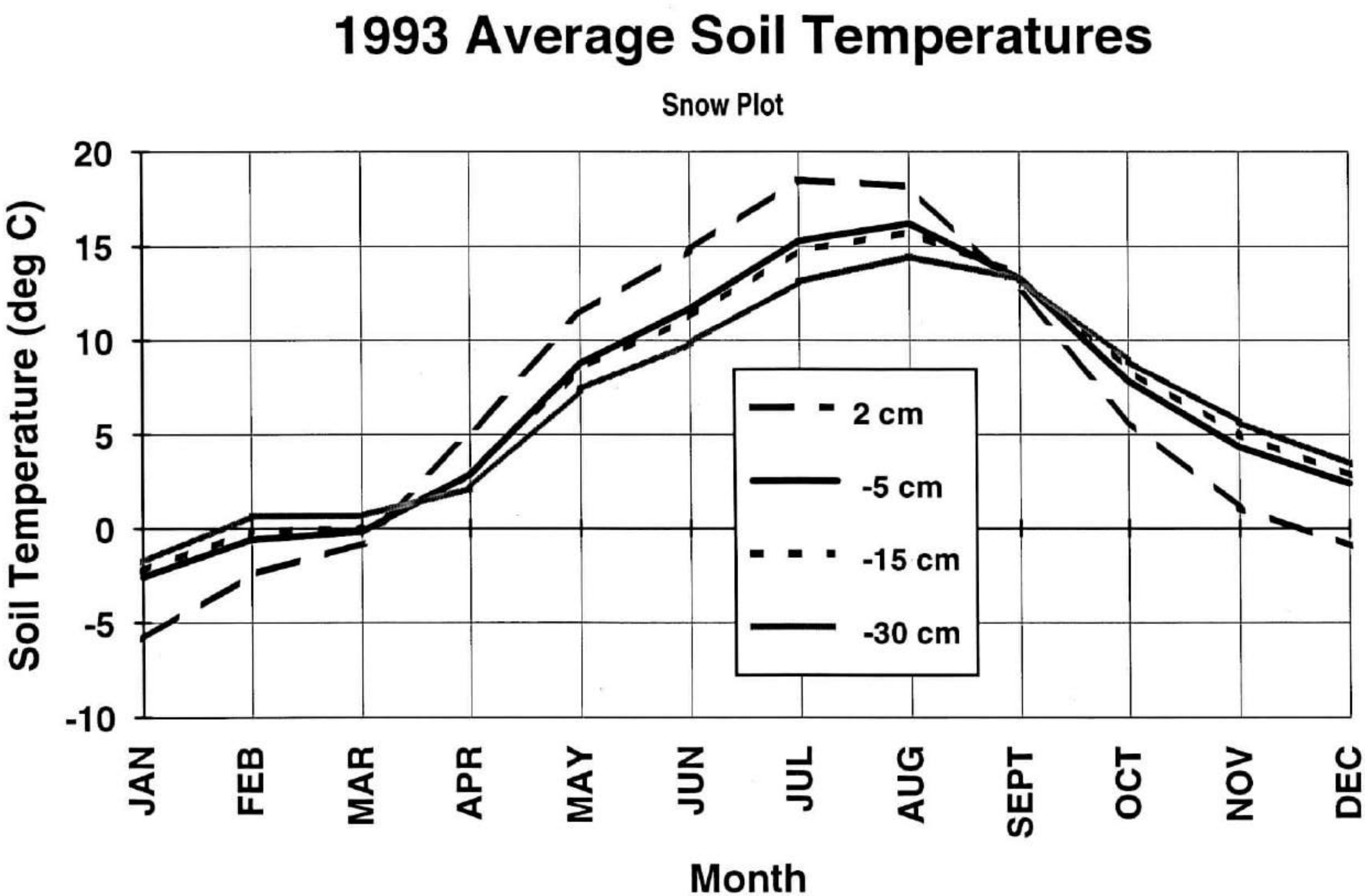
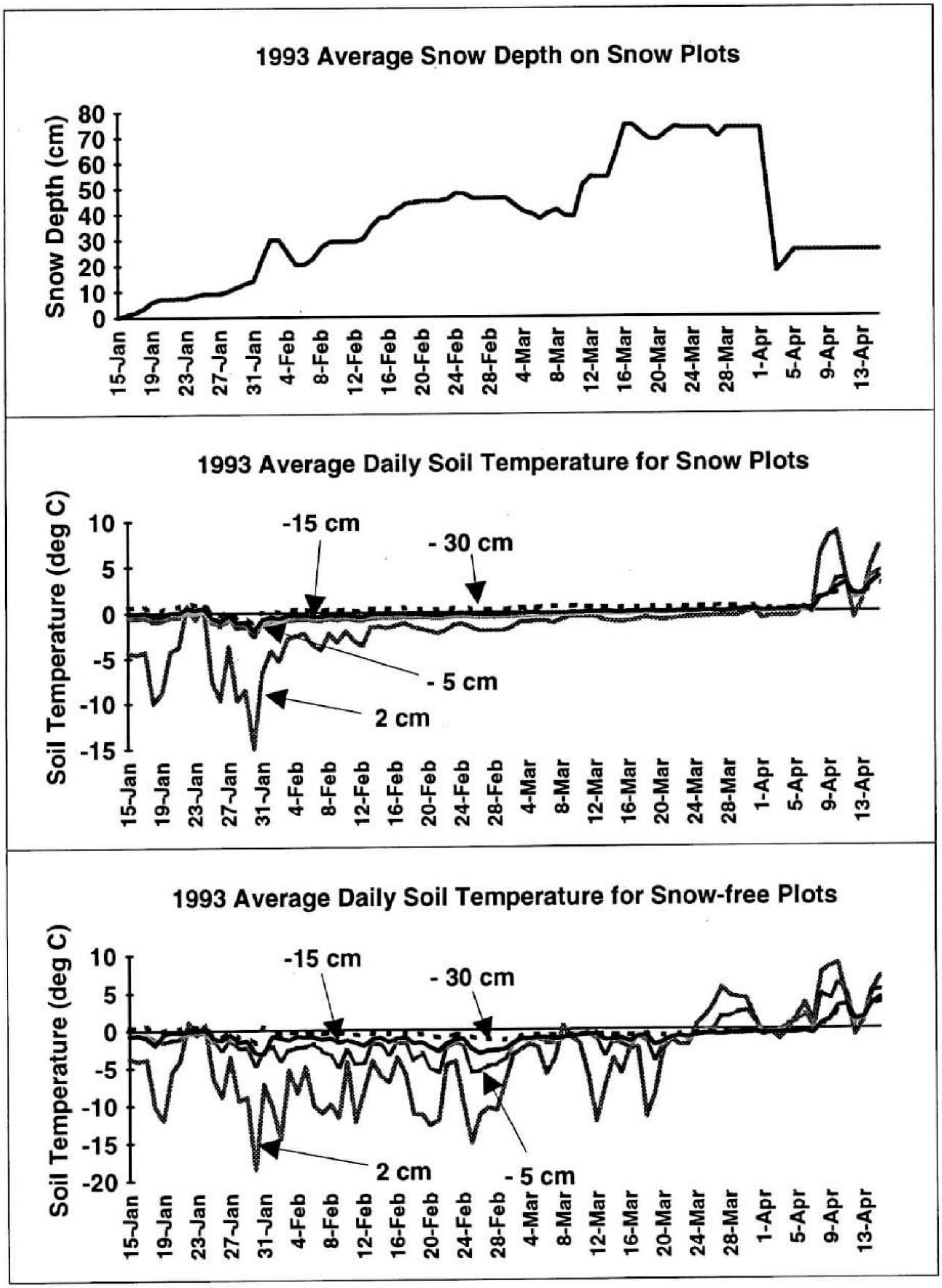


Figure 2. Average snow depth and average daily soil temperature for snow-covered (snow) and snow-free plots from 15 January to 15 April 1993 measured in a northern hardwood forest stand at the Proctor Maple Research Center in Underhill, VT.



Specific results show that beginning in early February soil temperatures at -30 cm were generally 0.5 to 0.75° C above freezing in the snow-covered plots and 0.3 to 1.5° C below freezing (-0.3 to -1.5° C) in snow-free plots (Fig. 3). At -15 cm soil temperatures in snow plots were slightly below freezing (-0.25 to -0.5° C) throughout much of the period, but increased gradually in late winter, as snow depth increased, to 0° C or slightly above in March before increasing rapidly in early April (Fig. 3). In contrast, soil temperatures in snow-free plots at -15 cm were consistently below freezing (about -1 to -3.5° C) before increasing rapidly in early April. Although soil temperatures at -5 cm were below freezing in both snow and snow-free plots, temperatures in snow plots warmed gradually throughout the winter, were less variable in temperature, and considerably warmer overall; not dropping below -1.5° C after early February (Fig. 3). Temperatures in snow-free plots at -5 cm fluctuated between -1 and -6° C until early April when temperatures in both snow and snow-free plots began to rise rapidly in response to warming ambient air temperatures.

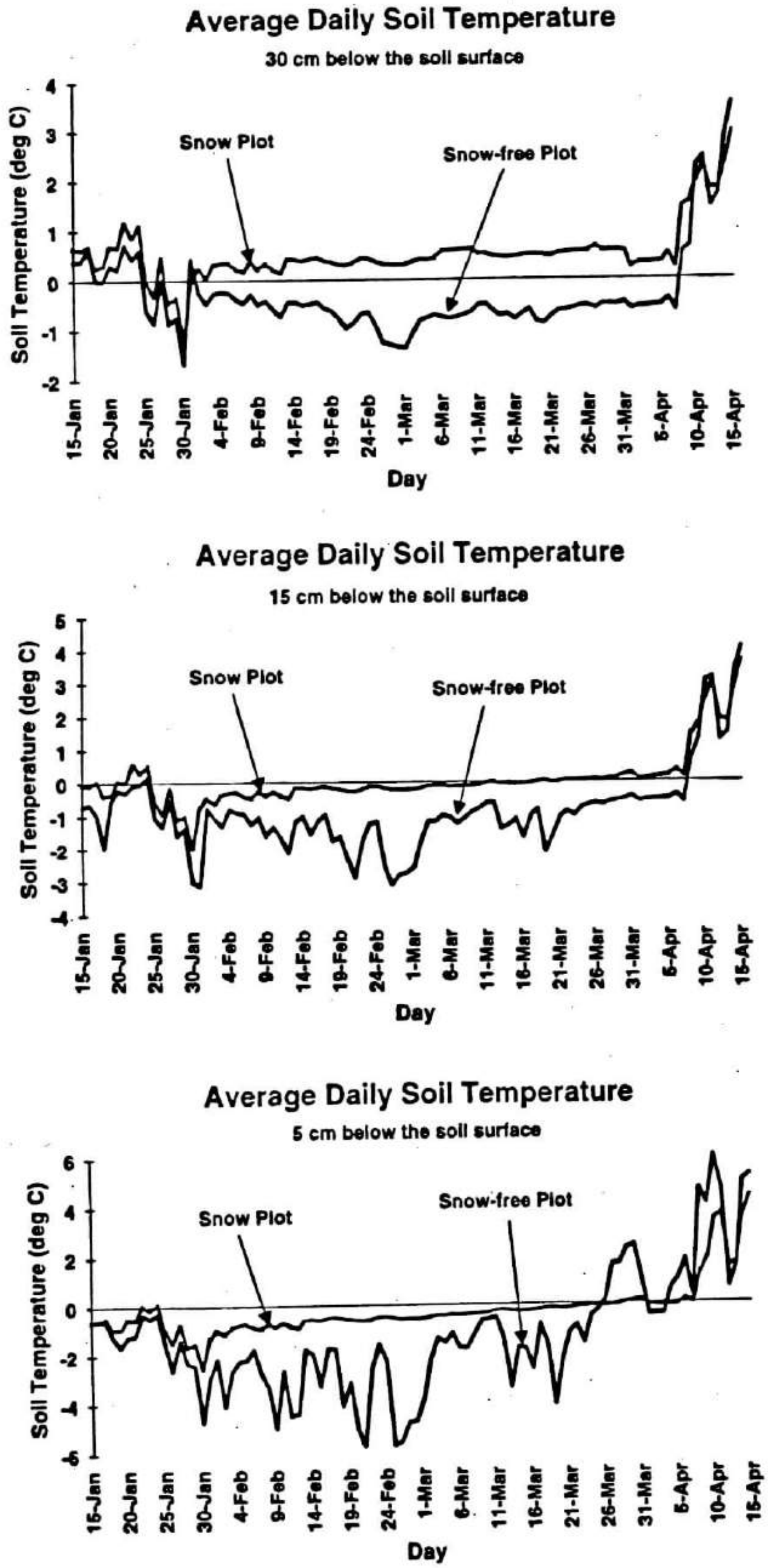
The number of hours (1 February to 15 April) that temperatures remained below freezing, at the various depths, in snow and snow-free plots is summarized in Table 1.

TABLE 1. NUMBER OF HOURS AND % OF TIME THAT SUBFREEZING SOIL TEMPERATURES OCCURRED, AT VARIOUS DEPTHS, BETWEEN 1 FEBRUARY AND 15 APRIL 1993 IN SNOW-COVERED AND SNOW-FREE PLOTS

Soil Depth	Snow-covered		Snow-free	
cm	hrs	(%)	hrs	(%)
2	1572	(89)	1331	(75)
-5	1473	(83)	1448	(82)
-15	1100	(62)	1579	(89)
-30	23	(01)	1581	(89)

The number of hours of subfreezing temperatures decreased with soil depth in snow-covered plots and increased with depth in snow-free plots. The insulating layer of snow (snow plots) increased the number of hours of subfreezing temperatures near the soil surface (2 cm) compared to snow-free plots. By contrast, the snow-free plots, in addition to experiencing freezing ambient temperatures, also experienced more hours of warmer temperatures than the snow plots, thus decreasing the total hours of freezing temperatures. At -5 cm there was no difference in the number of hours of below freezing temperatures occurring in snow-covered and snow-free plots, although the distribution of

Figure 3. Average daily soil temperature from 15 January to15 April 1993 measured at 30, 15, and 5 cm below the soil surface on snow and snow-free plots within a northern hardwood stand at the Proctor Maple Research Center in Underhill, VT.



freezing temperatures was probably different; this will be investigated. In the snow-free plots, no difference in time of exposure to subfreezing temperatures was found between -15 and -30 cm. Below freezing temperatures occurred only 1% of the time at -30 cm when snow cover was present, but 89% of the time when absent.

DISCUSSION

Soil temperature is an important factor affecting establishment, growth and productivity, and survival of forest trees. In winter, soil temperature influences the degree of cold hardiness in roots of woody plants, regulates the supply of available moisture, and affects insect populations (i.e., pear thrips) and other soil-dwelling organisms. Winter desiccation, a particular problem in some conifer species, results when plants are deprived of moisture due to frozen soils and possibly frozen roots at the same time water is being lost through transpiration. In winter, length and frequency of soil freeze-thaw cycles, as well as depth of freezing, influence the severity of physiological and physical perturbation to trees and other biota. Extremes in high as well as low soil temperatures can also have detrimental effects on many forest organisms.

Data from winter (1993) show that in the absence of snow cover, soil temperatures can be below freezing to a depth of -30 cm. At lesser depths of -5 and -15 cm, soil temperature in the absence of snow cover can be as low as -6 and -3^{o} C, respectively. These depths encompass the major rooting zone for many tree species, subjecting roots (and other soil biota) to significant freezing events. These conditions probably occur during winters with extended periods of little or no snow cover.

Soil temperatures well below freezing are certain to cause freezing of soil water, but it is unclear if temperatures slightly below freezing also cause soil water to freeze. It seems probable that matric and solute forces in soil water may prevent freezing at temperatures -1 or -2^{o} C. Once winter acclimated, some plant tissues are protected by solute effects to temperatures well below freezing, but root tissues may not be so well protected (A. Auclair, pers. comm.). There is a need for more information about the effects of freezing degree and frequency on root physiology, as well as about the occurrence of freezing and high temperature events in soils. There are limited continuous multi-depth data on soil temperatures available, so these data provide valuable information about this fundamental property of soils and its important effects on plant roots and soil biota.

Year-to-year variability in timing and amount of snow cover make it difficult to draw conclusions based on data from a single winter. In this particular season, continuous snow cover did not occur until early February. It is possible that the gradual warming in soil temperatures evident at -5 and -15 cm in snow plots was the result of early freezing and the late snow cover during the 1992-93 season. Perhaps if snow cover had occurred earlier, soil temperatures would have been more stable and warmer at these depths.

FUTURE PLANS

We plan to continue the experiment over several winters in an attempt to characterize soil temperature patterns under a variety of winter climatic conditions. Additional analyses will be done to examine number and timing of freeze-thaw cycles and extremes in high soil temperature.

FUNDING SOURCES

Support for this project comes from the VMC, the U.S. Forest Service Northeastern Forest Experiment Station (cooperative agreement #23-758), the UVM School of Natural Resources (SNR), and SNR McIntire-Stennis program.

Mount Mansfield

Surface Waters

AQUATIC MACROINVERTEBRATE MONITORING AT THE VERMONT MONITORING COOPERATIVE SITE UNDERHILL, VERMONT

by the
Vermont Department of Environmental Conservation

SUMMARY

Aquatic macroinvertebrates were sampled at two sites in the upper Brown's River drainage basin using standardized sampling methods. The macroinvertebrate communities were dominated by mayflies, stoneflies, and caddisflies and were fairly typical of high-quality, high-elevation, high-gradient streams in the Green Mountains. Slight differences in community structure suggest potential differences in watershed character. 1993 is the third year of DEC sampling at these sites. Comparison of data between years shows considerable annual variation within certain structural components of the macroinvertebrate community. Overall biological integrity at both sites is excellent.

INTRODUCTION

The Vermont Department of Environmental Conservation (DEC) maintains a Statewide monitoring program, the Ambient Biomonitoring Network (ABN), which samples aquatic biological communities in rivers and streams at 50-70 sites annually. There is a core of 30-40 sites that are sampled every year during the late summer/fall period for the purpose of evaluating temporal variability and tracking long-term trends in biological integrity at those sites. Other sites are sampled on a one time basis for the purpose of making site-specific water quality/habitat evaluations related to some specific watershed disturbance. In 1991, DEC added two sites, located in the vicinity of the Vermont Monitoring Cooperative (VMC) research area on the west slope of Mount Mansfield, to the core sites sampled as part of the ABN. These sites have been integrated into the Statewide long-term biological monitoring program and were sampled in October of 1991 and 1992, and September of 1993. The results of the 1991 and 1992 sampling were reported last year. This report will present and discuss the 1993 sampling results and observations on results from the sampling to date.

LOCATION

The two sampling sites are located in the upper reaches of the Brown's River watershed - one on Stevensville Brook and one on the Brown's River upstream of its confluence with Stevensville Brook. Both sampling sites are located at an elevation of 1400 feet. The Stevensville Brook site is located about 50m above the bridge at the parking lot for the Nebraska Notch trail (lat 44 30 21:long 72 50 45) and drains approximately 5.2 km^2 of forested watershed. The Brown's River site is located about 100m above the last bridge before the State Park gate (lat 44 51 09:long 72 31 28) and drains approximately 6.1 km^2 of forested watershed. Physical characteristics at the two sampling sites are very similar: substrate composition is similar with 35% boulder, 30% cobble, 20% course gravel, 10% gravel, and 5% sand at both sites; canopy cover (shading) is approximately 80% at both sites; sampling depth averages 0.2 m at both sites. Both sites were sampled on September 24, 1993.

METHODS

Duplicate samples of aquatic macroinvertebrates were collected from riffle areas using a standardized "kick-net" procedure used by DEC at all ABN sites. The use of standardized sampling methods results in an equal sampling effort applied to all sites sampled, providing a quantitative basis for making comparisons between sites. The sampler holds a 500u mesh D-frame net in the stream and vigorously disturbs the substrate immediately above the net, dislodging macroinvertebrates associated with the substrate and allowing them to be carried into the net by the current. A sample consists of all the organisms and detritus that are dislodged from the substrate during two minutes (as timed by a stopwatch) of active substrate disturbance. During the two minute active sampling period, the sampler moves the net to a minimum of four locations, representing an equal number of high and low water velocity habitats. The sample is removed from the net, placed in labeled jars, and preserved in alcohol. A habitat evaluation of the sample site is conducted at the time of sampling. Temperature, pH, alkalinity, and specific conductance of the water column are measured at the time the sample is collected. Samples are returned to the DEC laboratory in Waterbury where organisms are separated from the detritus, sorted into taxonomic groups, and identified to the lowest possible taxonomic levels, usually genus/species, using appropriate identification keys. Data are tabulated and entered into a computer data management system using Paradox software and IBM-compatible DOS-PC systems. Data can be outloaded in a variety of formats, including ASCII, dBase, and Lotus.

The data are analyzed by calculating various community structural and functional attributes that are indicative of overall biological integrity at the sampling site. Calculated attributes can be affected by habitat and water quality, riparian characteristics in the watershed, as well as the hydro-geo-physical nature of the watershed. Appendix 1 summarizes the potential information obtained from the evaluation of some of the major community attributes which DEC regularly calculates.

RESULTS

In 1993, 41 and 44 taxa of aquatic invertebrates were identified from Browns River and Stevensville Brook respectively. In general, the composition of the invertebrate communities was typical of high elevation oligotrophic streams draining steep forested watersheds, dominated by species of mayflies, stoneflies, and caddisflies. There were some differences between the two streams.

There were six and seven taxa that made up 4% or more of the community composition at Stevensville Brook and Brown's River respectively, indicating good evenness of taxa distribution within the community. In Stevensville Brook, three stonefly families (Peltoperlidae, Chloroperlidae, and Leuctridae) were the dominant taxa, making up sixty-two percent (62%) of the overall community. In the Brown's River, two stonefly families (Chloroperlidae and Leuctridae) and one Caddisfly genus (Lepidostoma) were the dominant taxa, making up fifty-five percent (55%) of the overall community. Taxa richness and diversity indices indicate excellent diversity at both sites.

DISCUSSION

The three years of data collected to date show considerable variability between years among certain community attributes describing structure and function of the macroinvertebrate community. The relative abundance of stoneflies was greatly reduced at both sites in 1992, due primarily to reduced numbers of the Leuctridae Family of stoneflies and increased abundance of mayflies and Chironomid dipterans. 1993 saw the return of stonefly dominance in both streams, with the caddisfly Lepidostoma sp. emerging as a co-dominant taxon in the Brown's River. The following Table describes the major community structure and function differences observed among the three years of sampling at the two sites by comparing the observed ranges in the relative abundance (per-cent composition) of the important taxonomic and functional groups. The attributes showing the greatest year-to-year variability are highlighted.

Taxonomic Order	% Comp Stevensville Range 91-93	% Comp Brown's Range 91-93
Diptera	8.5 - 19	**16 - 47**
Ephemeroptera	**2.0 - 40**	11 - 29
Plecoptera	**28 - 76**	**13 - 43**
Trichoptera	12 - 22	10 - 31
Functional Group		
Collector/Gatherer	**5.3 - 54**	**15 - 74**
Collector/Filterer	5.4 - 10.4	6.3 - 8.0
Predator	10 - 29	12 - 30
Detrital Shredder	**28 - 67**	**6.8 - 40**

The community attributes found at these two sites can be compared with a Statewide data-base for 23 stream sites with similar watershed characteristics, including watershed area and elevation. The following table compares Statewide ranges of community attributes with those found at these sites.

Attribute[1]	Statewide Range	Stevensville 1991 - 1993	Brown's 1991 - 1993
Mean Richness	25.5 - 51	27.5 - 37.5	29 - 32
EPT Richness	13 - 29.5	18 - 21	17 - 20
Biotic Index	.52 - 2.03	**.52** - .96	.71 - 1.27
% Mayflies	2 - 47	**2** - 40	11 - 29
% Stoneflies	6 - 76	28 - **76**	13 - 43
% Diptera	9 - 53	**9** - 19	14 - 47
% Collector/Gatherer	5.3 - 74	**5.3** - 54	15 - **74**
% Detrital Shredder	3 - 67	28 - **67**	6.8 - 40

1 - see Table 1 for description of attributes
bold - extreme of Statewide range for similar stream types

Several of the attributes for the 1991 Stevensville Brook sample represent extremes of the Statewide distribution for streams of similar size and elevation. Overall biological integrity at both sites, as determined from community attribute evaluation, is excellent.

While the total number of taxa, the total number of EPT taxa, and the overall percent composition of the EPT taxa have remained relatively consistent between streams and years, structural and functional composition at the species level shows considerable variability between years.

	Total Taxa Richness	Total EPT Taxa Richness	EPT Taxa as Percent Total Taxa Richness
Stevensville Brook	37 - 44	22 - 24	55 - 66
Brown's River	37 - 41	21 - 24	59 - 68

Figures 1-3 show differences between streams across years in three attributes: relative abundance; percent composition of stoneflies, a structural attribute; and percent composition of detrital shredders, a functional atrribute. The most interesting observation to be made here is that although there are differences between streams and years, both streams appear to respond in the same manner to whatever factors, be they physical or biological, are responsible for the annual variability in macroinvertebrate community attributes. It is probable that annual variations in stream biota in undisturbed watersheds occur primarily due to meteorological and hydrological differences between years, as well as the timing of the sampling event relative to seasonal events such as leaf fall and emergence/diapause.

Figure 1: Relative Abundance of Macroinvertebrates
Stevensville Brook and Browm's River

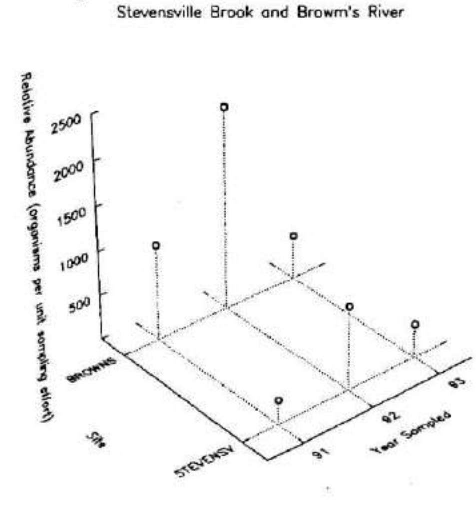


Figure 2: Plecoptera % Composition
Stevensville Brook and Brown's River

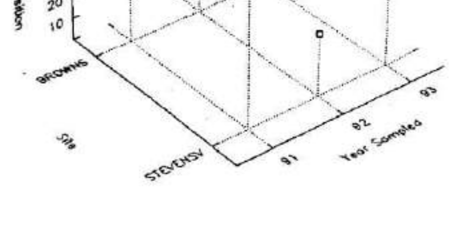
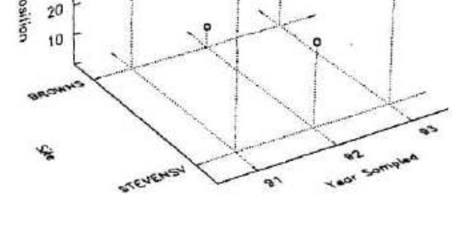


Figure 3: Percent Composition of Shredder Functional Group
Aquatic Macroinvertebrate Commmunity
Stevensville Brook and Brown's River



One of the primary goals of Statewide biological monitoring programs is to determine biological conditions that fall outside the range of natural variability and thus represent an abnormal condition that may be related to antropogenic stressors. The most efficient indicators for determining "abnormal" conditions would be those that show the greatest amount of independence from measurements which show a great deal of natural variability. Data from these two sites provide some insights into the appropriate choice of macroinvertebrate community metrics for general use as water quality indicators that behave independently of annual variability, and thus are most likely to be of use when evaluating biological conditions.

It is clear from these data, and from other data collected Statewide, that the measurement of "relative abundance" of organisms exhibits considerable variability from year to year. These data also suggest, based in part on covariance seen in Figures 1-3, that metrics based on "percent composition" or ratios show a large degree of dependence on relative abundance estimates and thus show similar variability behaviour. Metrics based on "species richness" appear to be less dependent on relative abundance variability and thus would be more useful for determining biological conditions that are abnorrmal or outside the range of natural variability. Complex metrics such as "diversity" and "biotic index" show intermediate dependence on relative abundance variability. Data from these sites will be combined with a Statewide data base to make more comprehensive evaluations of these variability factors.

DEC will continue monitoring these sites on an annual basis. Continued monitoring will permit future evaluation of annual variability observed during the first three years of sampling. Other research occurring in the watersheds, including hydrology, stream chemistry, tree phenology, and adult insect sampling will provide important information relative to evaluating the causes of annual variation in stream biological communities. More intensive sampling could perhaps lead to some clearer definition of the observed differences in community structure between the two watersheds and provide some information relative to the factors causing these differences.

db\vmc-1993.rep

Water Quality Division - Vt. Dept. of Environmental Conservation
Biomonitoring and Aquatic Studies Unit

4/04/94

Browns River 20.8
Site Id: 461100000208

Ambient Biomonitoring Summary Report

Town: Underhill
Waterbody Id: VT07-11

Description: Located above last bridge before State Park gate about 100m.

	10/30/91	10/19/92	9/24/93							
MACROINVERTEBRATES: Id#	91.086	92.097	93.092							
Sampling Method	KN	KN	KN							
Density/Unit	1068	2262	495							
Species Richness	29.5	29.0	32.0							
EPT Richness	19.5	17.0	20.0							
EPT/Richness	.66	.59	.64							
Bio Index	.71	1.27	.83							
Diversity	3.89	3.12	3.79							
# E/P/T Taxa	5/8/9	5/9/11	8/7/9							
EPT/EPTChiro										
Hydro/Total										
Dominant Taxa %	23	38	20							
Coleoptera %	.8	.8	3.7							
Diptera %	15.5	47.0	13.7							
Ephemeroptera %	26.2	29.0	10.7							
Trichoptera %	14.5	10.3	31.3							
Plecoptera %	42.9	12.8	39.9							
Oligochaeta %	0.0	0.0	.2							
Other %	0.0	.1	.5							
Collector Gatherer %	39.0	74.1	15.2							
Collector Filterer %	8.0	6.3	8.1							
Predator %	15.4	11.5	30.3							
Shredder - Detritus %	36.5	6.8	39.7							
Shredder - Herbivore %	0.0	.1	.5							
Scraper	.8	.9	4.5							
Comm. Assessment	good	exc	exc							

Dominant Taxa	10/30/91	10/19/92	9/24/93							
Oulimnius	.8	.6	3.7							
Parametriocnemus	.7	.4	4.5							
Polypedilum	3.9	4.7	.2							
Micropsectra	6.7	38.0	.2							
Hexatoma	.2	.1	3.0							
Baetidae	6.7									
Baetis	7.0	14.7	6.1							
Epeorus	10.5	13.5	2.3							
Lepidostoma	1.3	1.7	20.1							
Dolophilodes	7.3	5.0	5.6							
Rhyacophila	4.5	2.2	2.3							
Chloroperlidae	7.1	7.7	18.9							
Leuctridae	22.6	1.0	16.1							
Taenionema	6.1	1.7								

Brown's River 9/24/93

Lab Id: 93.092 Composites/Rep: 1 Area: m2

Order	Genera	species	Count 1	Count 2	Count 3	Count 4	Count 5	Count 6	Count 7	Count 8	Count 9	Count 10
COLEOPTERA	OULIMNIUS	latiusculus	15	8								
DIPTERA	CERATOPOGON	sp	1	0								
DIPTERA	CORYNONEURA	sp	0	1								
DIPTERA	DICRANOTA	sp	3	13								
DIPTERA	EMPIDIDAE	unid	0	4								
DIPTERA	HEXATOMA	sp	4	14								
DIPTERA	MICROPSECTRA	sp	0	1								
DIPTERA	MOLOPHILUS	sp	1	0								
DIPTERA	ORTHOCLADIUS	sp	1	0								
DIPTERA	PARACHAETOCLADIUS	sp	0	3								
DIPTERA	PARAMETRIOCNEMUS	sp	9	18								
DIPTERA	POLYPEDILUM	aviceps	0	1								
DIPTERA	SIMULIUM	tubersom	0	1								
DIPTERA	PSEUDOLIMNOPHILA	sp	0	1								
DIPTERA	THIENEMANNEMYIA	sp	0	1								
DIPTERA	TVETENIA	bavarica	3	2								
EPHEMEROPTERA	BAETIS	flavistriga	2	0								
EPHEMEROPTERA	BAETIS	sp	7	3								
EPHEMEROPTERA	BAETIS	tricaudatus	12	14								
EPHEMEROPTERA	EPEORUS	sp	8	6								
EPHEMEROPTERA	EURYLOPHELLA	funeralis	3	0								
EPHEMEROPTERA	HEPTAGENIIDAE	unid	4	1								
EPHEMEROPTERA	LEPTOPHLEBIIDAE	unid	4	2								
EPHEMEROPTERA	PSEUDOCLOEON	sp	1	0								
ODONATA	GOMPHIDAE	imm	1	2								
OLIGOCHAETA	ENCHYTRAEIDAE	unid	0	1								
PLECOPTERA	CAPNIIDAE	imm	1	1								
PLECOPTERA	CHLOROPERLIDAE	imm	57	59								
PLECOPTERA	LEUCTRIDAE	imm	41	57								
PLECOPTERA	MALIREKUS	hastatus	5	4								
PLECOPTERA	PELTOPERLA	sp	8	3								
PLECOPTERA	PTERONARCYS	proteus	2	6								
PLECOPTERA	TAENIOPTERYGIDAE	imm	1	0								
TRICHOPTERA	DOLOPHILODES	sp	19	16								
TRICHOPTERA	GLOSSOSOMA	sp	0	2								
TRICHOPTERA	LEPIDOSTOMA	sp	56	67								
TRICHOPTERA	NEOPHYLAX	sp	2	0								
TRICHOPTERA	PARAPSYCHE	apicalis	1	3								
TRICHOPTERA	POLYCENTROPUS	sp	1	1								
TRICHOPTERA	RHYACOPHILA	carolina spa	2	2								
TRICHOPTERA	RHYACOPHILA	carolina spb	4	6								
TRICHOPTERA	SYMPHITOPSYCHE	slossonae	5	5								

Stevensville Brook 2.1
Site Id: 461143000021

Ambient Biomonitoring Summary Report

Town: Underhill
Waterbody Id: VT07-10

Description: Located above bridge at parking area for Nebraska Notch trail,about 50m.

	10/30/91	10/19/92	9/24/93
MACROINVERTEBRATES: Id#	91.087	92.098	93.094
Sampling Method	KN	KN	KN
Density/Unit	269	945	376
Species Richness	27.5	37.5	35.5
EPT Richness	18.0	20.5	21.0
EPT/Richness	.65	.55	.59
Bio Index	.52	.96	.64
Diversity	3.32	3.87	3.65
# E/P/T Taxa	3/7/11	3/8/11	4/9/11
EPT/EPTChiro			
Hydro/Total			
Dominant Taxa %	38	29	22
Coleoptera %	.4	.1	.5
Diptera %	9.5	18.7	8.5
Ephemeroptera %	2.0	40.1	2.8
Trichoptera %	11.9	12.5	21.8
Plecoptera %	76.2	28.3	66.0
Oligochaeta %	0.0	.1	0.0
Other %	0.0	.1	.4
Collector Gatherer %	7.8	54.0	5.3
Collector Filterer %	5.4	5.4	10.4
Predator %	18.2	9.8	28.6
Shredder - Detritus %	67.5	28.4	53.5
Shredder - Herbivore %	0.0	2.0	.4
Scraper	1.1	.4	.9
Comm. Assessment	good	exc	exc

Dominant Taxa	10/30/91	10/19/92	9/24/93							
Micropsectra	3.2	9.7	.7							
Baetis	.4	28.7	.8							
Epeorus	1.1	10.6	.5							
Parapsyche	1.7	1.3	3.6							
Lepidostoma	1.1	3.6	4.4							
Dolophilodes	1.5	2.4	3.5							
Rhyacophila	4.1	3.5	6.4							
Capniidae	6.3	2.7	1.7							
Chloroperlidae	11.9	4.6	17.8							
Leuctridae	38.5	7.3	21.9							
Peltoperlidae			22.5							
Peltoperla	9.7	4.5								
Taenionema	7.1	5.5								

Stevensville Brook 9/24/93

Lab Id: 93.094 Composites/Rep: 1 Area: m2

Order	Genera	species	Count 1	Count 2	Count 3	Count 4	Count 5	Count 6	Count 7	Count 8	Count 9	Count 10
COLEOPTERA	OULIMNIUS	latiusculus	2	1								
COLEOPTERA	PROMORESIA	tardella	0	1								
DECAPODA	CAMBARUS	bartoni	1	0								
DIPTERA	BRILLIA	sp	3	0								
DIPTERA	CRICOTOPUS	sp	0	1								
DIPTERA	DICRANOTA	sp	5	10								
DIPTERA	EMPIDIDAE	unid	1	0								
DIPTERA	EUKIEFFERIELLA	brevicalar	5	2								
DIPTERA	HEXATOMA	sp	5	1								
DIPTERA	MICROPSECTRA	sp	3	2								
DIPTERA	PARACHAETOCLADIUS	sp	4	2								
DIPTERA	PARAMETRIOCNEMUS	sp	2	1								
DIPTERA	RHEOCRICOTOPUS	sp	2	0								
DIPTERA	SIMULIUM	tubersom	3	3								
DIPTERA	THIENEMANNEMYIA	sp	0	2								
DIPTERA	TIPULA	sp	0	2								
DIPTERA	TVETENIA	bavarica	2	2								
DIPTERA	UNID		1	0								
EPHEMEROPTERA	BAETIS	sp	1	2								
EPHEMEROPTERA	BAETIS	tricaudatus	1	2								
EPHEMEROPTERA	EPEORUS	sp	4	0								
EPHEMEROPTERA	EURYLOPHELLA	funeralis	1	0								
EPHEMEROPTERA	EURYLOPHELLA	sp	0	2								
EPHEMEROPTERA	HEPTAGENIIDAE	imm	4	1								
EPHEMEROPTERA	STENONEMA	sp	3	0								
LEPIDOPTERA	PYRALIDAE	unid	1	0								
LEPIDOPTERA	TORTRICIDAE	unid	1	0								
PLECOPTERA	ACRONEURIA	carolinesis	0	1								
PLECOPTERA	ACRONEURIA	sp	0	1								
PLECOPTERA	CAPNIIDAE	imm	5	8								
PLECOPTERA	CHLOROPERLIDAE	imm	70	64								
PLECOPTERA	ISOPERLA	sp	2	2								
PLECOPTERA	LEUCTRIDAE	imm	71	94								
PLECOPTERA	MALIREKUS	hastatus	1	0								
PLECOPTERA	PELTOPERLIDAE	unid	82	87								
PLECOPTERA	SOYEDINA	sp	1	0								
PLECOPTERA	TAENIOPTERYGIDAE	imm	0	7								
TRICHOPTERA	DOLOPHILODES	sp	12	14								
TRICHOPTERA	LEPIDOSTOMA	sp	15	18								
TRICHOPTERA	PALAEGAPETUS	sp	7	2								
TRICHOPTERA	PARAPSYCHE	apicalis	15	12								
TRICHOPTERA	POLYCENTROPUS	sp	1	1								
TRICHOPTERA	RHYACOPHILA	carolina spa	4	3								
TRICHOPTERA	RHYACOPHILA	carolina spb	3	2								
TRICHOPTERA	RHYACOPHILA	fuscula	17	10								
TRICHOPTERA	RHYACOPHILA	minora	5	4								
TRICHOPTERA	SYMPHITOPSYCHE	macleodi	5	3								
TRICHOPTERA	SYMPHITOPSYCHE	slossonae	5	6								

Streamflow and water quality monitoring on Mt. Mansfield

James Shanley and Jon Denner, U.S. Geological Survey, Montpelier, Vermont

Cooperators:

Tim Scherbatskoy, School of Natural Resources, University of Vermont
Carl Waite, School of Natural Resources, University of Vermont
M.S. students, School of Natural Resources, University of Vermont

Introduction: The Water Resources Division of the U.S. Geological Survey operates a network of stream gaging stations nationwide. This network provides a continuous long-term record of streamflow quantity which is valuable to hydrologic research as well as engineering applications. The Division also has expertise in water quality, and has an ongoing program to monitor the quality of U.S. streams and rivers. This tradition in water quantity and quality measurements has given rise to a more recent interest in watershed biogeochemical cycling; determination of hydrologic and chemical fluxes are important elements of such studies.

The USGS became active in the VMC in 1992. USGS participation helps to meet the need for water quantity and quality information in support of VMC ecosystem research, while at the same time it provides streamflow information in an area of Vermont that is otherwise poorly represented. It also marks one of the few high-elevation stream-gaging sites in the state.

On November 6, 1992, a reconnaissance sampling effort was made in the Browns River (6.1 sq. km) and Stevensville Brook (5.2 sq. km) watersheds, to collect preliminary data for the siting of the monitoring stations. Measurements of temperature, pH, and specific conductance were made. As a follow-up, 3 low-elevation sites (Browns River and two branches of Stevensville Brook) were sampled for full major ion analysis on November 13, 1992.

In general, waters draining the west slope of Mt. Mansfield are poorly buffered. Headwater streams at high elevation, in particular, are quite acidic (pH<5.0). This is attributed to the relatively unreactive quartz-mica-albite schist bedrock, limited thickness of overburden (glacial till), and limited soil development. Buffering increases as stream size increases. The extent of buffering is greater at Browns River than at Stevensville Brook. Low elevation areas are at pH 5.5 to 6.5, compared to near 7.0 at Browns River. It appears that significant neutralization in the Browns River watershed occurs in the lowest 20% of the basin. The lower alkalinities at Stevensville result from slightly higher sulfate and lower base cation concentrations relative to Browns River.

The low dissolved load of these streams implies a tight nutrient economy in the forested watersheds that they drain. Weathering rates are slow, and forest productivity may be limited by nutrient availability. The acidic character and elevated aluminum concentrations of these streams suggests a possible negative impact on aquatic fauna and forest health.

Nettle Brook, a small tributary to the North Branch of Stevensville Brook, was chosen as the initial site for a stream gaging station. The reconnaissance survey revealed this stream to be less acidic than other headwater streams at Mt. Mansfield, perhaps an indication of greater groundwater inputs. We felt that choosing this basin would provide the opportunity to study neutralization processes, because more acidic conditions probably prevail in the stream in its higher reaches. Also, the stream may be subject to episodic acidification during higher flows such as the spring snowmelt period. One advantage of the site is that other studies already are underway within the Nettle Brook basin for which hydrologic and chemical load information would be useful. A second benefit is that the findings at Nettle Brook will be directly interpreted and compared to ongoing biogeochemical and hydrologic research by the authors in streams of similar size and elevation (albeit very different geology) at Sleepers River near Danville, Vermont.

Objectives: The objectives of the project are to:
1) calculate an annual water budget, and thereby estimate evapotranspiration,
2) analyze individual storm events, i.e., the timing and quantity of runoff relative to precipitation inputs, to form a conceptual model of the hydrologic functioning of the watershed,
3) use chemistry and hydrology together to identify biogeochemical pathways,
4) quantify fluxes of major solutes in streamflow,
5) assess the degree of "nitrogen saturation" in the forest,
6) evaluate the susceptibility of the stream to acidification from atmospheric deposition and the threat of aluminum toxicity to fish, and
7) generalize findings to the Stevensville Brook and Browns River watersheds, based on reconnaissance work and scale considerations.

Methods: A site was chosen for weir construction on Nettle Brook, near its confluence with the north branch of Stevensville Brook. The weir was constructed in late September 1993 so that stream discharge measurements could begin in time for the start of the hydrologic water year on October 1.

A 90° V-notch weir was constructed of plywood with a plexiglass insert for the notch. Stage is logged electronically at 5-minute intervals with a potentiometer driven by a float in a stilling well adjacent to the weir. The datalogger and data storage module are housed in a small structure mounted on top of the well.

Solute budgets for the gaged watershed will be determined using data from the NADP (wet deposition) and NDDN (dry deposition) stations at Proctor Forest (inputs) and streamflow and stream chemistry data (outputs). Hydrologic and chemical data from the monitoring stations will establish a baseline for assessing the effects of global change, and will complement VMC ecosystem research projects on Mt. Mansfield.

At least 30 samples annually will be collected at each site, including monthly and selected high-flow samples. Samples will be analyzed for nutrients, major inorganic solutes, silica, aluminum, and dissolved organic carbon.

Results: The weir and stage recording equipment have been functioning well. The initial 3 months of flow data (October, November, and December 1993) have been error-checked and corrected. Corrections included minor adjustments for backwater from leaf and other tree debris (a typical autumn problem) and from ice. There were no discrepancies between observed and recorded stage during site visits, thus no additional adjustments to the record were necessary. The hydrograph for the first three months is given in fig. 1.

October was a wet month. Several storms with rainfall > 2 cm occurred. The stream showed the characteristic "flashy" response of a steep mountain catchment. This response is typified by the storm of October 16-17 (fig. 2). In that storm, 14.6 mm rain fell in 27 hours. The rain fell in several bursts of moderate intensity. In each case, the stream responded within 2 hours after the onset of rain, and the hydrograph peaked within 2 hours of peak rain intensity. If no additional rain occurs, the stream returns to base flow in 2-3 days (fig. 1).

November was relatively dry, although it had the three highest daily flows for the quarter. The high flows for November 5 and 6 resulted from rain on snow following a significant snowfall on November 2. The high flow at the end of November was caused by rain. December precipitation was primarily stored in the form of snow, thus stream discharge receded to winter baseflow conditions.

Stream samples were collected approximately monthly during the period but no analyses are available as yet.

Future plans: The stream gage on Nettle Brook is intended for long-term recording. Flow measurements in 1994 will be augmented by several additional measurements at the site, including air, water, and soil temperature at 5, 15, and 30 cm depth. During the winter period, snow depth and reflected shortwave radiation also will be measured and logged electronically. Stream sampling will be intensified to daily or twice daily during the main spring melt. Some samples of snow core and snowmelt water (from snowmelt lysimeters) also will be collected for analysis. A minimum of monthly stream sampling will continue throughout the year; selected rain storms will be sampled intensively.

All samples will be analyzed for major cations and anions (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, NO_3^{-}, SO_4^{2-}, Cl^{-}, alkalinity), Al, Si, DOC, and NH_4^{+}.During the summer, the spring runoff samples will be analyzed, and initial interpretations of the processes controlling stream flow and stream chemistry will be made. Dennis Daly, a M.S. candidate at UVM School of Natural Resources, will contribute to this interpretation in his directed study of nitrate export. Water and solute budgets for Water Year 1994 will be made after the water year ends in September.

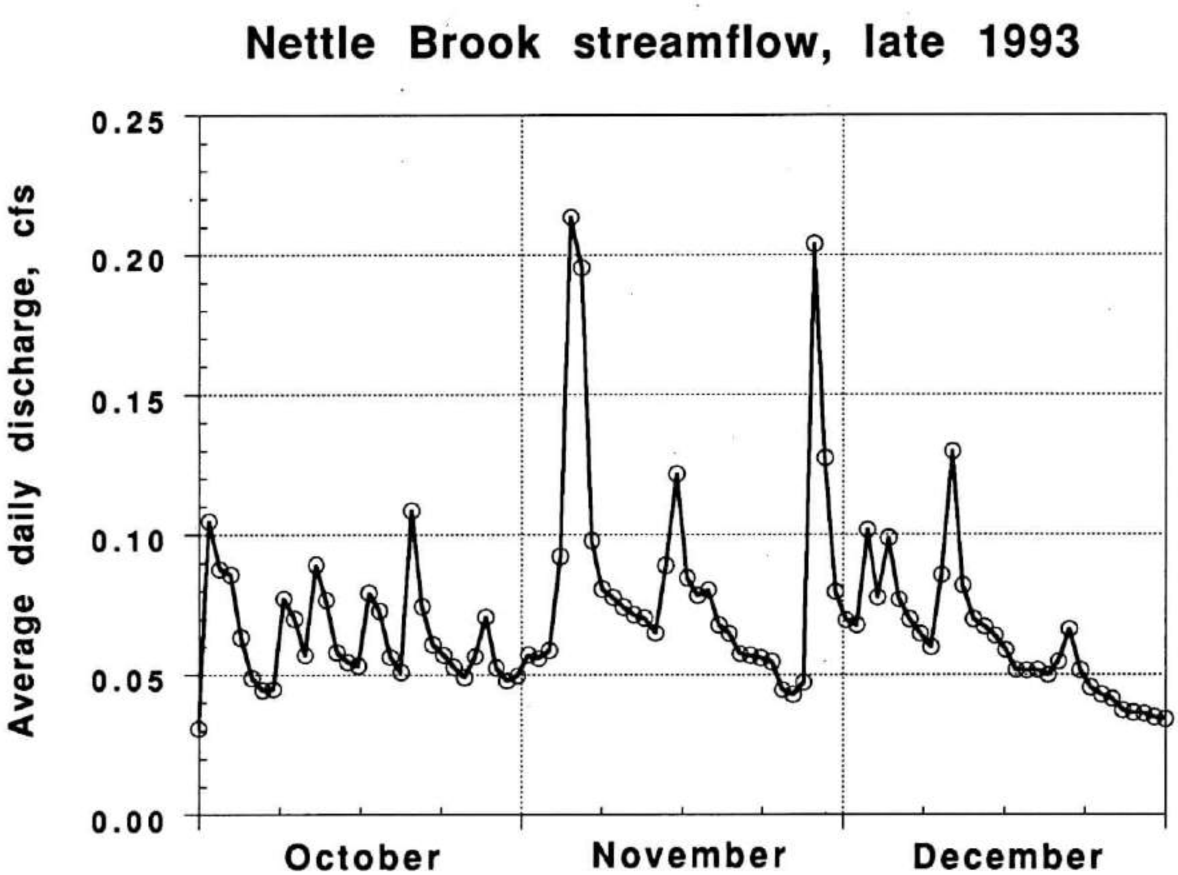


Figure 1. Daily average streamflow at Nettle Brook, October - December, 1993

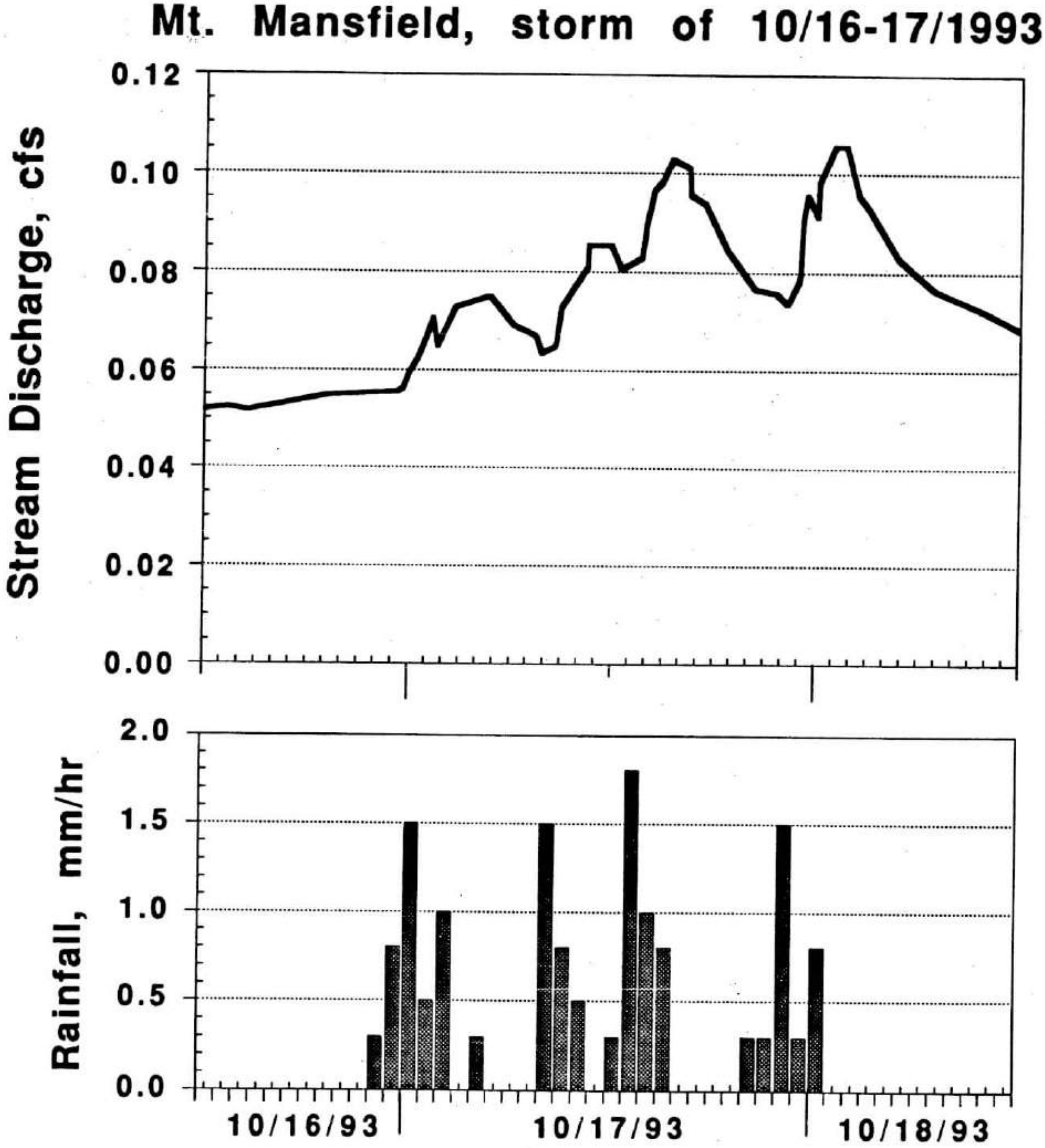


Figure 2. Response of Nettle Brook to rain storm of October 16-17, 1993

Terrestrial Flora

ANNUAL ASSESSMENT OF FOREST HEALTH ON MOUNT MANSFIELD

Vermont Department of Forests, Parks & Recreation
Sandra H. Wilmot

Cooperators

H. Brenton Teillon, Thomas Simmons, Michael Johnson, Pete Reed, Bernard Barton, Jay Lackey, Bradley Greenough and Ronald Wells, Vermont Forestry Division; and the North American Maple Project.

ABSTRACT

From 1988 to 1991, sugar maples monitored on a North American Maple Project plot-cluster improved in crown condition. But over the past two years, there has been some indication that trees are less healthy. Although average dieback remained stable from 1992 to 1993, the percentage of trees healthy and the foliage transparency of sugar maples was slightly worse, but still considered in good condition. This is similar to the statewide trend of trees on these monitoring plots. An increase in pear thrips populations and damage was observed in the stand this year, causing some trees to refoliate.

Results from additional forest health monitoring plots in the design of the National Forest Health Monitoring Program show an increase in dieback from 1992 at most elevations and on most species. Little change in other crown measurements (density and transparency) and no new mortality was recorded.

Balsam fir trees at the 3800 foot elevation continue to have high amounts of dieback (20.5%) and standing dead trees (45.5%). A high percentage of standing dead red spruce trees at the 3000 foot elevation plots continues to be of concern. However, an improvement in the amount of branch dieback on dominant and codominant spruce (from 15.6 to 11.1% dieback from 1992 to 1993) was recorded.

INTRODUCTION

A system is now in place to conduct long-term monitoring of tree conditions on Mount Mansfield. The objective is to determine trends in conditions of trees along an elevational gradient, and relate changes in condition to trends in forest stressors. Ultimately, this information will aid in explaining statewide relationships between forest condition and forest stressors.

An additional goal is to standardize information on forest condition at this site with other sites in Vermont and nationwide that use the same set of measurements and plot design. This information should prove useful in evaluating statewide, regional and national forest ecosystem related issues.

NORTH AMERICAN MAPLE PROJECT PLOT-CLUSTER

METHODS

The five-point plot-cluster establishment, site characterization, annual training and certification, and annual tree evaluations follow standardized NAMP protocols (Millers et al, 1991). In 1993, remeasurement of DBH, additional ingrowth, improvements to the tree vigor measurement and seed production ratings were completed in addition to the normal data collection of early defoliation rating and mid-season crown assessments.

RESULTS AND DISCUSSION

The condition of dominant and codominant sugar maple tree crowns has been slightly less healthy over the past two years as compared to 1991 conditions (Table 1). Dieback remained stable, but transparency (the amount of light coming through foliage) and the percent of trees healthy (less than 15% dieback) was not as good in 1993 as in the previous 2 years. This trend is similar to statewide trends as observed in other Vermont NAMP plots. No new mortality occurred in 1993.

Table 1. Trend in average dieback, transparency, new mortality and healthy trees (less than 16% dieback) for North American Maple Project plot-cluster at the Proctor Maple Research Center, Underhill, VT.

YEAR	DIEBACK (%)	TRANSPARENCY (%)	MORTALITY (%)	% HEALTHY TREES
1988	11.3	27.3	0	88.6
1989	7.1	23.0	0	91.4
1990	7.6	14.0	0	91.4
1991	3.0	10.9	0	97.1
1992	8.1	14.3	0	94.3
1993	8.1	15.0	0	92.0

An increase in pear thrips populations and damage was observed in the stand, causing some trees to refoliate. Maple leaf cutter damage remained light. Seed production was light. Low counts of sugar maple seedlings and saplings was recorded in NAMP plots.

FOREST HEALTH MONITORING PLOTS

METHODS

Eight paired plots are used to monitor tree condition at four elevations on the west slope of Mount Mansfield (1400, 2200, 3000 and 3800 feet). Seven plots were evaluated in 1992, and one plot was added at the 3800 foot elevation in 1993. The design and measurements are those used in the National Forest Health Monitoring Program (Conkling & Byers, 1993). Field crews are trained and certified along with the NFHM crews. Annual crown ratings and damage assessments are conducted on the plots in mid-season. Ozone bioindicator plants are only assessed at a low elevation plot at the Proctor Maple Research Center, since no large openings nor sensitive species have been found near the plots.

Additional information on within season variability in crown ratings is taken four times during the summer. Crown dieback, transparency and density variables are assessed at 3 week intervals on two plots.

RESULTS AND DISCUSSION

Overall, there was an increase in the average dieback of dominant and codominant trees at all elevations except at the 3000 foot plots, where red spruce and paper birch had less dieback in 1993 than in 1992 (Table 2). No new mortality was recorded on plot trees, but the average number of standing dead trees increased at the 3000 foot level, due to missed trees the previous year, and at 3800 foot level, due to the additional plot established at that elevation in 1993.

Balsam fir trees monitored at 3000 feet had slightly fewer trees in the healthy category ($\leq$ 15 % dieback) in 1993, but plots at the highest elevation, 3800 feet, had more healthy trees (Table 3). Transparency and density ratings remained similar between years. A few trees showed winter injury on 1 year old foliage, with only 5 - 10 % of total foliage affected.

Red spruce showed a small improvement in the average amount of dieback on dominant and codominant trees at 3000 feet. No new mortality was observed. There was no winter injury symptoms detected on red spruce trees in our plots, although other trees on the mountain were reported symptomatic from aerial surveys.

Hardwood species at the lower elevations (1400 and 2200 feet) had more dieback in 1993 than in 1992 (Table 2), except for yellow birch trees in plots at 1400 feet. No other trends in crown measurements were found from the data. Sugar maple trees in our plots showed light (1 - 30 %) defoliation from pear thrips, bruce spanworm and maple leaf cutter. Other trees on the mountain were more seriously defoliated by pear thrips, as recorded during our aerial survey.

Table 2. Average percent dieback by species and elevation of trees growing in long-term forest health monitoring plots on the west slope of Mount Mansfield, 1993.

SPECIES	ELEVATION	1992 DIEBACK (%)	1993 DIEBACK (%)
BALSAM FIR	3000	5.6	6.8
	3800	18.8	20.5
RED SPRUCE	3000	15.6	11.1
RED MAPLE	1400	3.0	6.0
SUGAR MAPLE	1400	4.2	5.6
	2200	8.3	10.8
YELLOW BIRCH	1400	5.7	5.7
	2200	6.6	7.1
PAPER BIRCH	3000	9.6	8.4
ALL SPECIES	1400	5.3	6.1
	2200	8.6	9.4
	3000	9.0	8.4
	3800	18.8	20.2

Table 3. The percentage of healthy trees, less than 15% dieback, by species and elevation, growing on long-term forest health monitoring plots on Mount Mansfield, 1993.

SPECIES	ELEVATION	1992 HEALTHY (%)	1993 HEALTHY (%)
BALSAM FIR	3000	100	91.3
	3800	54.0	60.6
RED SPRUCE	3000	66.7	77.8
RED MAPLE	1400	100	100
SUGAR MAPLE	1400	100	100
	2200	83.3	100
YELLOW BIRCH	1400	100	100
	2200	94.7	94.7
PAPER BIRCH	3000	88.5	83.3
ALL SPECIES	1400	97.0	100
	2200	90.6	90.6
	3000	89.8	88.5
	3800	54.0	60.6

REMEASUREMENT PLOTS

METHODS

Two hardwood plots were measured four times between mid-June and the end of August, at 3 week intervals, to determine the variability in crown ratings as a function of observation time. The three crown variables recorded were crown dieback, foliage transparency and crown density.

RESULTS AND DISCUSSION

No trend was observed in any of the crown measurements taken four times during the field season (Table 4). Similar results were found in the past two years of this study. Although these results suggest that crown measurements can be taken at any time between June 15 and August 30 with no measurable difference, this may not be true in every year. If a moderate-heavy defoliation was to occur, or any other major stress event during the growing season, it is likely that the time when crown measurements were taken would be important. Since this did not occur during this study, the only conclusion that can be drawn is that under "normal" growing season conditions, crown measurements can be taken at any point within the sampling window. This study will not be repeated in 1994. It is expected that the National Forest Health Monitoring Program will initiated studies to address the issue of Index Period Stability using a wider variety of species and geographic locations, using larger sample sizes.

Table 4. Crown measurement results from two forest health monitoring plots revisited four times during the season. Mount Mansfield, 1993.

DATE	DIEBACK (%)	TRANSPARENCY (%)	DENSITY (%)
6-23-93	6.9	14.0	51.9
7-15-93	6.5	15.2	51.2
8-3-93	6.1	14.9	51.2
8-27-93	6.8	15.1	51.8

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CANOPY ION EXCHANGE MECHANISMS
- 1993 -

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ABSTRACT

Field studies have been conducted to identify mechanisms involved in the regulation of foliar leaching and throughfall chemistry in sugar maple (*Acer saccharum* Marsh.). In 1991 field and laboratory experiments were initiated to determine the relative importance of foliage *vs* stems in canopy ion exchange. This was accomplished by comparing the foliar leachate chemistry of normal sugar maple branches (leaves and stems) with that of artificially-defoliated branches (stems only). Please see the 1991 VMC Annual Report for details of this study and results. A second study designed to examine the contribution of leaf surface deposits to canopy ion exchange was performed in 1992. Leachate chemistry was examined for 30 sugar maple branches treated with an acidic solution, or a deionized water rinse, or left unwashed and then sequentially misted with an artificial precipitation solution at pH 3.8 or 5.3. Treated and untreated (control) branches were collected for tissue ion analysis to examine the relationship between ion concentrations in leachate and foliage. Ion inputs from surface deposits ranged from 0% of the Na to 50% of the Mg (an amount equal to that leached from sugar maple foliage over a 2 hour misting event). Contributions of ions from surface deposits were also relatively large for Ca, K, and NO_3, exceeding 40% of the total amount released. Ions removed from surface exchange sites accounted for 20% and 16%, respectively of the Ca and Na leached and smaller percentages of the Mg, K, and NO_3. Acidity of misting treatments affected the leaching of most ions except NO_3 which was unaffected. In general, more ions were removed from foliage misted with artificial precipitation solution of lower pH. Statistical analyses and interpretation of data from this study will continue in 1994.

INTRODUCTION

Integrated field and laboratory experiments were conducted with sugar maple (*Acer saccharum* Marsh.) during two growing seasons. In 1991, the objective was to identify the relative importance of foliage *vs* stems in canopy ion exchange. This was done by comparing the chemistry of foliar leachate from normal and artificially-defoliated branches, and evaluating the kinetics of ion exchange in each. Please see the 1991 VMC Annual Report for details of methods and significant findings from this portion of the study. Also in 1991, laboratory studies examined the ion transport properties of isolated leaf cuticles from the field foliage in order to calculate ion permeability rates. These data will be used to compare ion flux between cuticle and branch levels. In 1992, a second experiment designed to evaluate the contribution of leaf surface deposits to canopy ion exchange was performed. Because of an unexpected and rather lengthy delay caused by an equipment breakdown, we did not receive laboratory results until 1993. This report will cover progress made during 1993 in analyses and interpretation of data from the 1992 field experiment.

Objectives:

The broad goal of this work is to better understand mechanisms controlling foliar ion exchange (foliar leaching and uptake) in forest canopies. This is important in order to properly assess effects of changing atmospheric chemistry and climate on nutrient cycling processes in forests. Specific objectives of this project include:

1. characterizing the ion exchange rates in sugar maple foliage during artificial precipitation events,

2. identifying the relative importance of possible sources and sinks for exchanging ions,

3. relating tissue ion concentrations to ion exchange rates, and

4. developing a mechanistic model predicting canopy ion exchange rates.

METHODS:

In early August 1992, an experiment designed to evaluate the contribution of leaf surface deposits to canopy ion exchange was conducted. This was done by comparing the chemistry of leachate collected sequentially from sugar maple foliage previously washed with either an acidic solution at pH 3.3 (deionized water adjusted to pH 3.3 with HCl), deionized water, or left unwashed. Foliage receiving the acidic solution or deionized water prewashes were briefly rinsed with deionized water and allowed to dry for 0.5 hr prior to misting. All foliage was subsequently misted for two hours with an artificial precipitation solution at either pH 3.8 or 5.3. These treatments were applied in a randomized complete block design to 30 sugar maple branches chosen from four open-grown trees at the Proctor Maple Research Center (400 m elevation). A total of six treatment combinations (3 prewashes x 2 acid mists) were used and the experiment was replicated five times for a total of 30 branches treated. Treatment solutions were applied as a mist to small branches contained in polyethylene branch chambers (1 x 0.3 x 0.3 m). This was the same branch misting chamber design and collection method used in 1991.

Leachate samples were collected sequentially from each branch chamber over 15 min intervals during the first hour and over 30 min intervals during the second hour for a total of six leachate samples per chamber per replicate. All prewash and rinse solutions were also collected and saved for chemical analysis. Following misting, all treated branches, as well as untreated (control) branches from each tree, were collected for leaf and stem surface area determination and analysis of tissue ion concentrations. Relationships between ion concentrations in the leachate and foliage tissues will be examined. Leaf cuticles were also collected from treated foliaged for further ion permeability measurements. Leachate samples were analyzed for major ions at the Institute of Ecosystem Studies in Millbrook, NY and foliage samples were analyzed at the UVM Agriculture Testing Laboratory.

RESULTS:

Chemical analyses of leachate and foliage samples have been completed. Preliminary analysis of leachate data are summarized here, providing information about the relative contribution of foliage surface deposits to canopy ion exchange. Foliage surface deposits can be considered to be of two types based on their affinity for leaf and stem ion exchange sites. One category includes ions and other substances loosely held on foliage and stem surfaces; these can be easily washed off the surface with water. Alternatively, ions and ionic compounds can be tightly held to cation exchange sites on and within surface materials; these are released through ion exchange, especially with more acidic solutions. The acidic and deionized water (DI) prewashes were designed to elucidate these different mechanisms.

The following table summarizes the proportions of each ion removed from branches by the two prewash treatments, relative to the total removed (prewash + rinse + 2 hr misting). The proportion leached by the DI prewash is assumed to be mainly surface deposits, while that leached by the acid prewash is assumed to include more tightly held ionic substances. The difference, therefore, represents additional ions released under acidic conditions from foliar cation exchange sites.

TABLE 1. RELATIVE CONTRIBUTION OF PREWASH TREATMENT SOLUTIONS TO THE TOTAL AMOUNT OF IONS LEACHED

Prewash:	Ca %	Mg %	K %	Na %	NO_3 %	SO_4 %	Cl %
DI water	44	50	45	0	44	--	29
Acid sol.	64	61	51	16	46	44	--
difference	20	11	6	16	2	--	--

Results from the DI water prewash show that surface deposits, depending on the specific ion, can account for 0% (Na) to an amount equal to that leached from tissues over a 2 hour misting event (Mg). Contributions of ions from surface deposits were generally large for Ca, K, and NO_3, exceeding 40% of the total amount of each ion released. These are overall results, averaged across both acid mist treatments. The difference between the quantity of ions removed by the acid prewash solution and those removed by the DI water prewash represents the percentage of ions tightly attached to surface exchange sites. For example, 20% of the total Ca leached was removed from these exchange sites.

A substantial proportion of these ions were removed from the foliage simply by deionized water, suggesting they are relatively loosely held to leaf and branch surfaces. For some ions, however, such as Ca and Na, a substantial proportion of the ions available for leaching appear to be located on ion exchange sites. This source is presumably particularly important under acidic precipitation conditions. It is notable that the removal of K, which is quantitatively important in throughfall, is affected very little by the acidic prewash.

The pH of acid mist treatments did significantly affect the leaching of Ca and Mg. The relative amounts of ions leached from sugar maple leaf and stem tissues at pH 3.8, compared to pH 5.3, are shown in the following table.

TABLE 2. RATIO OF IONS LEACHED AT pH 3.8 RELATIVE TO pH 5.3

Ca	Mg	K	Na	NO_3	SO_4
2.37	2.75	1.20	1.22	1.00	1.16

More than twice the quantity of Ca and Mg was leached from sugar maple foliage misted with pH 3.8. Similar results were found for sugar maple by Lovett and Hubbell (1991). Under the pH 3.8 mist, significantly more K was leached during the first hour, but differences due to pH were no longer evident following a second hour of misting.

As was found in 1991, NH_4 was consistently taken up by sugar maple foliage (leaves and stems). Although NH_4 was released during misting of defoliated stems in the 1991 study, any NH_4 leaching from stems during this experiment was apparently masked by the uptake by leaves, presumably due to the large amount of leaf surface area compared to stem surface area.

DISCUSSION

Over much of the world forest canopies provide the dominant receptor surface for pollutants deposited to the earth from the atmosphere. As global environmental change occurs, it becomes increasingly important to understand the biological and chemical factors controlling rates of canopy nutrient exchange. It has been hypothesized that acidic deposition or other environmental stresses may affect foliar exchange mechanisms and possibly disrupt forest nutrient cycling processes. The concern is that these stresses might affect the flux of ions between the leaf apoplast and precipitation. This study will provide information about important sources, sinks, and pathways for ion exchange during precipitation. Knowledge of ion exchange rates and direction and mechanisms of transport at the leaf and branch levels are necessary first steps toward understanding nutrient/chemical cycling processes in plants and ecosystems.

Preliminary analysis of the data from these two field experiments indicate that our experimental approach was successful in teasing apart foliar leaching processes, including the relative importance of leaves and stems (1991 experiment) and the effects of acidity and prewashing (1992 experiment). In the first experiment, we showed that branch stems make a disproportionately large contribution (for their surface area) to foliar leaching. In both studies we saw that most of the flux of ions occurs during the first 15 minutes of a precipitation event. In the second experiment, we have obtained information about the sources of leached ions and the relative effect of pH on leaching.

FUTURE PLANS:

Work remaining includes completion of all statistical analyses, determination of relationships between leachate chemistry and canopy tissue ion concentrations, completion of cuticle structure and ionic permeability work, and development of a mechanistic model. The purpose of the model is to predict canopy exchange rates from information on the distribution of leaves and stems, deposition chemistry, and cuticle permeability. In 1994, we will also begin working on a manuscript describing this work and results.

FUNDING SOURCES:

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FOLIAR NITROGEN VARIABILITY AND RESORPTION DURING AUTUMN LEAF SENESCENCE IN SUGAR MAPLE

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ABSTRACT

Resorption in plants represents an important mechanism for reducing nutrient loss during autumn leaf senescence. This study examined nitrogen resorption in sugar maples in the Stevensville Brook Watershed on Mt. Mansfield, VT. Percent resorption can be calculated as the maximum nitrogen pool in green leaves minus the nitrogen pool in leaf litter and the nitrogen leached by rain, all divided by the maximum nitrogen pool. During July and August of 1993 green leaves were collected from the canopies of sugar maple trees to obtain the maximum nitrogen pool. Nitrogen lost during leaf fall and from leaching was estimated from leaf litter and throughfall samples collected in the autumn of 1993. The green leaf tissue, leaf litter and water samples have been analyzed for nitrogen content. Statistical analysis of the resultant data has not yet been completed.

INTRODUCTION

The resorption of inorganic nutrients from senescing leaves in autumn represents an important nutrient conservation mechanism for the plant. There is substantial evidence that trees can reduce nutrient loss during leaf fall through withdrawal of nutrients from senescing leaves before abscission (Bukovac and Wittwer 1965; Ryan 1979; Ostman and Weaver 1982). The evidence for nutrient resorption from tree leaves is suggested by a decrease in absolute amounts of N, P, and K in leaves during senescence (Woodwell 1974). Measurements of resorption rely on the assumption that all nutrients lost from the leaves are resorbed, or leached by rain and appear in throughfall (Eaton et al. 1973).

Nitrogen is an essential plant nutrient often limiting to forest production (Birk and Vitousek 1986), and resorption represents an important mechanism for reducing nitrogen loss during leaf fall. Nutrients resorbed and reused within trees are not subject to mineralization and potential loss from the ecosystem in drainage water. Resorption, storage, and remobilization also allows trees to be somewhat independent of soil supplies of critical nutrients during periods of high demand, such as during springtime flush. Resorption may also dampen fluctuations in annual growth and may provide more uniform growth from year to year (Ryan 1982). The pattern of changes in foliar nitrogen concentration has been reported by Ryan (1979) and Ostman and Weaver (1982) to reach a constant peak level during mid-summer and then to undergo a sharp decrease in concentration during leaf senescence. Resorption can account for most of this decrease in nitrogen and is a key process by which plants achieve maximum efficiency in the use of this element. Ryan (1982) found that resorption during senescence can contribute 34% of nitrogen used annually by trees.

The present study investigated nitrogen resorption in sugar maple on Mt. Mansfield, VT. Previous resorption studies have all been at the stand level, pooling samples from individual trees to obtain a single measure of resorption per hectare. The purpose of this study is to clarify discrepancies found in previous studies (Chapin and Kedrowski 1983; Birk and Vitousek 1986) in determining the relationship between the amount of resorption and leaf nitrogen content. This is done by characterizing tree to tree variability in nitrogen content and resorption within a stand. The objectives of this research are:

1. Establish a relationship between foliar nitrogen content and the amount of nitrogen resorbed.

2. Characterize variation in resorption efficiency of nitrogen during senescence between individual sugar maple trees.

3. Develop a data-set of nitrogen levels in leaf tissue, leaf litter, throughfall, and soil which can be used as baseline information for longterm ecological monitoring.

METHODS

A stand, composed predominantly of mature sugar maple trees, was located off the Butler Lodge trail on the west face of Mount Mansfield at an elevation of 1700 feet. Twenty sugar maple trees were randomly selected on the site for sampling. The average dbh of trees sampled is six inches, and the average height is 63 feet. Included in the understory is sugar maple, striped maple, beech, yellow birch, elderberry, and hobble bush. The site is in the drainage of Nettle Brook, a small tributary to the north branch of Stevensville Brook, with a continuous stage recorder and regular water chemistry measurements. The location of the site is within the planned area for experimental silvicultural treatment in 1996.

Samples of attached leaves were collected once in mid-July and once in mid-August to obtain a measure of the maximum nitrogen pool. Foliar nutrient concentrations are most stable from mid-July to mid-August. Using a combination of pole pruners, ladders and rope climbing techniques, six samples of green foliage from each tree were obtained on each sampling date. One sample each was collected from the north and south sides of the tree, from the lower, middle and upper portions of the canopies.

Leaf litter was collected throughout the leaf drop period, September 20 to October 22, 1993. One litter trap was placed under each tree, positioned so that minimal litter would fall in from surrounding trees. Leaf litter was collected twice a week.

Estimates of resorption should be corrected for nutrient loss in throughfall during the resorption period; however, both Tukey (1970) and Chapin and Van Cleve (1991) found that leaching of nitrogen during resorption is minimal except under high nitrogen concentrations and might be ignored. However, since little information exists on the nutrient cycling of this stand and to evaluate whether correcting for leached nitrogen is important, throughfall was collected under five trees. Two funnel collectors were placed under each tree, one on the north and one on the south side of the tree. The collectors were placed half way between the bole and the canopy drip line and positioned to minimize other tree contributions to throughfall. Stemflow was not collected since it is not important to this study. Two funnel collectors were placed in an open area in close proximity to the site to collect rain as a control.

After each sampling, leaf tissue was run through a leaf area meter, assigned a thrips damage index number, oven dried at 70^{0}C to a constant weight, and ground in a Wiley mill. Total nitrogen was determined with a Leeman Laboratories CHN CE440 Elemental Analyzer. Throughfall and rain samples were weighed for volume and tested for pH. Chloroform (100 ul in 100 ml of sample) was used to preserve the samples which were then refrigerated at 4^{0}C until analysis. Nitrate was analyzed with a Dionex Ion Chromatograph Model 2010i, and ammonium was tested colorimetrically using a Lachat Quick Chem AE flow injection analysis.

Nutrient resorption is the proportion of the leaf nutrient pool that is withdrawn prior to leaf abscission (Chapin and Van Cleve 1991). Nitrogen resorption will be calculated as:

$$\%\ \text{N resorbed} = 100 \times \frac{(\text{max. N mass/leaf area})-(\text{litter N mass/leaf area})-\text{NTF}}{\text{max. N mass/leaf area}}$$

NTF = net throughfall, (Fahey and Birk 1991).

Only those individuals for which throughfall is collected will have net throughfall subtracted from the numerator. Net throughfall is estimated as the nutrient content of precipitation under the canopy, throughfall, minus that of bulk precipitation in the open, rain.

RESULTS

Although statistical analysis has not been completed, data from the green leaf tissue analysis indicate that some degree of variability does exist in nitrogen content between sugar maple trees on the site (Figure 1). The mean nitrogen content for July is 129.47 $\pm$ 18.05 ug/cm^2 leaf area and for August it is 132.95 $\pm$ 14.99 ug/cm^2 leaf area.

These data also indicate that foliar nitrogen content increases with height in the canopy (Figure 2). No difference is discernable between the north and south sides of the trees. However, figure 2 suggests that the maximum foliar nitrogen content might be in August.

All green leaf samples were assigned a pear thrips damage index number, 0 meaning no visible damage through 5 meaning the highest visible damage. Foliage with a higher nitrogen content appears to have more pear thrips damage than foliage with lower nitrogen content (Figure 3).

Results from data on leaf litter and throughfall nitrogen have not yet been analyzed. Therefore, at this time it is difficult to discuss the ecological significance of these data. Further data analysis is also underway for resorption calculations.

FUTURE PLANS

Immediate plans include completion of chemical analysis on rain and throughfall samples and statistical data analysis. In the spring of 1994 soil samples will be collected to gain an indication of site quality and soil nutrient availability. During the summer of 1994 I plan to write and complete my thesis. The site will be marked for future use as a long term monitoring study area. In addition to providing important data on nitrogen resorption processes, these data will also be useful for long term studies.

ACKNOWLEDGEMENT

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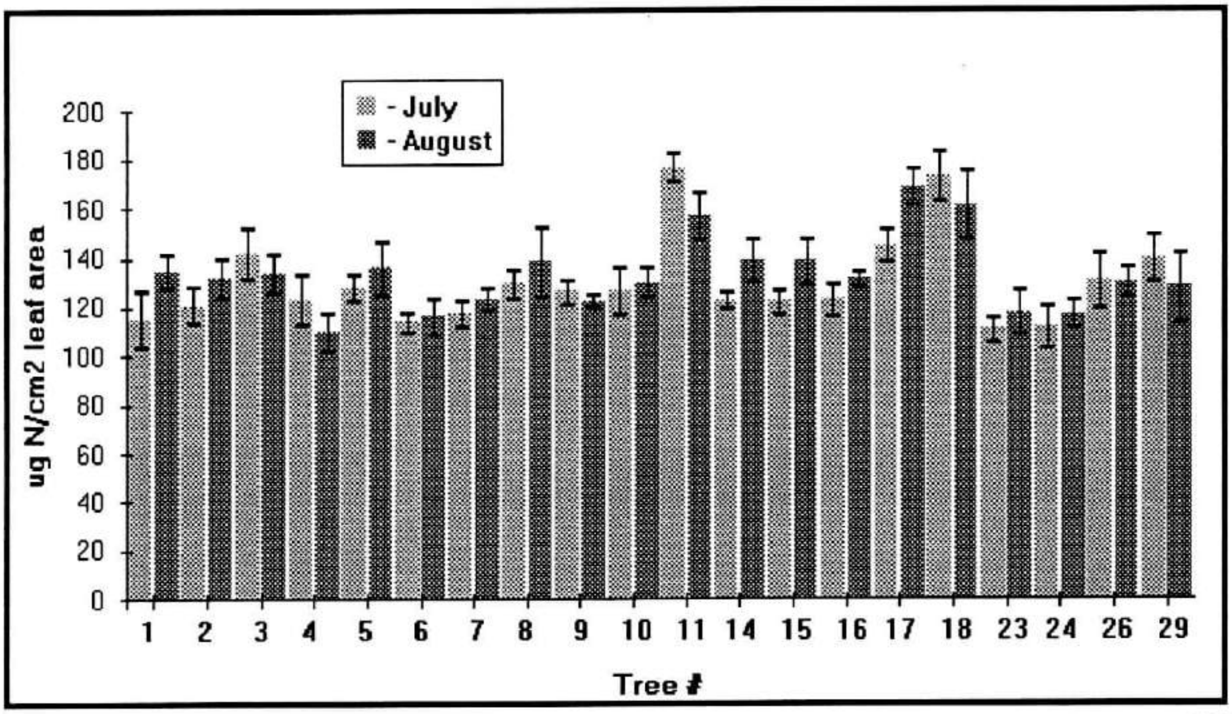

Figure 1. Foliar nitrogen content of individual sugar maple trees for July and August 1993.

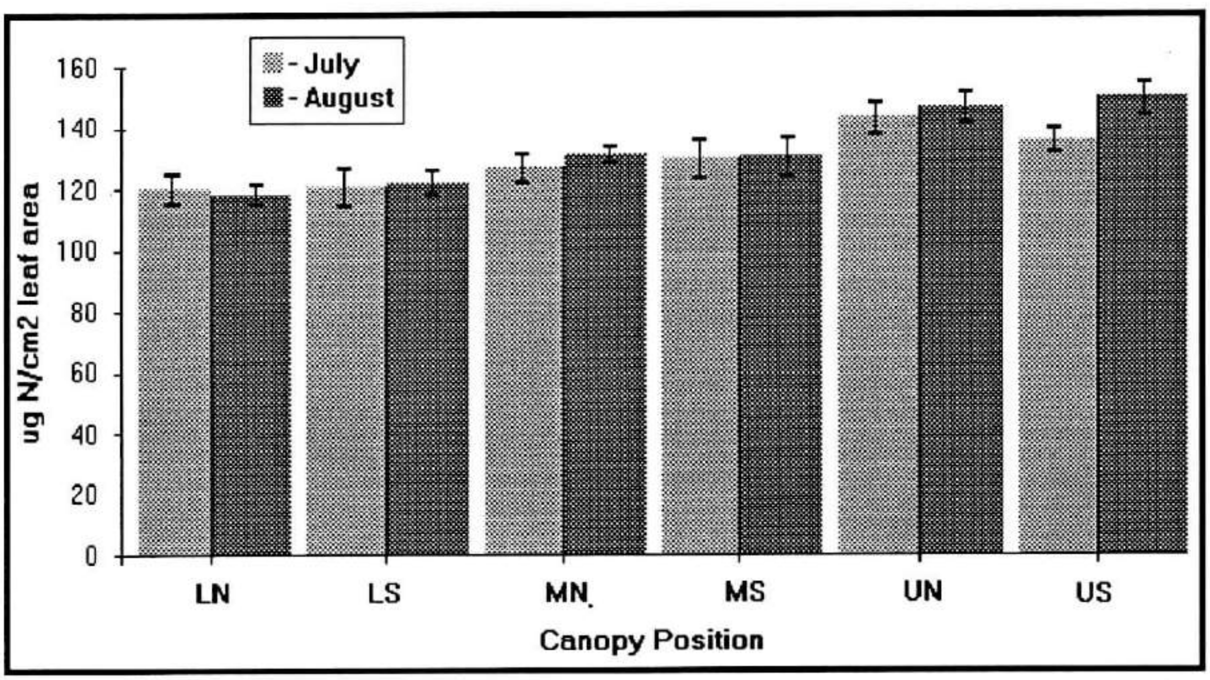

Figure 2. Foliar nitrogen content for different canopy positions in sugar maple during July and August 1993. LN = lower north, LS = lower south, MN = middle north, MS = middle south, UN= upper north, US = upper south.

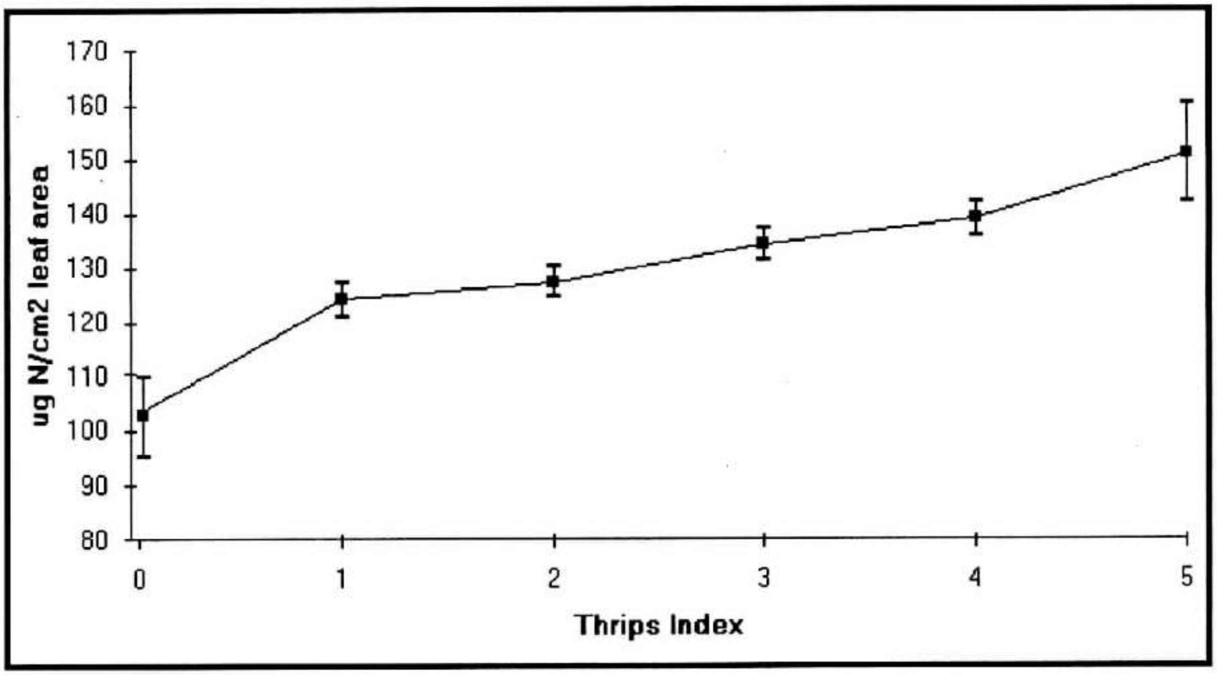

Figure 3. Foliar nitrogen content in relation to pear thrips damage in sugar maple. 0 = no thrips damage and 5 = highest damage.

FOREST CANOPY HEALTH: USE OF A STANDARD PHOTOGRAPHIC METHOD FOR LONG-TERM MONITORING AND EVALUATION

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ABSTRACT

In 1993, canopy photos were taken for the same forest health monitoring plots as in 1991 and 1992 at the July timing. All photos (Ektachrome slides) were compared to 1992 photos from the same points by the slide projection method to determine percent canopy cover. Canopy cover values for the two forest health monitoring sites at 1400 feet elevation decreased 2.7 and 7.2 percent, respectively, from 1992 values. This is attributed to light to moderate defoliation by pear thrips, *Taeniothrips*, inconsequence in 1994. Canopy cover at the non-defoliated 220-foot elevation site was similar to 1992 values.

INTRODUCTION

Forest canopy assessments related to tree health have historically been obtained by visual evaluations done by field personnel trained in how to evaluate such things as dieback, defoliation, and crown transparency. Such procedures lack permanent documentary records, such as photographs, from which future investigators can make comparisons, or check procedures. In 1991 and 1992, a photographic method to quantify canopy cover was developed and published in a manual (Curtis and Kelley, 1993). Canopy assessments were continued in the same plots this year to continue the annual evaluations and maintain long-term documentation of canopy cover changes.

METHODS

Methods were the same as used in 1991 and 1992, except that the number of photo points was reduced from 141 to 73 and photography was timed for late July when canopy cover should be at or near optimum levels. An analysis of 1992 data showed that the number of points per subplot could be reduced from 9 to 5.6 with little change in variation.

Photography

Using a 35mm camera with a 17mm wide angle lens, Ektachrome slides (IS0200) were taken beneath tree crowns by orienting the camera vertically over 73 permanent points established within the following northern hardwood forest health monitoring sites in Underhill, Vermont:

1. North American Maple Project (NAMP 014), Proctor Maple Research Center (PMRC) in Underhill - 25 points.

2. Forest Health Monitoring (VMC1400) at PMRC - 24 points.

3. Forest Health Monitoring (VMC2200) at Underhill State Park - 24 points.

Photographs were taken at the corner stakes plus center stake of each NAMP subplot, and were at a different, but comparable, spacing in the FHM systems. Orange fiberglass rods were used for photo point stakes.

With certain modifications, field procedure was based on a method developed by the Institute for Ecosystems Studies (Fergione, 1985). No weather criterion was applied except to avoid rain and excessive breeze.

The camera, equipped with a right-angle view finder, was mounted on a tripod with the lens facing up and the base of the camera facing true east. This arrangement, with the long axis of the film parallel to the true north-south axis, minimized the period at midday during which the sun might appear in the image. The camera tripod was erected over the photo point such that a plumb bob, hung directly under lens center, would be within 2.5 cm of the base of the photo point stake. Camera height was 1 m from the base of the stake to the optical center of the lens (about 2 cm from the lens front). A meter stick was carried for this purpose. The camera was leveled with a plate-mounted bubble level that was placed on the lens. This adjustment is the most critical for repeated comparisons of images taken from the same point, as small variations in leveling tend to magnify error in portions of the image from the upper canopy. All foliage up to 1 m from the camera lens was removed in an arc containing the image. After set-up was complete, three exposures were taken: one at the camera meter's setting, one a full stop over, and one a full stop under. The overexposures obtained tend to show better color and are useful in revealing leaf damage due to insects, diseases or other factors. Underexposures afford more sky/canopy contrast and are more suitable for image scoring. In cases in which the sun appeared in the picture, it was blocked out with a device consisting of a film canister cap mounted on a wire. While exposures were being made, it was positioned such that the disc, at a distance of 60-70 cm from the lens, blocked out the sun.

Complete notes were taken for each set of exposures, including photo point ID, time of day, an estimate of cloud cover to the nearest 10 percent, f-stop, shutter speed, and exposure number.

Image Analysis

In order to develop a scoring procedure for canopy cover on the slides, a manual/visual method was compared to a computer-image analysis in 1991. The term, canopy cover, is used here to refer to the percent of sky obscured by vegetation, including woody tree parts. The computer analysis system (Swathkit) was more efficient for processing large numbers of slides but with the reduced number of slides in 1993, the manual slide projection method was preferred.

Each slide was projected onto a radial grid composed of 12 concentric circles intersecting with 12 lines radiating from the center. The number of grid intersections (out of 144) falling on visible sky were tallied and then converted to percent canopy cover. Both 1991 and 1992 slides of similar exposure were projected to make the comparisons. Usually the slide least exposed during bracketing at each photo point was selected for best contrast.

RESULTS

The two sites at Proctor Maple Research Center, at an elevation of 1400 feet, decreased in canopy cover compared to 1992 (Figure 1). This is attributed to light to moderate defoliation of sugar maple at this location by pear thrips. This occurred in May, 1993, resulting in smaller than normal leaves on many trees. The VMC 1400 site decreased an average of 7.2 percent in canopy cover while the NAMP 014 site decreased 2.7 percent in canopy cover. This drop in canopy cover was significant (<0.05) for the VMC site (90.9% to 84.4%) and when the VMC plots were combined with the NAMP plots. The decrease was not significant for the NAMP site alone (89.3% to 86.9%) because of an increase in canopy cover for plot 2. This plot has a lot of American beech in the understory which showed a noticeable increase in canopy foliage as viewed in the photographic slides. This increase may have resulted from increased sunlight due to defoliation of the overstory sugar maples.

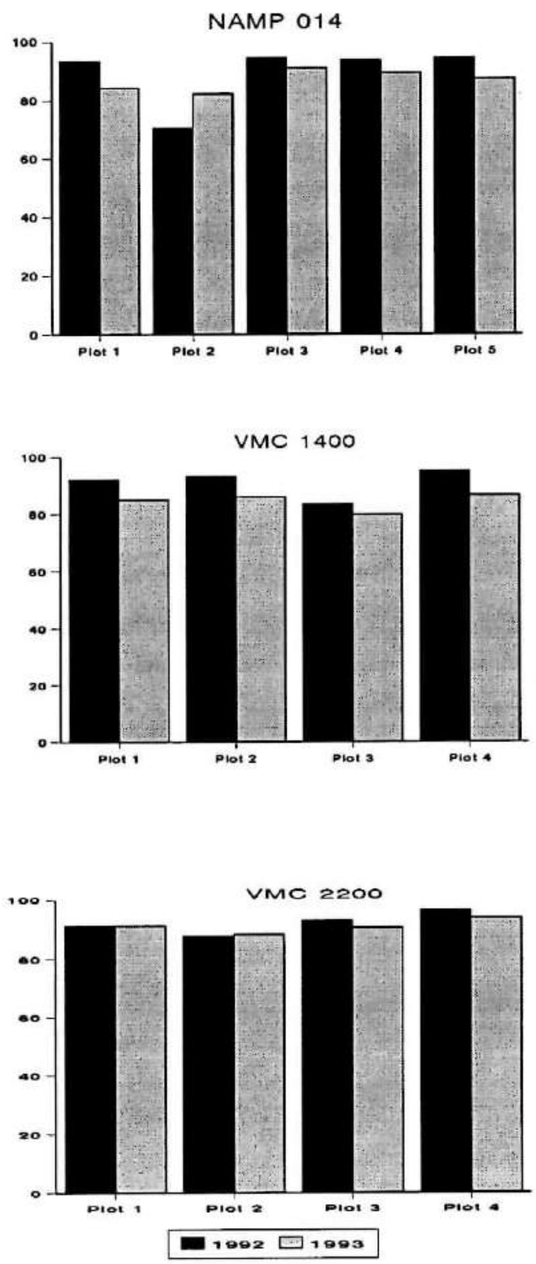

Figure 1. Crown Canopy Cover Changes from 1992 to 1993 in one Namp site and two FHM forest health monitoring sites.

In contrast, the VMC 2200 site at an elevation of 2200 feet had an average canopy cover that was very similar (no significant difference) to 1992 values (Figure 1). Percent canopy cover averaged 91.0 percent in 1993 compared to 92.0 percent in 1992. This site had no visible defoliation in 1993.

Sugar maple foliage transparency ratings (amount of light coming through the foliage) for these three sites done by ground observers in July also showed the greatest increase from 1992 (decrease in foliar density) for the VMC 1400 site.

FUTURE PLANS

The forest health monitoring photo points will continue to be photographed once annually in late July, to obtain archiveable images that can be compared with data since 1991.

CONTEXT

These Vermont monitoring cooperative plots are the only ones being evaluated by this method on an annual basis. The method was field tested in two additional NAMP plots, in Albany and Braintree, in 1993.

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FOREST PEST MONITORING ON MOUNT MANSFIELD

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Vermont Department of Forests, Parks & Recreation

ABSTRACT

Damage to forests is monitored annually to detect changes in populations of major insect pests and to document the incidence of damage from insect, disease, weather or air pollution. Techniques used include pheromone trapping of adult insects, damage assessments on individual trees, aerial surveys to detect damaged areas, and use of plant species sensitive to ozone injury. Five of the six major insect pests monitored on Mount Mansfield decreased to or maintained a low population level in 1993. The exception was pear thrips, which increased in number and in damage across the mountain. Other damage detected in 1993 included winter injury to red spruce, moderate to heavy damage to paper and yellow birch from birch leaf miner and birch leaf skeletonizers, light damage to sugar maple from Bruce spanworm and maple leaf cutter, and ozone injury to one of three bioindicator plant species (milkweed).

INTRODUCTION

Damage to forest trees from insects, diseases and weather has played a major role in widespread tree declines in the past. Monitoring pest population trends and tree damage is conducted annually on a statewide basis to understanding trends in stress agent occurrence in relation to forest health. More recently, concerns about the role of air pollutants in forest health have prompted monitoring of injury to sensitive plants from ground level ozone.

The objective is to monitor trends in the populations of major insect pests, and to document the occurrence of damage to the forests on Mount Mansfield from any detectable stress agents.

METHODS

There are many different methods for measuring forest pest populations. Some forest pests do not yet have reliable, meaningful survey methods developed. At present, the forest pests monitored on Mount Mansfield include: pear thrips (PT), gypsy moth (GM), forest tent caterpillar (FTC), spring hemlock looper (SHL), fall hemlock looper (FHL) and spruce budworm (SBW). Defoliation is monitored on ground plots and from the air.

In addition to forest pest monitoring, plants sensitive to ground level ozone are monitored throughout the growing season to detect symptoms of ozone injury to vegetation at the site.

FOREST TENT CATERPILLAR, SPRING AND FALL HEMLOCK LOOPER, AND SPRUCE BUDWORM

These pests are monitored using pheromone traps [multipher traps with a biolure and a vaportape insecticide], which attract male moths during their flight period, indicating relative population levels in the area. FTC trapping is done using a 5 trap cluster in northern hardwood stands. Spring and fall hemlock looper trapping uses 1 trap per site placed in hemlock or balsam fir stands. SBW trapping uses a 3 trap cluster placed in spruce and fir stands. Protocols for these surveys is in accordance with that of other statewide surveys for these pests (Teillon et al, 1993).

Each trap type is deployed during the adult moth flight period. FTC traps are activated between June 20 and August 15. SHL traps are placed out between April 7 and July 15. FHL catches are made from August 31 to October 31. SBW traps are deployed between June 14 and September 5. Trap catches were returned to the VT FPR Laboratory in Waterbury for identification and counting of target and non-target species.

PEAR THRIPS

PT are a relatively new pest to Vermont sugar maple trees, and therefore lack the depth of understanding in relating trap catches to population densities and subsequent damage. At present 2 different population assessment methods are in use for monitoring this pest: soil samples for fall and winter population estimates and yellow sticky traps for adult population estimates and flight period. Both methods are used at the PMRC [1360 ft. (415 m) elevation].

Soil samples are collected annually in the fall to estimate the overwintering pear thrips population. Field and laboratory protocols previously established for statewide and regional PT surveys are used (Parker et al, 1990). Basically, 5 sugar maple trees were identified in 1988 as reference points for soil sampling, using a bulb planter collecting tool, and resultant damage assessments. Two soil samples are taken at each tree, for a total of 10 samples per site. Damage assessments are made in June.

Yellow sticky traps are used to monitor the timing and duration of adult PT activity above ground, as well as to monitor trends in adult populations over time. Standard protocols were developed under the CAPS program (Cooperative Agricultural Pest Survey Program) and consisted of placement of 4 yellow sticky traps at a 1-m height off the ground in the vicinity of 8 sugar maple trees to be used for monitoring bud phenology and PT damage. Weekly trap collections are made, with trap catch counts verified by VT FPR Laboratory staff. Bud development is monitored weekly, from April to June, and damage ratings are made in June.

GYPSY MOTH

A gypsy moth population monitoring plot is used to monitor trends in GM egg masses counts over time. This plot is located in a small stand of quaking aspen, a preferred host of the GM. Protocols for this survey follow standards used in other Vermont GM focal areas (Teillon et al., 1993). Burlap bands placed at DBH on live trees within a 1/5th acre plot attract egg bearing females, who tend to lay their egg masses under or near the burlap. Counts of egg masses in the fall are used to estimate the resident population.

AERIAL SURVEY OF FOREST DAMAGE

Aerial surveying of the mountain was conducted by trained FPR staff in April, June and August in 1993. The purpose is to detect areas of defoliation, discoloration, heavy dieback or mortality, and determine the cause of this injury. Two observers sketch damaged areas onto topographic maps, indicate possible cause, then later conduct ground surveys to verify location, extent, and possible cause of injury. Procedures are standardized statewide and remeasurement is conducted on 10% of the area evaluated (Teillon et al, 1993).

OZONE BIOINDICATOR PLANTS

Plants sensitive to ground level ozone are monitored throughout the growing season as part of the National Forest Health Monitoring Program (Conkling and Byers, 1993). During the period of maximum exposure, August 8-19, 10-30 plants of sensitive species growing naturally in large openings are examined for symptoms of ozone injury.

At this site, the sensitive species available include milkweed, black cherry and blackberry. Symptoms are verified by a regional expert in ozone injury identification as part of the NFHM.

RESULTS AND DISCUSSION

Five of the six major forest insect pests monitored on Mount Mansfield decreased or maintained a low population level in 1993 (Table 1). The exception was pear thrips, which increased in number and in damage across the mountain (Table 2, Figure 1). No FTC or SHL was trapped at any of the elevations in 1993. The FTC trapping may be due to a failure in the effectiveness of the pheromone lure rather than absence of the insect.

PT populations increased, but the timing of adult activity was also early, allowing entry into open maple buds at a vulnerable stage (Figure 2). The timing of adult activity in relation to sugar maple bud development is key to determining whether or not substantial damage occurs to a stand or individual tree. While only light damage was observed on sample trees, other trees within the stand at PMRC and on the mountain had moderate and heavy defoliation.

Other damage detected on the mountain was winter injury on red spruce, birch leaf miner and birch leaf skeletonizer damage to paper and yellow birch, Bruce spanworm defoliation on sugar maple, and maple leaf cutter damage on sugar maple. Ozone injury was detected on one of the sensitive species monitored (milkweed) but not on the others (blackberry and black cherry) (Figure 3). Damage to sensitive species was also detected at a similar site in Bennington County (Merck Forest, Rupert) where milkweed, black cherry and blackberry exhibited symptoms of ozone injury, while white ash did not. No ozone injury was detected on forest trees through aerial and ground surveys.

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Table 1. Survey results on six forest pests monitored on Mount Mansfield from 1991 to 1993. Results are in total population counted unless otherwise indicated. Blanks for 1991 indicate pests and elevations not included in the survey for that year.

TARGET PEST	SURVEY TYPE	ELEV.	RESULTS IN 1991	RESULTS IN 1992	RESULTS IN 1993
Forest Tent Caterpillar	Pheromone traps	1400' 2200' 3800'	0	0 0 0	0 0 0
Spring Hemlock Looper	Pheromone traps	1400' 2200' 3800'		0 0 -	0 0 0
Fall Hemlock Looper	Pheromone traps	1400' 2200' 3800'		325 521 41	80 - 0
Spruce Budworm	Pheromone traps	1400' 2200' 3800'	19.7 ave	29.0 ave 5.0 ave 2.3 ave	16.0 ave 6.3 ave 1.7 ave
Gypsy Moth	Burlap banded trees	1400'	3 egg masses	4 egg masses	1 egg mass
Pear Thrips	Adult sticky traps	1400'	8	313	1472

Table 2. Pear thrips soil populations and resulting damage to sugar maple foliage at 1400' on Mount Mansfield from 1989 through 1993. Soil populations are recorded in units of pear thrips per bulb planter of soil to allow comparison between other Vermont sites.

YEAR	SOIL POPULATION	RESULTING DAMAGE AFFECTING:				
		TREES			SAPLINGS	SEEDLING
		GENERAL DAMAGE RATING	DIEBACK	TRANS-PARENCY	GENERAL DAMAGE RATING	GENERAL DAMAGE RATING
1989	17.5	LIGHT			MOD.	---
1990	10.6	LIGHT			LIGHT	LIGHT
1991	0.6	LIGHT	15.0	17.0	LIGHT	LIGHT
1992	0.8	LIGHT	12.0	9.0	LIGHT	LIGHT
1993	8.1	LIGHT	22.0	19.0	MOD.	LIGHT

Soil Population based on average number of thrips in 10 bulb planter sized samples
Light Damage = 1-30 % of leaves affected; Moderate Damage = 31-60 % of leaves affected
Dieback = average % of recently dead branches; Transparency = average % of light coming through the foliage

Figure . Areas on Mount Mansfield with damage to trees detected from aerial surveys, 1993.

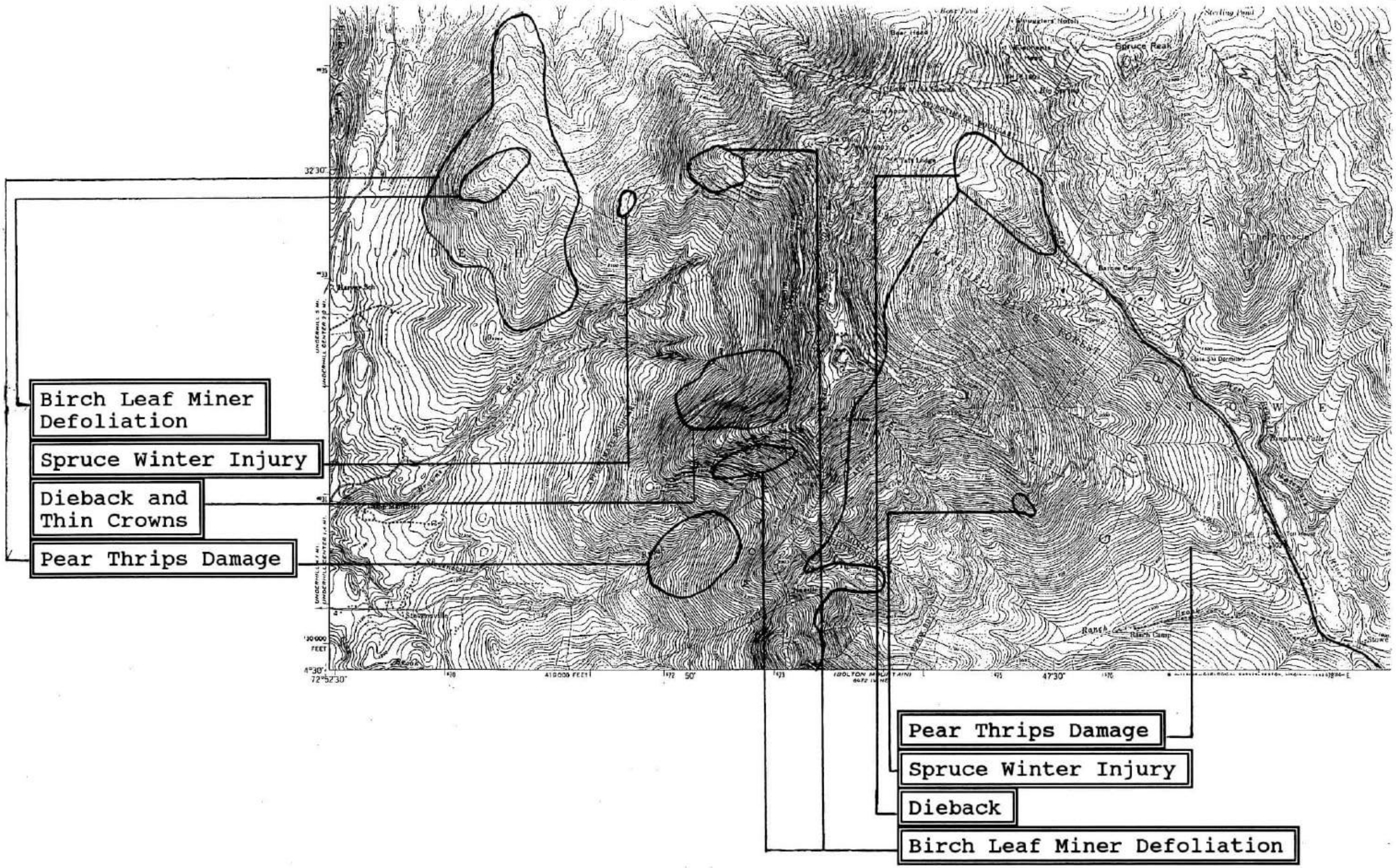


Figure 2. Pear thrips adult activity in 1992 and 1993 compared to sugar maple bud development at the Proctor Maple Research Center, Underhill, VT.

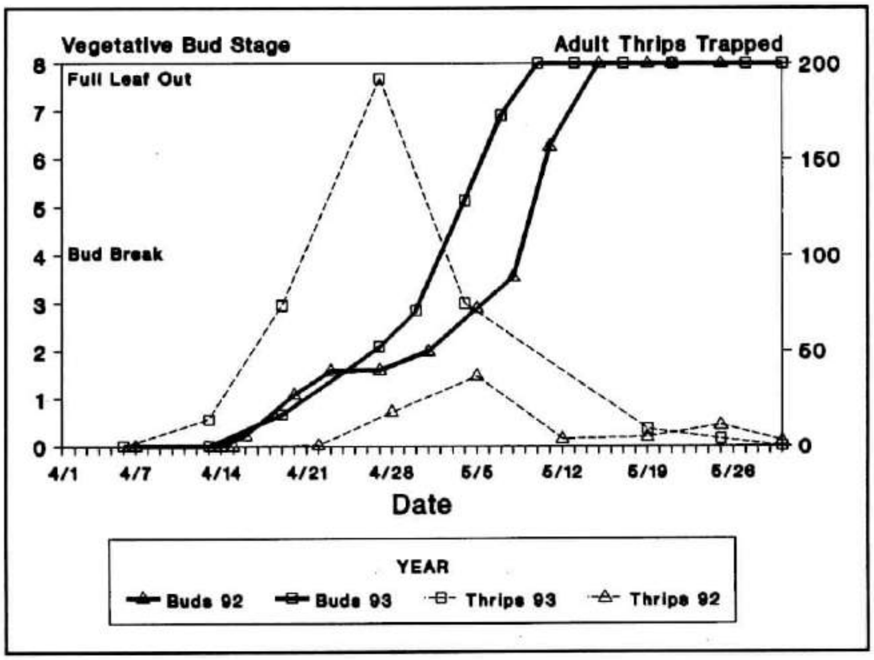
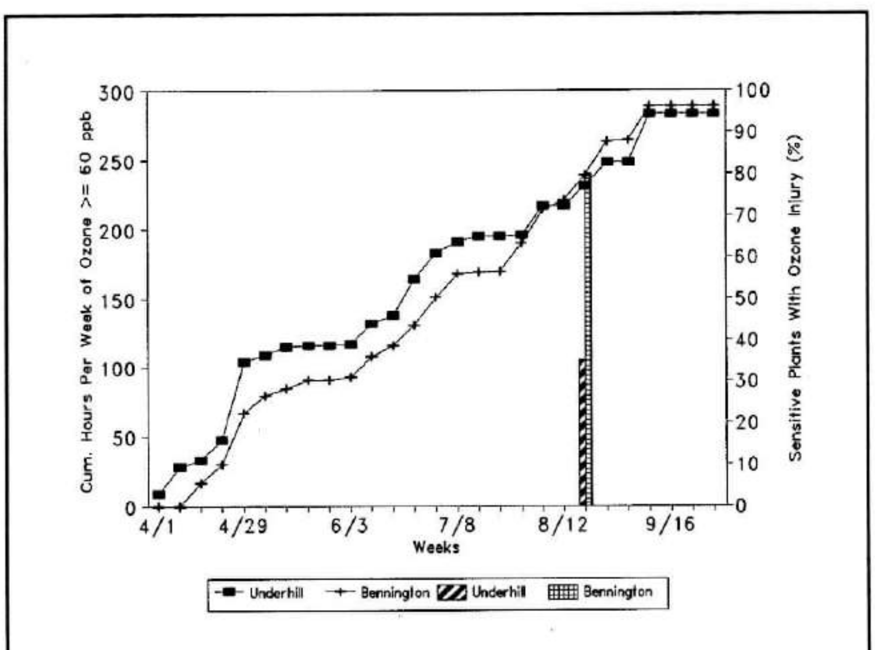


Figure 3. Cumulative weekly ozone levels above 60 ppb from April through September compared with injury observed on sensitive plant species. Underhill and Bennington, Vermont, 1993.



TREE PHENOLOGY MONITORING ON MOUNT MANSFIELD

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ABSTRACT

Monitoring of bud development, leaf size, and fall color and leaf drop is conducted on three tree species growing at two elevations on Mount Mansfield. Yellow birch, American beech and sugar maple trees are monitored at 1400 and 2200' on the west slope of the mountain. The purpose of this monitoring effort is to begin gathering baseline information on these fundamental tree processes. Three years of sugar maple bud monitoring at the Proctor Maple Research Center (1400' elevation) has shown differences in the timing of budbreak of up to 9 days between years, with average budbreak in 1991 occurring on April 29, in 1992 on May 8 and in 1993 on May 2. Full leaf expansion in 1991 occurred around May 12, in 1992 on May 15 and in 1993 on May 9. Full leaf size does not occur, however, until early June. Most trees had similar leaf size in 1993 and 1992, except sugar maples growing at the 1400' elevation, which had smaller leaves in 1993 than in the two previous years. Yellow birch trees growing at 2200' had reduced leaf areas from June to August, due to wind damage and insect defoliation.

INTRODUCTION

Monitoring of bud development, annual leaf size, and fall color and leaf drop began in 1991 on sugar maple and one elevation (1400') on Mount Mansfield. The following year, a higher elevation was added (2200') and two additional hardwood species, yellow birch and American beech. The purpose of this monitoring effort is to begin gathering baseline information on this fundamental tree process. Understanding the timing of developmental stages in relation to weather phenomena (such as early fall frost) and insect pest activity (such as pear thrips feeding in sugar maple buds) improves our knowledge of interrelations between tree physiology and stress events.

METHODS

BUD DEVELOPMENT

Bud development is recorded twice weekly from early April through mid-June using visual ratings as seen through a high powered spotting scope. Five mature trees and 5 saplings of sugar maple, yellow birch and American beech are monitored at two elevations (1400 and 2200') for a total of 30 trees and 30 saplings. Bud stages are recorded from the upper canopy, lower canopy and regeneration from dormancy through full leaf expansion (Table 1). Descriptions of sugar maple bud stages have been modified for yellow birch and beech to allow between year comparisons of bud and leaf development.

LEAF SIZE

Three mid-canopy leaf collections are made annually in late-June, -July, and -August using pole pruners. Ten leaves from 2 sides of each tree are collected, pressed, and measured for leaf area using a leaf area meter.

FALL COLOR AND LEAF DROP

Initial crown ratings were recorded on each tree and sapling in late July to establish a baseline for trees with full foliage. These ratings include crown dieback, foliage transparency and discoloration. From mid-August through October, trees and saplings

Table 1. System for rating vegetative and flowering bud stages for sugar maple, yellow birch and American beech.

VEGETATIVE STAGE	SUGAR MAPLE	YELLOW BIRCH	BEECH
V0	dormant	dormant	dormant
V1	initial swell	initial swell	lengthening
V2	bud elongation		wide at bud base, exaggerated point at tip
V3	green tip stage		scales separating and bending back slightly
V4	bud break, leaf tips expanded beyond the bud tip	bud break, leaf tip exposed	bud break, leaf tips exposed
V5	extended bud break, leaves not yet spread apart	extended bud break	extended bud break
V6	initial leaf expansion	initial leaf expansion	initial leaf expansion
V7	leaves unfolded slightly,but individual leaves not yet expanded	leaves unfolded slightly	leaves unfolded slightly
V8	leaves expanded, may not be full size yet	leaves expanded, may not be full size yet	leaves expanded, may not be full size yet

FLOWER STAGES	SUGAR MAPLE	YELLOW BIRCH	BEECH
F0	dormant	dormant	dormant
F1	initial bud swell		
F2	bud elongation, buds more rounded at tip than vegetative buds	bud elongation	
F3	green tip stage	full bud elongation	
F4	bud break, flower tips show expanded beyond bud tip		
F5	initial flower expansion, flower bundle expands beyond bud scales	initial flower expansion	
F6	full flower expansion and pollen dispersal	full flower expansion and pollen dispersal	full flower expansion and pollen dispersal
F7	flower senescence and drop	flower senescence and drop	flower senescence and drop

were rated for color and leaf drop. Color was rated in 5% categories using the North American Maple Project definitions for discoloration. Leaf drop was measured using crown dieback and foliage transparency ratings as per the National Forest Health Monitoring Program.

RESULTS

SPRING PHENOLOGY

Three years of sugar maple bud monitoring at the Proctor Maple Research Center (1400' elevation) has shown differences in the timing of budbreak between years (Table 2). Average budbreak in 1991 occurred on April 29, in 1992 on May 8 and in 1993 on May 2. Full leaf expansion in 1991 occurred around May 12, in 1992 on May 15 and in 1993 on May 9. Full leaf size does not occur, however, until early June.

Monitoring of sugar maples at the 2200' elevation showed later bud development and leaf expansion. Bud break occurred on May 16 in 1992 and on May 8 in 1993. Full leaf expansion, however, occurred on similar dates in the two years, May 28 and May 26, respectively.

Table 2. Bud development for sugar maple, yellow birch and American beech growing at two elevations on Mount Mansfield, Vermont.

SPECIES	ELEV.	DATE OF BUDBREAK BY YEAR			DATE OF FULL LEAF EXPANSION BY YEAR		
		1991	1992	1993	1991	1992	1993
Sugar Maple	1400	April 29	May 8	May 2	May 12	May 15	May 9
Sugar Maple	2200		May 16	May 8		May 28	May 26
Yellow Birch	1400		May 9	May 3		May 28	May 13
Yellow Birch	2200		May 14	May 8		June 2	June 10
Beech	1400		May 11	May 8		May 20	May 17
Beech	2200		May 19	May 23		June 2	June 10

LEAF SIZE

Most trees had similar leaf size in 1993 and 1992, except sugar maples growing at the 1400' elevation, which had smaller leaves in 1993 than in the two previous years (Table 3). Yellow birch trees growing at 2200' had reduced leaf areas from June to August, due to wind damage and insect defoliation.

Table 3. Average leaf size for 1993 of sugar maple, yellow birch and American beech growing at two elevations on Mount Mansfield, VT.

SPECIES	ELEVATION	AVERAGE LEAF SIZE (cm2) BY DATE		
		June	July	August
SUGAR MAPLE	1400'	33.13	32.92	36.73
	2200'	43.64	39.23	40.41
YELLOW BIRCH	1400'	22.00	17.54	17.11
	2200'	23.62	17.08	11.98
BEECH	1400'	34.71	29.45	31.58
	2200'	30.08	27.15	22.37

FALL COLOR AND LEAF DROP

Initial fall coloration was 1-2 weeks later in 1993 than in 1991 and 1992 (Table 4). Peak color (>50% color) for yellow birch and beech at both elevations was the same as 1992, and lower elevation sugar maple was within a few days of 1991 and 1992. Only the high elevation sugar maple (2200') reach peak color more than one week later in 1993 than in 1992.

The timing of leaf drop was similar between years for all species and elevations (Table 5). Between October 6 and 14, all species and elevations had lost half their leaves, and by October 18, 75% of leaf drop had occurred for all species and elevations.

Table 4. Timing of fall color for three hardwood species at two elevations on Mount Mansfield, VT.

SPECIES	ELEVATION	DATE OF 25% COLOR BY YEAR			DATE OF 50% COLOR BY YEAR		
		1991	1992	1993	1991	1992	1993
SUGAR MAPLE	1400'	Sept. 22	Sept. 19	Oct. 2	Sept. 29	Oct. 6	Oct. 8
	2200'		Sept. 15	Sept. 29		Sept. 26	Oct. 6
YELLOW BIRCH	1400'		Oct. 5	Oct. 5		Oct. 8	Oct. 8
	2200'		Sept. 22	Sept. 24		Sept. 29	Sept. 30
BEECH	1400'		Sept. 22	Sept. 28		Oct. 1	Oct. 1
	2200'		Sept. 25	Oct. 1		Oct. 5	Oct. 6

Table 5. Timing of fall leaf drop for three hardwood species at two elevations on Mount Mansfield, VT.

SPECIES	ELEVATION	DATE OF 50% LEAF DROP BY YEAR			DATE OF 75% LEAF DROP BY YEAR		
		1991	1992	1993	1991	1992	1993
SUGAR MAPLE	1400'	Oct. 12	Oct. 14	Oct. 14	Oct. 13	Oct. 18	Oct. 18
	2200'		Oct. 8	Oct. 8		Oct. 10	Oct. 10
YELLOW BIRCH	1400'		Oct. 11	Oct. 9		Oct. 14	Oct. 13
	2200'		Oct. 8	Oct. 6		Oct. 11	Oct. 10
BEECH	1400'		Oct. 8	Oct. 9		Oct. 11	Oct. 13
	2200'		Oct. 14	Oct. 10			Oct. 16

DISCUSSION

The number and description of bud developmental stages differs between the three hardwood species examined. We have modified the sugar maple bud development rating system to accommodate the development characteristics of the other species. While we will continue to rate bud development according to this system, a further modification could be done to simplify the process and make fewer field visits necessary in monitoring key bud developmental stages. In general, bud development was slightly earlier in 1993 than in 1992. Further analysis of bud development in relation to biologically significant weather events will be made in future years.

One additional year of leaf size information will be collected to establish a solid baseline leaf area for all species and elevations.

In 1993, fall coloration began later than other years. But peak color and leaf drop were closer in timing to 1992.

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Terrestrial Fauna

AMPHIBIAN MONITORING ON MOUNT MANSFIELD

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Abstract:

Populations of all amphibian species are monitored annually on Mount Mansfield to (1) document the occurrence of amphibian species in this area, (2) establish a baseline data set on their distributions and abundances for future analysis of changes in these species, and (3) monitor year-to-year changes in their status. Amphibians are targeted for this kind of study because their unique life-history characteristics, involving close association with both water and soil, as well as yearly breeding activity, makes them especially well suited as an indicator taxa of changes in environmental conditions in forest environments.

Highlights of our activities and results for 1993 include (1) the beginning of active searches at two new sites (Nebraska Notch and the orchard above the Proctor Maple Research Center), (2) the wood frog (Rana sylvatica) appears to have increased in the area and bred successfully at ponds that did not dry up early, (3) the spotted salamander (Ambystoma maculatum) appears to have increased in the area but reproduction was still not successful at breeding pools, (4) the pH of breeding pools increased over last year, (6) we began to measure the intensity of chorusing at frog breeding sites and make morphological measurements of individuals caught in drift fences and on roads, and (7) we have begun the development of a new set of maps for dissemination of species distribution and abundance data. Monitoring efforts have not yet gone on long enough to make any conclusive statements about population trends, but over the past three years there have been apparent increases in the spotted salamander and wood frog, an apparent decline in the redback salamander (Plethodon cinereus), and conflicting information on the red-spotted newt (Notophthalmus viridescens) and the spring peeper (Pseudacris crucifer). We have also begun long-term monitoring of amphibians at Abbey Pond and the Lye Brook Wilderness Area in the Green Mountain National Forest, which will offer is a regional context for our data from Mt. Mansfield.

Introduction:

Amphibians such as frogs and salamanders are ideal indicators of forest health and water quality because their survival depends on clean water and a narrow range of soil and water acidity. Changes in amphibian populations over time may indicate changes in environmental quality that might only be discovered after much longer periods of time and with more expensive monitoring procedures. Also, different species of amphibians are sensitive to different conditions. Therefore, comparing the changes in different species may identify exactly what kind of environmental changes are occurring in the study area. The following report describes our results for 1993 as well as the overall design for our continued monitoring activity.

The purpose of this study is to (1) document the occurrence of amphibian species in this area, (2) establish a baseline data set on their distributions and abundances for future analysis of changes in these species, and (3) monitor year-to-year changes in their status. On-going monitoring of key indicator species will aid in the assessment of changes in their abundance over time.

Methods:

Three techniques are used to inventory the amphibian species in this area and to monitor their abundances. First, four drift fences have been built at three elevations on the west slope: 1200 feet (2 fences), 2200 feet (1), and 3200 feet (1). Each fence, with the exception of the fence at 3200 feet, is made of two 50-foot sections of 20 inch wide metal flashing buried 4 inches below the surface of the ground. The two sections are placed at right angles to each other, resulting in 100 feet of flashing set upright as a 16 inch high fence. Buckets are buried every 12.5 feet on both sides of the fence so that the top edges of the buckets are flush with the ground. The fence at 3200 feet is made of only one 50-foot section of flashing with buckets at 12.5-foot intervals. Amphibians that encounter a fence while moving through the forest will turn to one side and eventually fall into a bucket. The lids are taken off the buckets in the late afternoon on rainy days, and the captured amphibians identified and counted the following morning. The locations of these four sites are indicated on Figure 1.

Second, night-time road surveys are done on rainy nights to identify all amphibians seen on roads and calling in the vicinity of roads. By driving a set route at a constant speed (10 mph), standardized estimates of amphibian abundances and locations of breeding sites can be made throughout the entire area covered by roads. The roads used for these road surveys are indicated on Figure 2.

Third, selected breeding ponds in the area are searched during the breeding season for eggs and males calling for mates. The number of egg masses provide an index of the abundance of each species. In 1993, pools monitored for egg masses and water pH were the West Bank of Harvey Brook, the vernal pool below the PMRC, the pond behind the PMRC sugar shack, the Lake of the Clouds, and Bear Pond.

In addition, active searches, involving turning over rocks and logs, are done irregularly during the day near the drift fences and other selected sites. The number of individuals of each species found in a given area in a given amount of time provide a direct measure of species presence and an index of species diversity and abundance. This technique is used when additional inventory is felt necessary for species or habitats not adequately inventoried by other methods.

The distribution of the methods over the slope of Mount Mansfield is displayed in Figure 3.

Results and Discussion:

We have so far identified 13 species of amphibians from this area, from a total possible of 24 species known from Vermont, 21 of which show evidence of breeding in recent years (Table 1, Figure 4). Six of these 13 were generally common, being observed or heard on almost all visits wherever suitable habitat is found:

Red-spotted newt: adults found in streams and ponds and terrestrial juveniles on roads and in the forest up to 3900 feet.
Redback salamander: found in the forest throughout most of the elevational range of the study area, but not observed above 3200 feet; extremely common.
Northern spring peeper: heard calling regularly from ponds throughout the area, mainly below 2000 feet.
Gray treefrog: heard calling regularly from ponds throughout the area, mainly below 2000 feet.
Wood frog: located up to tree line where breeding ponds occur.
Eastern American toad: concentrated below 2200 feet, but also occasionally found at elevations near 4000 feet.

Five species were locally common, being seen regularly in their limited appropriate habitat:

Spotted salamander: egg masses found in the spring in a few of the ponds in the area.
Northern dusky salamander: streams up to 2200 feet.
Northern spring salamander: streams up to 2200 feet.
Northern two-lined salamander: streams up to 3900 feet.
Green frog: heard calling regularly from ponds throughout the area, mainly below 2000 feet.

The pickeral frog was occasionally observed, but only below 2200 feet. The occurrence of the bullfrog was confirmed by a record at the same site it was heard at in 1991. However, these two observations may be of different individuals that were separately introduced into the area.

We have only three years of data on these species (1991-93). It is too soon to draw any conclusions on trends in their demography; however, the following summarizes what we have observed to date (Table 2-7).

Spring peepers: commonly observed during both night-time road surveys and surveys of breeding choruses. They are by far the most common species observed on the roads and had 15 times the number of choruses (78) than any other species. Data from drift fences and choruses suggest an increase from previous years, but data from night-time road surveys suggest a decline.

Gray treefrogs: observed only twice during searches, but this is expected due to their secretive behavior. Four choruses were noted. Populations are probably too small to assess trends without many more years of data.

Redback salamanders: commonly found in drift fences. There was a possible decline in 1993 from previous years but this species is difficult to see on the roads at night, so our conclusions are based solely on numbers caught at drift fences.

Spotted salamanders: Sixteen individuals were found in drift fences. Egg mass were located in all of the pools and the Lake of the Clouds. A large number of egg mass was seen in one vernal pool, but we don't know if any of them successfully hatched. Reproduction failed at the other sites. Measurements of pH in these ponds indicate that most are very close to the lethal pH measured in other studies (4.0-4.5), suggesting a possible explanation for the low level of successful reproduction. (Of note is that two ponds showed an increase in pH from 1992.) The number of egg masses increased from 1992, suggesting an increase in the number of breeding adults. This corresponds to increases seen in their numbers at drift fences and on night-time road surveys.

Wood frogs: commonly observed on night-time road surveys, surveys for choruses, and in drift fences. Wood frogs successful bred in at least 2 of the 5 ponds studied. Their populations appear to have increased.

We have also completed the development of a new mapping protocol that we will use to summarize and disseminate all data (see Figure 5 for an example of a draft of this map for one species). We plan to have these maps available for all species with current data by Fall 1994.

Future plans:

We plan to continue monitoring the amphibian populations throughout this area following the techniques we have employed so far. We feel confident that we have a complete survey of the species in the study area; therefore, our efforts focus exclusively on monitoring the populations to build a picture of long-term trends in their distributions and abundances. We especially plan to expand our efforts to monitor water quality and breeding success of amphibians in vernal pools and lakes in the area.

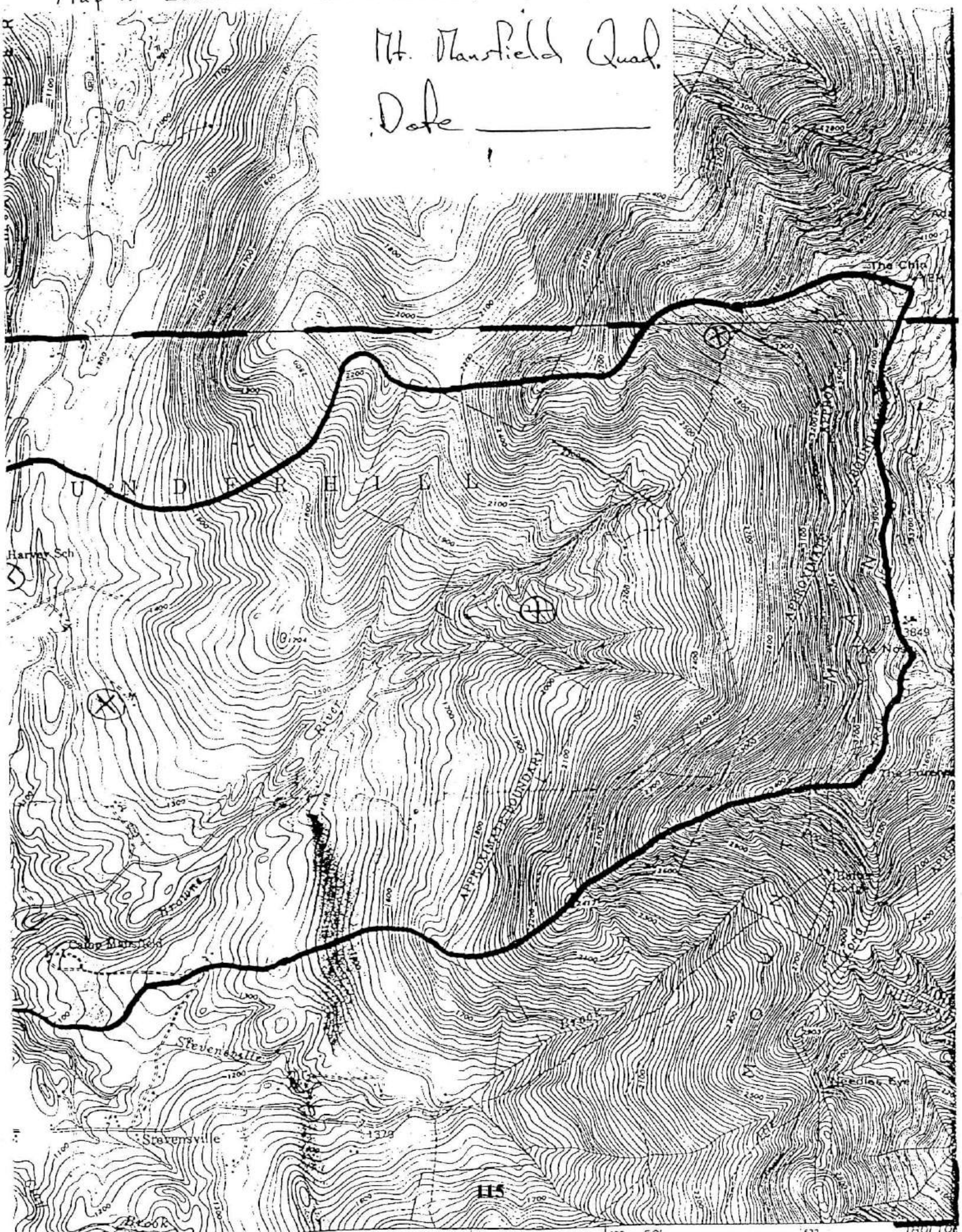
Context:

This work on Mount Mansfield is part of a large survey and monitoring effort we are conducting throughout western Vermont. We have similar sites at several locations in the lowlands of the Champlain Basin, at Abbey Pond in the northern Green Mountain National Forest, and in the Lye Brook Wilderness Area of the southern Green Mountain National Forest. It is our hope that by conducting monitoring activity over a large geographic area that trends in the status of amphibian populations over regional scales can be determined.

Acknowledgments:

Our work on Mt. Mansfield this year was helped a great deal by Mr. Robert Smith at Mt. Mansfield High School, and his students Jason McKnight, Ryan Walker, and Christian Shawn Ohmland. We are extremely grateful for their interest in amphibians at Mt. Mansfield and all their hard work.

Map 1. Location of drift fences (X)



Map 2.
Mt. Mansfield
Road Search Area

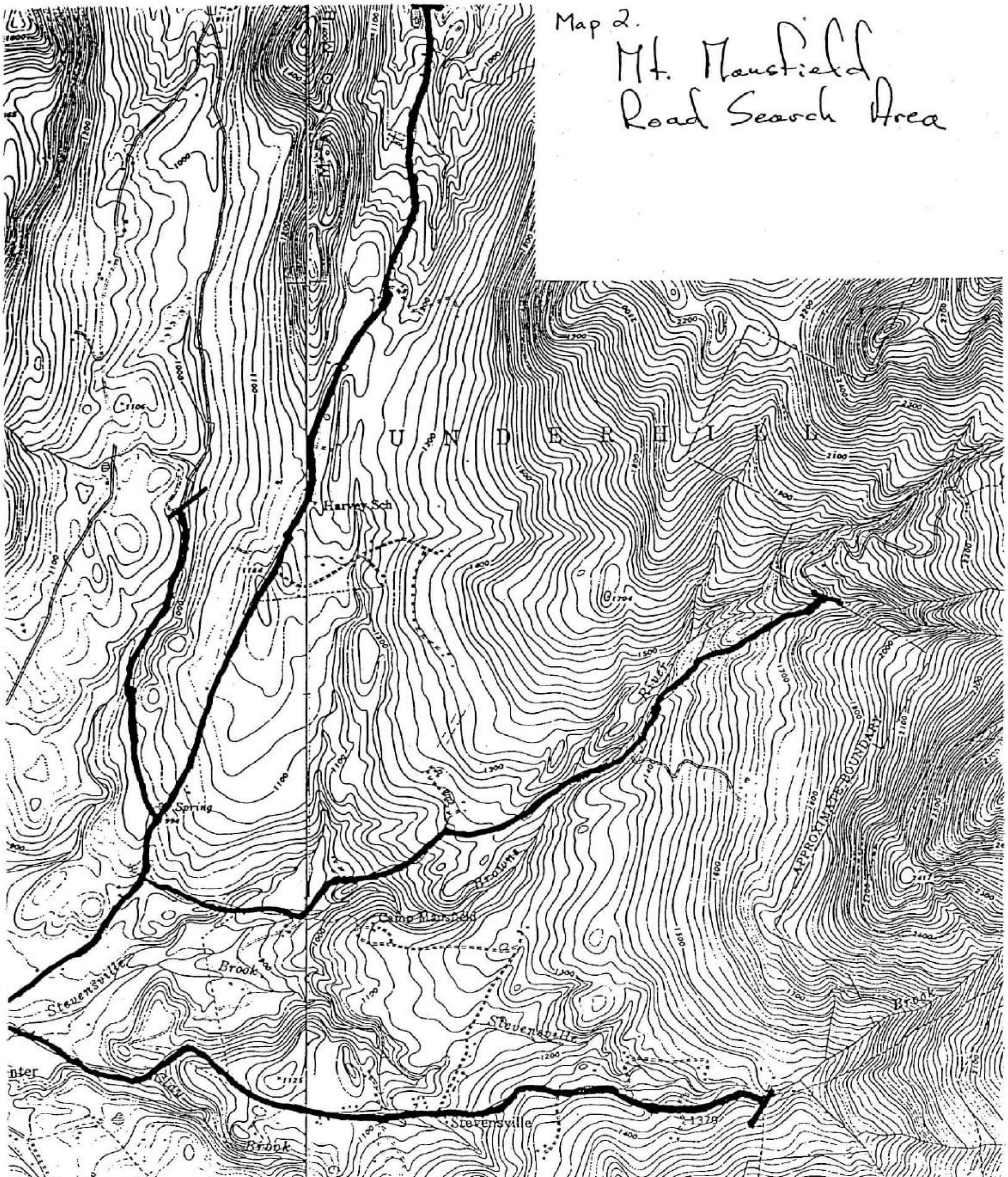
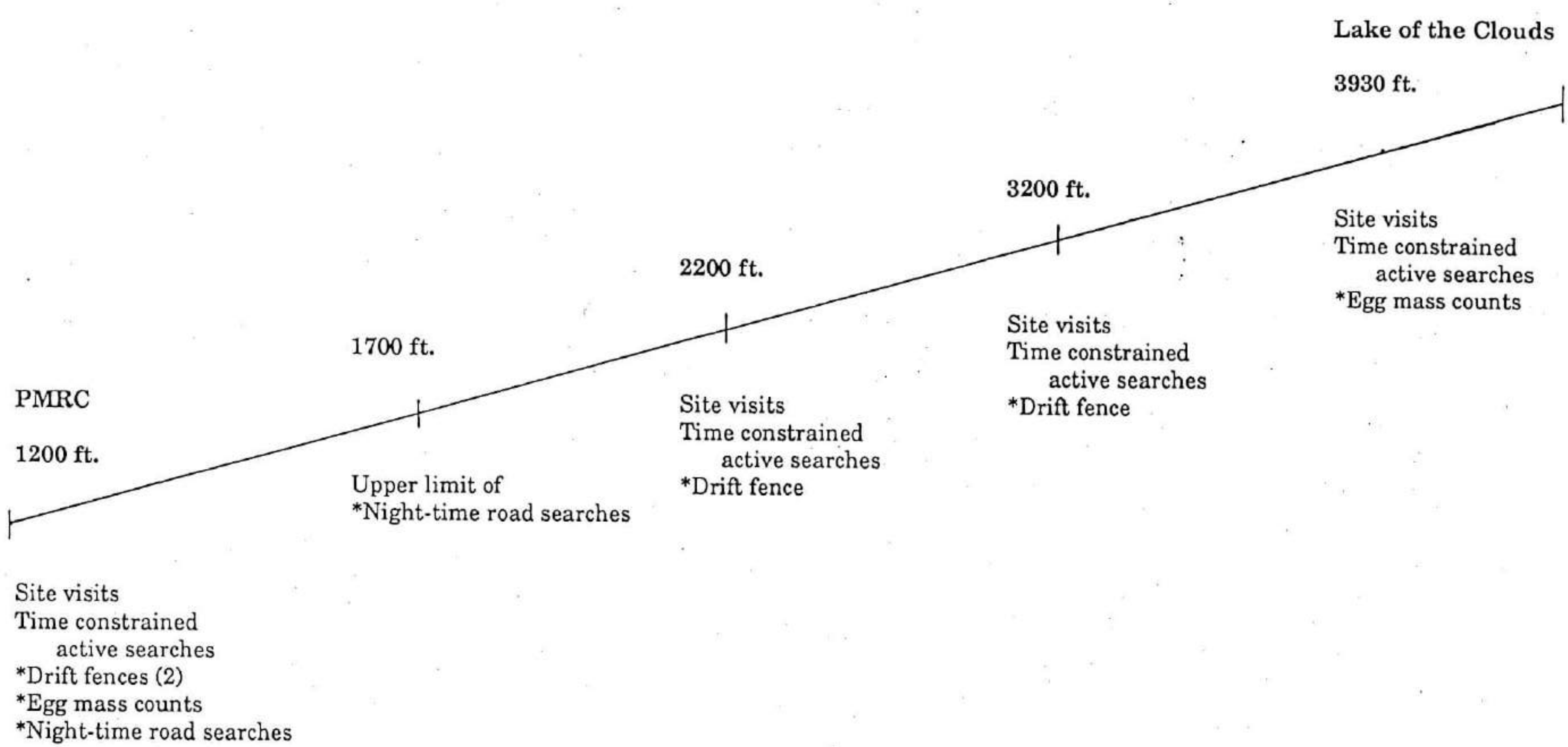


Figure 3

Mt. Mansfield Inventory Methods by Elevation



*method to be continued for long-term monitoring

Table 1. Amphibians of Mt. Mansfield, Vermont, based on surveys from Spring 1991 to Fall 1993, relatively to the known amphibian fauna of Vermont.

Species name	Common name	S^a	C^b
Necturus maculosus	Mudpuppy	U	
Ambystoma jeffersonianum complex	Jefferson salamander complex	U	
Ambystoma laterale complex	Blue-spotted salamander complex	U	
Ambystoma maculatum	Spotted salamander	K	LC
Ambystoma opacum	Marbled salamander	U	
Notophthalmus viridescens	Red-spotted newt	K	A
Desmognathus fuscus	Northern dusky salamander	K	LC
Desmognathus ochrophaeus	Mountain dusky salamander	U	
Plethodon cinereus	Redback salamander	K	A
Plethodon glutinosus	Slimy salamander	U	
Hemidactylium scutatum	Four-toed salamander	U	
Gyrinophilus porphyriticus	Northern spring salamander	K	LC
Eurycea bislineata	Northern two-lined salamander	K	LC
Hyla versicolor	Gray treefrog	K	A
Pseudacris crucifer	Northern spring peeper	K	A
Pseudacris triseriata	Western chorus frog	U	
Rana catesbeiana	Bullfrog	K	R
Rana clamitans	Green frog	K	LC
Rana septentrionalis	Mink frog	U	
Rana sylvatica	Wood frog	K	A
Rana pipiens	Northern leopard frog	U	
Rana palustris	Pickerel frog	K	O
Bufo americanus	Eastern American toad	K	A

Bufo woodhousei	Fowler's toad	U	

Key

a: Status

U	=	unlikely
K	=	known
S	=	suspected, based on published range maps

b: Commonality

A	=	abundant, present in most appropriate habitats and observed on most visits
LC	=	locally common, found regularly but in only a few areas
O	=	occasional, found uncommonly
R	=	observed only once or twice

Figure 4

Results of Mt. Mansfield Inventory 1991-1992
(Data Combined from all Methods)

PMRC

1200 ft.

Ambystoma maculatum
Bufo americanus
Desmognathus fuscus
Eurycea bislineata
Gyrinophilus porphyriticus
Hyla versicolor
Notophthalmus viridescens
Plethodon cinereus
Pseudacris crucifer
Rana catesbeiana
Rana clamitans
Rana sylvatica
Rana palustris

2200 ft.

Eurycea bislineata
Gyrinophilus porphyriticus
Plethodon cinereus
Bufo americanus
Notophthalmus viridescens
Rana sylvatica

Found at 1200 ft. but not located at this elevation.

A. maculatum
D. fuscus
H. versicolor
P. crucifer
R. catesbeiana
R. clamitans

3200 ft.

Notophthalmus viridescens
Plethodon cinereus
Rana sylvatica

A. maculatum
B. americanus
D. fuscus
E. bislineata
G. porphyriticus
H. versicolor
P. crucifer
R. catesbeiana
R. clamitans
R. sylvatica
R. palustris

Lake of the Clouds

3930 ft.

Eurycea bislineata
Notophthalmus viridescens
Ambystoma maculatum
Rana sylvatica
Bufo americanus

D. fuscus
G. porphyriticus
H. versicolor
P. cinereus
P. crucifer
R. catesbeiana
R. clamitans
R. sylvatica
R. palustris

13 species located and confirmed

Table 2

A Comparison of Drift Fence Data for Mt. Mansfield, Vermont, Based on Surveys During the 1991-1993 Field Seasons, Using Balanced* Data.

Species name	Common name	# of ind.		# per trapping*		% of total catch	
		91-2	93	91-2	93	91-2	93
Ambystoma maculatum	Spotted salamander	2	16	.4	1.6	4	12
Desmognathus fuscus	Northern dusky salamander	4	3	.8	.3	9	2
Eurycea bislineata	Northern two-lined salamander	4	4	.8	.4	9	3
Gyrinophilus porphyriticus	Spring Salamander	0	1	0	.1	0	1
Notophthalmus viridescens	Red-spotted newt	11	8	2.2	.8	24	6
Plethodon cinereus	Redback salamander	11	9	2.2	.9	24	7
Bufo americanus	Eastern American toad	2	9	.4	.9	4	7
Pseudacris crucifer	Northern spring peeper	1	24	.2	2.4	2	18
Rana clamitans	Green frog	1	0	.2	0	2	0
Rana palustris	Pickerel frog	1	0	.2	0	2	0
Rana sylvatica	Wood frog	9	60	1.8	6.0	20	4.5
Totals		46	134	9.2	13.4	100	101

*1993 data included trappings during times of the year that were not sampled during 1991-91. These data were not used in this comparison. In addition some data sets from 1993 were not used in order to balance the distribution of data sets at different times of the year. Trappings not included in this comparison are; 5/16, 5/29, 8/11, 8/21, 9/1, 9/28, 10/13 and10/21.

**Number per trapping are rounded to the nearest .1. All other figures are rounded to the nearest whole number.

Total trappings used for this comparison from 1991-1992 = 5 out of 5.
Total trappings used for this comparison from 1993 = 10 out of 15.

Trappings counted are those nights or adjacent nights combined where at least 2 of the three lower traps were opened under appropriate weather conditions for amphibian movement.

Table 3

Total Choruses Surveyed During Night-time Road Searches in the 1993 Field Season

Species name	Common name	# of total choruses		size of choruses		# per NTRS **		% of total choruses	
		91-2	93	91-2	93	91-2	93	91-2	93
Hyla versicolor	Gray tree frog	4	4	*	O L-3 M-1 H	.7	.4	6	5
Pseudacris crucifer	Northern spring peeper	50	78	*	O-5 L-17 M-53 H-3	8.3	7	81	90
Rana sylvatica	Wood frog	8	5	*	O L M-5 H	1.3	.5	13	6
Totals		62	87	*	O-5 L-20 M-59 H--3	10.3	7.9	100	101

Total night-time road searches during 1991-1992 field seasons = 6

Total night-time road searches during 1993 field season = 11

*not differentiated in 1991-92

**Number per NTRS are rounded to the nearest .1. All other figures are rounded to the nearest whole number.

Table 4

A Comparison of Night -time Road Search Data for Mt. Mansfield, Vermont, Based on Balanced Surveys

During the 1991-1993 Field Seasons.

During the 1993 field season a greater number of NTR searches were performed than during the two previous seasons combined. Of more importance is the fact that some of the searches were performed during times of the year which were not sampled during the first two years. This would have the effect of altering the species percentages toward the later breeding and mid-summer species. To fairly compare these two data sets we only include data from April and May of each year.

Individuals

Species name	Common name	# of ind.		# per NTRS **		% of total count	
		91-2	93	91-2	93	91-2	93
Ambystoma maculatum	Spotted salamander	0	6	0	1.5	0	4
Gyrinophilus porphyriticus	Spring salamander	1	0	.2	0	1	0
Notophthalmus viridescens	Red-spotted newt	2	23	.4	4.6	2	15
Bufo americanus	Eastern American toad	14	16	2.8	3.2	11.0	11
Hyla versicolor	Gray treefrog	0	2	0	.5	0	1
Pseudacris crucifer	Northern spring peeper	93	43	18.6	8.6	73	29
Rana catesbeiana	Bullfrog	1	0	.2	0	1	0
Rana clamitans	Green frog	2	5	.4	1	2	3
Rana palustris	Pickerel frog	0	3	0	.6	0	2
Rana sylvatica	Wood frog	14	53	2.8	10.6	11	35
Totals		127	151	25.4	30.2	101	100

Number of night-time road searches used for this comparison from the 1991-1992 field seasons = 5 out of 6.

Number of night-time road searches used for this comparison from the 1993 field season = 4 out of 11.

**Number per NTRS are rounded to the nearest .1. All other figures are rounded to the nearest whole number.

Table 5

1993 Egg mass Data from Mt. Mansfield

Site No.	Location/Date	# of A. mac. egg masses	mean # of eggs	# of R. syl. egg masses	mean # of eggs	mean pH
1	Bear Pond					
	5/18	26	140	20		6.9±.2
2	West bank of Harvey Brook					
	4/26	8		0		
	5/6	9		0		6.2 ±.3 (6.1 in mass)
	5/25	4	28±3.3	0		
	6/9	1	50	0		
	7/7	0		0		
3	Vernal pool below PMRC					
	4/26	7	77±2.4	36	403±14.0	
	5/6	6		30		4.3±.5 (3.6 in mass)
	5/25	12	75±5.6	tadpoles		
	6/9	6	67±4.8	tadpoles		5.1±.7
	7/7	dried egg masses				dry
4	Pond behind sugar shack					
	4/26	0		82	400 (n=1)	
	5/6	6		tadpoles		4.8±.4
	5/25	3	42.3±5.9	tadpoles		
	6/9	0		tadpoles		6.2±.9
	7/7	0				almost dry
5	Lake of the Clouds					
	5/8	12	52.5±4.5	46	400 (n=1)	4.9±.6
	6/2	1	80	2	285±15	5.0±.2
	6/24	0		2	130±3.8	5.0±.5

Table 6

A Comparison of 1992 & 1993 Egg mass Data from Mt. Mansfield

	A. maculatum				R. sylvatica				pH	
Site	**High # of egg masses**		**Mean # of eggs at peak**		**High # of egg masses**		**Mean # of eggs at peak**		**Range of mean pH**	
	1992	1993	1992	1993	1992	1993	1992	1993	1992	1993
West Bank of Harvey Brook	7	9	51.3	28	0	0			?	6.9
Vernal pool Below the PMRC	18	12	?	75	36	36	?	403	?	4.3-5.1
Pond Behind the Sugar Shack at PMRC	3	6	69.3	42.3	hatched	82	?	400	4.4	4.8-6.2
Lake of the Clouds	2	12	55	52.5	22	46	415	400	4.58	4.9-5.0

Table 7

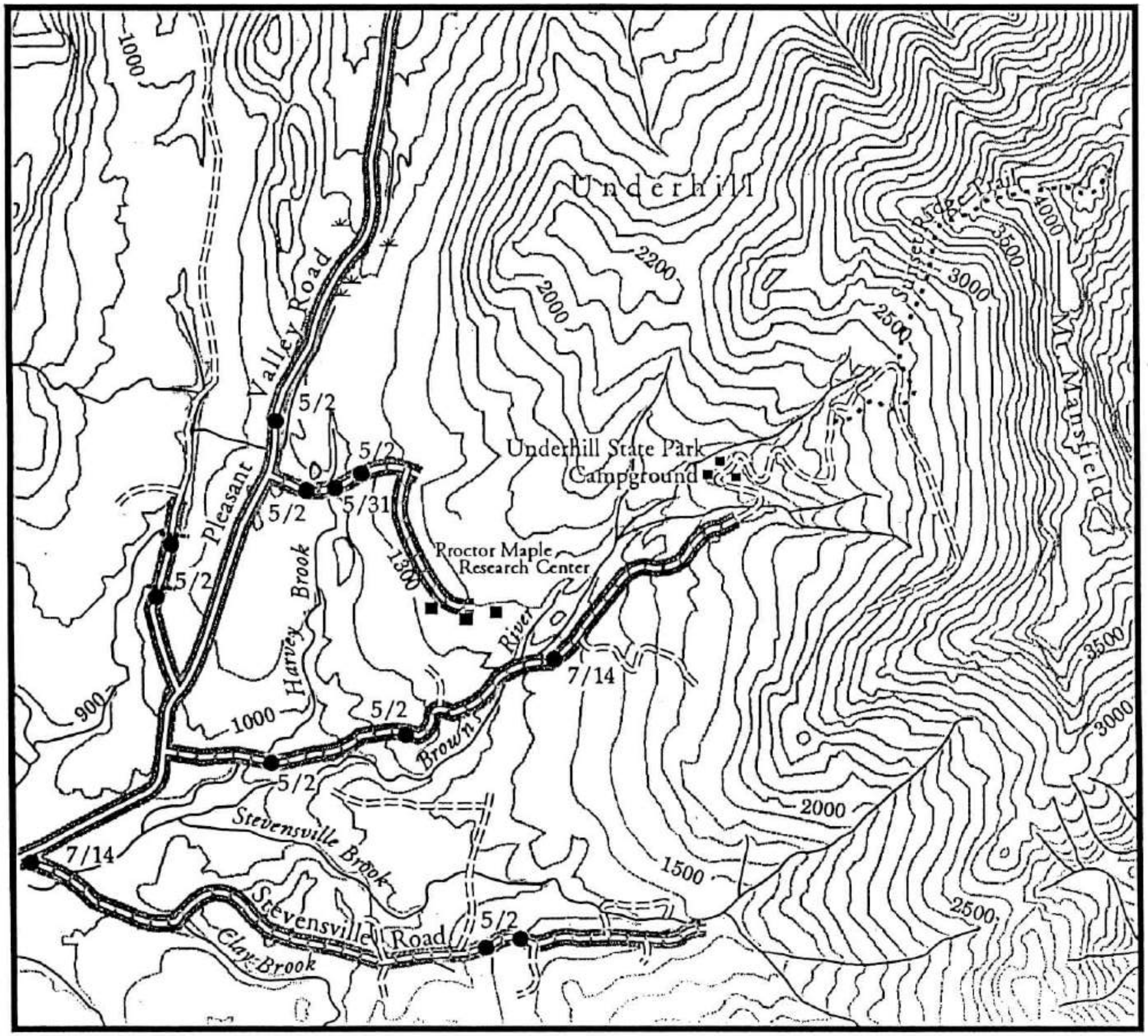
Summary of Population Changes of Selected Species, Between the 1991-2 and 1993 Field Seasons as Suggested by Three Indicators at Mt. Mansfield Vermont

Species shown are only those species whose index changed by 1.0 or greater by any one method. Only one species shows nonconflicting evidence of population growth by more than one index, and none show a decline. However, these results are too short term to suggest or discount any meaningful trends caused by anthropogenic causes. We suspect that the effects of natural environmental changes such as breeding conditions are likely to have a larger short term impact on populations. Natural population changes of these magnitudes have been shown to occur annually in some amphibian species. These results only suggest species to watch.

There were no significant, site wide population changes indicated through egg mass counts.

Species	Drift Fence Indices Using Balanced Data in Individuals per trap-night	Night-time Road Search Indices Using Balanced Data in Individuals per NTRS	Night-time Road Search Indices Using Balanced Data in Choruses per NTRS	Thoughts
A. maculatum	up 1.2	up 1.5	n/a	appears real
N. viridescens	down 1.4	up 4.2	n/a	go figure, artifact of search image?
P. cinereus	down 1.3	insufficient data	n/a	unfortunately very difficult to see on roads
P. crucifer	up 2.2	down 10.0	up 4.3	go figure
R. sylvatica	up 4.2	up 7.8	down .3	age class difference?, very sensitive to sampling times
Totals for all species	up 4.2	up 5.8	up 3.1	appears real

Figure 5



Bufo americanus

(American toad)

Results of Night-time Road Searches conducted from

May 31, 1991 to July 14, 1992

Mount Mansfield Road Search

Underhill, Vermont

- ● an individual
- road search area
- walk area

Road Search Dates & Number Located

	Dates	Indiv.
1991	5/31	1
1992	3/26	0
	4/07	0
	4/22	0
	4/24	0
	5/02	9
	5/27	0
	7/14	2
Totals	8	12

N MN 15°

0 .5 1

kilometers

contour interval 100 feet

FOREST BIRD SURVEYS ON MT. MANSFIELD

Christopher C. Rimmer
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Woodstock, VT 05091

Abstract: Censuses of breeding bird populations on two Mount Mansfield sites were conducted for a third year in 1993. One site in Underhill State Park at 650 m elevation consisted of mature northern hardwoods, while the second site on the Mt. Mansfield ridgeline at 1160 m elevation consisted of subalpine spruce-fir. Ten-minute counts at each of 5 sampling points in the two habitats were conducted twice during June. Fourteen species were recorded at Underhill State Park, with a maximum of 70 individuals on 28 June and a mean of 67.5 for both visits. Relative abundance indices of several common species at Underhill State Park revealed generally lower densities there than at other northern hardwoods study sites in Vermont. Reasons for this are probably related to site-specific habitat characteristics. Fifteen species were recorded on Mt. Mansfield, with a maximum of 104 individuals on 24 June and a combined mean of 96. Species diversity and numerical abundance were lower at both sites in 1993 than in 1992. The causes of this decrease, whether reflecting actual changes in bird populations or an artifact of differing sampling conditions between the two years, are not entirely clear. Declines at both sites were more pronounced among species occurring at low densities. Populations of the most abundant species at each site have not changed markedly in three years.

FOREST BIRD SURVEYS ON MT. MANSFIELD

Introduction: In 1993, breeding bird censuses were conducted for a third consecutive year on two permanent study sites on Mt. Mansfield, as part of a long-term Vermont Forest Bird Monitoring Program conducted by the Vermont Institute of Natural Science (VINS). This program was initiated in 1989 with the primary goal of conducting habitat-specific monitoring of forest interior breeding bird populations in Vermont and tracking long-term changes. As of 1993, VINS has selected, marked and censused 17 permanently protected sites of mature forest habitat in Vermont. The specific objectives of the Mt. Mansfield study include: 1) adding a bird monitoring component to the integrated ecological research being conducted under the VMC; 2) adding two study sites to VINS' statewide monitoring program; and 3) sampling bird populations in the high elevation spruce-fir zone.

Methods: Survey methods were identical to those in 1991 and 1992. Each site consists of a series of five sampling points spaced 200-300 meters apart. Preliminary site visits were made in late spring to check the condition of vinyl flagging and metal tree tags. Each site was censused twice during the height of breeding activities in June. Each census consisted of 10-minute counts of all birds seen and heard at each of the five sampling points. Field data were transcribed onto standardized forms and subsequently computerized, using DBASE3. Vegetation sampling was postponed until 1994, pending development of a continentwide, standardized protocol for measuring habitat in relation to bird diversity and abundance.

Results and Discussion: Overall numerical abundance was significantly lower at both sites in 1993 than in 1992, although somewhat higher than in 1991 (Table 1). Species diversity also dropped at the two sites from 1992. Fourteen species were recorded at Underhill State Park, with a maximum of 70 individuals (111 in 1992) on 28 June and a mean of 67.5 (103.5 in 1992) for both visits (Table 2). Declines at the Underhill site were more pronounced among species occurring at low densities and in fewer than three years than among those recorded at higher densities and in all three years. Of the five most abundant species (Red-eyed Vireo, Black-throated Warbler, Black-throated Green Warbler, Ovenbird, and Canada Warbler), only two declined in 1993, and only Black-throated Blue Warblers decreased significantly (41%) in number. However, four species recorded at low densities in 1991 and 1992 dropped out completely in 1993, and an additional nine species previously recorded only in 1992 either declined (n=5) or went undetected (n=4) in 1993 (Table 1).

Comparing 1991-93 means of eight species at Underhill State Park and at VINS' five other northern hardwoods sites reveals generally lower densities at Underhill (Table 3). Red-eyed Vireos, in particular, occur at surprisingly low density at the Underhill site. Populations of Black-throated Blue Warblers and Ovenbirds, while low, fall within the ranges recorded at other northern hardwoods sites. Black-throated Green and Canada warblers, in contrast, are both relatively abundant at Underhill. It is difficult to advance an explanation for these between-site differences, given the marked variation that exists within each species over the six sites (Table 3). Bird populations undoubtedly vary with site-specific habitat characteristics, such as relative proportions and sizes of dominant hardwood species, proportions of mature spruce trees, and density and composition of the understory shrub layer. We anticipate that detailed habitat sampling in 1994 will provide insights into differences in the composition and relative abundance of bird populations among all sites.

Fifteen species were recorded on Mt. Mansfield in 1993, with a maximum of 104 individuals (141 in 1992) on 24 June and a combined mean of 96 (133 in 1992). Of nine species recorded in each year since 1991, eight declined from 1992 levels (Table 4). However, five of these decreasing species occurred in numbers greater or equal to those recorded in 1991. Four of the five most abundant species at the site (Winter Wren, Yellow-rumped Warbler, Blackpoll Warbler, and White-throated Sparrow) changed relatively little, while Gray-cheeked [Bicknell's] Thrush numbers dropped by 35% (Table 4). Strong westerly winds on both count dates may have hindered song behavior and detectability at two sampling points on the mountain's west slope. Counts of thrushes may have been particularly influenced by this.

The changes in bird populations recorded at Underhill State Park and Mt. Mansfield in 1993 may have been influenced by a combination of factors. Changes in insect food availability, migration or breeding season weather, interspecific competition, overwinter survival, or habitat changes can all cause short-term population fluctuations. It is also possible that bird populations have changed little since 1991, and that variable detection rates between years, based on weather or breeding chronology, have exaggerated real changes. Small sample sizes of many species preclude meaningful analysis of their population trends. However, it appears that populations of the most abundant species at each site have not changed markedly in three years. The sharp declines of some species, such as Swainson's Thrush on Mt. Mansfield and Winter Wren at Underhill State Park, must be interpreted cautiously. With only three years of census data, it is premature to draw conclusions. Several years of additional data collection, and their correlation with other VMC data, will be necessary to elucidate population trends of various species and groups at the two sites.

Acknowledgements: Funding for VINS' 1993 work at these two sites was provided by the VMC. Support for monitoring at VINS' additional 15 Vermont study sites was provided in part by a grant from the Merck Family Fund. Chip Darmstadt deserves special thanks for collecting field data at Underhill State Park.

Table 1. Maximum counts of individual birds recorded on Mt. Mansfield and Underhill State Park, 1991-93.

Species	Mansfield 91	Mansfield 92	Mansfield 93	Underhill 91	Underhill 92	Underhill 93
Yellow-bellied Sapsucker					2	
Northern Flicker			1			2
Pileated Woodpecker				2	1	2
Yellow-bellied Flycatcher			2			
Blue Jay		1				
Common Raven			1			
Black-capped Chickadee					2	1
Red-breasted Nuthatch		2	3			
Winter Wren	20	18	14		12	4
Ruby-crowned Kinglet		4				
Veery				2	2	
Gray-cheeked Thrush	10	23	15			
Swainson's Thrush	6	16	2		2	
Hermit Thrush					7	2
Wood Thrush				1	2	
American Robin	2	7	2			
Cedar Waxwing		1	4			
Solitary Vireo				1	4	
Red-eyed Vireo				5	8	8
Blue-winged Warbler					2	
Nashville Warbler	4					
Magnolia Warbler	2	4				
Black-throated Blue Warbler				11	17	10
Yellow-rumped Warbler	22	21	16			4
Black-throated Green Warbler				9	14	12
Blackpoll Warbler	20	18	18			
Black-and-white Warbler					6	4
American Redstart					6	
Ovenbird			2	7	20	22
Canada Warbler				5	8	8
Rose-breasted Grosbeak				7	3	
Lincoln's Sparrow	4					
White-throated Sparrow	14	28	26	2		2
Dark-eyed Junco	8	17	10		6	2
Purple Finch	2	8	2			
Pine Siskin		1				
Evening Grosbeak		2				
Number of individuals	114	171	118	52	112	83
Number of species	12	16	15	11	18	14

Table 2. Numbers of individual birds recorded in Underhill State Park in 1993. Maximum count for each species represents relative abundance index to be used in population analyses.

Species	10 June	28 June
Northern Flicker		2
Pileated Woodpecker		2
Black-capped Chickadee	1	
Winter Wren	4	4
Hermit Thrush		2
Red-eyed Vireo	8	6
Black-throated Blue Warbler	6	10
Yellow-rumped Warbler	4	
Black-throated Green Warbler	12	12
Black-and-white Warbler	4	4
Ovenbird	16	22
Canada Warbler	8	2
White-throated Sparrow	2	2
Dark-eyed Junco		2
Number of individuals	65	70
Number of species	10	12

Table 3. Mean 1991-93 relative abundance indices of eight species found on VINS' northern hardwoods study sites, compared with 1991-93 means from Underhill State Park.

Species	DB	SH	TC	CW	MP	ALL[a]	UN
Winter Wren	6.7	0	8.0	6.7	2.7	4.4	5.3
Wood Thrush	6.0	4.7	7.0	0	0	3.5	1.0
Red-eyed Vireo	20.0	26.0	19.3	23.3	22.0	22.1	7.0
Black-thr. Blue Warbler	17.7	17.7	10.7	19.0	12.0	15.4	12.7
Black-thr. Green Warbler	5.0	2.0	4.7	13.3	15.0	8.0	11.7
Ovenbird	25.0	13.3	21.3	29.3	21.0	22.0	16.3
Canada Warbler	0.7	0	3.7	0	1.0	1.1	7.0
Rose-breasted Grosbeak	9.7	6.7	6.3	0	3.3	5.2	3.3

[a] ALL = pooled mean of first five sites, excluding UN.

DB = Dorset Bat Cave (Dorset)
SH = Sugar Hollow Preserve (Pittsford)
TC = The Cape (Chittenden)
CW = Concord Woods (Concord)
MP = May Pond Preserve (Barton)
UN = Underhill State Park (Underhill)

Table 4. Numbers of individual birds recorded on Mt. Mansfield in 1993. Maximum count for each species represents relative abundance index to be used in population analyses.

Species	10 June	24 June
Northern Flicker	1	
Yellow-bellied Flycatcher		2
Common Raven		1
Red-breasted Nuthatch		3
Winter Wren	14	12
Gray-cheeked Thrush	14	15
Swainson's Thrush		2
American Robin	2	
Cedar Waxwing		4
Yellow-rumped Warbler	13	16
Blackpoll Warbler	18	15
Ovenbird		2
White-throated Sparrow	16	26
Dark-eyed Junco	10	4
Purple Finch		2
Number of individuals	88	104
Number of species	8	13

Genetic variation in a long-distance migrant bird,
the Bicknell's Thrush (*Catharus [minimus] bicknellii*).

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Abstract

I hope to assess the genetic relatedness among apparently isolated populations of the Bicknell's Thrush. These birds occur above 900 m in mountains of the northeastern U.S.A., thus there appears to be isolation of breeding populations within and among mountain ranges. I propose to document the amount of gene flow among Bicknell's Thrush populations as a test of the effectiveness of long-distance migration in overcoming the geographic isolation of mountain-top bird populations. To achieve this end I will examine variation of microsatellite DNA loci among thrush populations in the Catskills, Adirondacks, Green and White mountains. Patterns of microsatellite DNA variation from Mt. Mansfield thrushes will be compared with patterns of variation from the other ranges listed above and other peaks in the Green Mountains. Four Bicknell's Thrushes were captured on Mt. Mansfield from 1-6 June 1993. DNA has been extracted from these samples as of February 1994. This study will have important implications for the conservation of migratory birds.

Introduction

Much recent research in conservation biology addresses the effects of habitat fragmentation and isolation (HFI, for birds see references in Hagan and Johnston 1992). It has been postulated that HFI may influence population structure including the possible interruption of gene flow among populations. These demographic processes can be modeled but are hard to examine under field conditions. Recent developments in molecular biology offer potential inferential tools for studying the genetic effects of HFI (Avise 1994). I plan to use a molecular marker system (microsatellite DNA loci) to document the population structure of Bicknell's Thrush which has a fragmented breeding distribution in the mountains of the northeastern U.S.A. I hope to estimate levels of inbreeding (in the population sense), and population isolation within and among mountain ranges. I believe this will enable me to establish the level of interaction between long-distance migration and isolation of breeding populations.

Molecular techniques that have been used to study population structure include protein electrophoresis (allozymes), mitochondrial DNA (mtDNA), and minisatellite DNA fingerprinting. Allozyme studies have limited value for establishing fine-scale population structure in birds due to low enzyme variability (Avise 1994). Although mtDNA can be used to detect population sub-division in birds (e.g., Avise and Nelson 1989), it appears to evolve too slowly for analysis of genetic variation at small geographic scales and time frames of less than one million years. Hypervariable repetitive nuclear DNA might be more appropriate for short-distance and geologically brief population separations. Nonetheless, minisatellite DNA is generally too variable and allows too little certainty in allele scoring to permit any more than crude estimates of population structure. Another hypervariable repetitive nuclear DNA class, microsatellite DNA, allows more precise identification and scoring of alleles combined with a large number of alleles per locus (Ellegren 1992, Queller *et al.* 1993). I propose to use microsatellite DNA to examine patterns of microgeographic variation in Bicknell's Thrush in the northeastern U.S., and compare these patterns with those of the closely related Gray-cheeked Thrush (*Catharus minimus*) of subarctic North America.

Bicknell's Thrush is a breeding endemic of northeastern North America ranging from the St. Lawrence River southward to the Catskill Mountains (Wallace 1939, Ouellet 1993), it is migratory, wintering in the Greater Antilles (Arendt 1992, Ouellet 1993). This bird is currently considered a subspecies of Gray-cheeked Thrush, however recent studies strongly suggest it is a separate species (Ouellet 1993). In its U.S. range Bicknell's Thrush is almost entirely restricted to stunted sub-alpine forest above 900 m elevation. Concern has recently arisen over the conservation status of this bird (Rimmer *et al.* 1993). Some populations have disappeared (e.g., Mt. Greylock, Massachusetts), and subalpine habitat has apparently been degraded by industrial pollution (Vogelmann 1982), and increased recreational pressure. Greater Antillean forest is also disappearing rapidly (Arendt 1992). A pressing question is: does the fragmented distribution of Bicknell's Thrush cause genetic partitioning of its population? It is imperative to separate the influence of long-distance migration and its potential value in source-sink population dynamics from the influence of natal philopatry on gene flow among this thrushes' isolated mountain populations.

Methods

I capture Bicknell's Thrushes in 6 m nylon mist nets by inducing aggressive behavior with a tape of territorial calls and songs, and a carved thrush model. Once I have a bird in-hand I band and color-mark it (on Mt. Mansfield the right-leg combination is always mauve and USFWS band), make several measurements (e.g., tarsus), and collect 100 µl of blood from a small puncture in the medial wing vein. I collect samples in heparinized capillary tubes and transfer them to microcentrifuge tubes with 1 ml of lysis buffer that prevents degradation of high molecular weight DNA. DNA remains intact for extended periods in lysis buffer even at temperatures up to 25°C, but I have stored samples at 4°C to ensure sample quality.

I obtain DNA from my samples via phenol-chloroform extraction. I have access to microsatellite DNA primers designed for *Aphelocoma* jays that should help me amplify Bicknell's Thrush microsatellite loci with the polymerase chain reaction. I then will use acrylamide gel electrophoresis to visualize alleles at these loci. I will calculate band-sharing indices to assess population variation.

Results

I caught four thrushes on Mt. Mansfield from 1 to 6 June 1993. Two were captured along the Toll Road from the Octagon to the Summit Station, one along the WCAX Access Road west of the Nose, and one near the Forehead Bypass Trail. I collected blood samples ranging from 60-100µl (mean=89.5 µl). I extracted and precipitated DNA from these samples in February 1994.

Future Plans

I plan to obtain five to ten further samples from thrushes on Mt. Mansfield from 24 May to 1 June 1994. I also will search for the birds I color-marked during the previous field season to determine site-faithfulness.

Context

My studies on Mt. Mansfield, as indicated above, are part of a broader study of genetic variation of Bicknell's Thrush among four northeastern U.S. mountain ranges, the Catskills, Adirondacks, Green and White mountains. I also collected blood from nine birds on four mountains in the Catskills, four birds from Whiteface Mt. in the Adirondacks, and from four birds on Shrewsbury Peak in the southern Green Mountains in 1993. I plan to expand sampling in the Adirondacks, and extend sampling to the White Mountains in 1994. I will also collect blood from Gray-cheeked Thrushes in northern Canada during the 1995 field season to compare population structure in this closely related form to Bicknell's Thrush. I am just beginning extraction and analysis of DNA from my samples. I hope to perfect my lab skills during a proposed ten week graduate fellowship at the National Zoo in Washington, D.C. this autumn.

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Insect Diversity on Mount Mansfield

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Abstract

Insects were collected from the three permanent survey plots at three different elevations on Mount Mansfield. Complete seasonal surveys were continued for selected groups of Lepidoptera, Coleoptera, Hymenoptera and Diptera. The 1993 collection of 391 species of Lepidoptera are listed. Lepidoptera diversity is compared between survey sites. Most species and individuals are represented by the families Noctuidae, Geometridae, Tortricidae, Pyralidae and Notodontidae. Seasonal patterns are illustrated for selected species.

Introduction

The 1993 season represents the third consecutive year of the insect biodiversity program on Mount Mansfield. The surveys are designed to record the taxonomic composition and abundance of selected insect groups, and monitor seasonal and annual changes taking place.

The major taxa being surveyed comprise the ground dwelling Carabidae (Coleoptera) from pitfall traps, the nocturnal Lepidoptera (moths) from light traps, and the macro-Hymenoptera (wasps, bees), and Diptera (flies) from canopy malaise traps. Preliminary species lists for these groups were presented in the 1991, and 1992 VMC Annual reports.

Methods

Sampling was continued at the established survey sites in a sugar maple forest at 400 m elevation (Proctor Maple Research Center; PMRC), a mixed hardwood forest at 600 m (Underhill State Park; USP), and a sub-alpine balsam fir forest at 1160 m near the southern summit of Mount Mansfield (MMS).

Five permanent 20 m diameter plots were established at each site with a malaise trap installed in the canopy of one dominant sugar maple or fir tree (sub-alpine site) in each of the four outlying plots. Six pitfall traps were installed around each plot at 60° intervals and a single light trap was located in the center plot. The 1993 survey covered the period from 6 May to 5 October. A detailed account of field and laboratory methods is outlined in the 1991 VMC Annual Report.

The 1991 and 1992 Lepidoptera surveys were concentrated on the larger bodied "macro-Lepidoptera". These moths are mostly larger-bodied species and are generally more accessible to precise identification. Many of the "micro-Lepidoptera", in contrast, are poorly known or require considerable specialist expertise for accurate identification. In 1993 the Lepidoptera survey was extended to include all species as a preliminary attempt to characterize overall diversity for Lepidoptera at the survey sites. The terms "micro-Lepidoptera" and "macro-Lepidoptera" do not comprise natural phylogenetic groups, and are used here for descriptive convenience only.

Lepidoptera were collected from a single light traps operated for only one night per week at each site. The objective of surveying all Lepidoptera species was to characterize species diversity for the larger taxa (families). Individual species identification was a secondary consideration. Most species listed in this report are, however, identified with reasonable confidence. Some micro-Lepidoptera, in particular, will require further evaluation to confirm identifications. Because of the difficulty of distinguishing very small species from external features the number of species listed under-estimates the total number of species collected at the traps.

Results

The Carabidae, Hymenoptera, and Diptera are sorted, identified, and entered into a computer database by J. Boone. The data for these groups will be statistically analyzed to evaluate differences in site diversity.

Lepidoptera diversity

A total of 391 species were identified (Table 1). The pattern of taxonomic representation at the family level was similar at each of the sites, the principal contrast being in the total numbers of individuals (Figs. 1-3). Family diversity for species and individuals was dominated by (in descending order) the Noctuidae, Geometridae, Tortricidae, Pyralidae. Most of the remaining families were represented by very small numbers of species and individuals. Of the dominant families, the Tortricidae and Pyralidae represent micro-lepidopteran groups. The total number of families was similar in the lower sites with five more families being present in PMRC. The greatest contrast involves MMS with only 10 families and just over 200 species for any one family.

Seasonal patterns

It is not practical to present seasonal patterns for all species documented in this report. The following examples illustrate some of the periodicities observed. The patterns do not distinguish between emergence and persistence of adults, except for groups such as the Saturniidae where adults are non-feeding and do not survive the period between light trap sampling.

The flight periods of the forest tent caterpillar (*Malacosoma disstria*) (Fig. 4) and eastern tent caterpillar (*M. americana*) (Fig. 5) represent an activity period of about five weeks, but with most moths appearing within a single week, possibly suggesting a high level of synchrony in emergence. Both species were most abundant at PMRC.

A number of Lepidoptera at Mount Mansfield exhibited distinct bivoltine generations. The geometrid *Campaea perlata* feeds on many different trees and shrubs including birches, maples, poplars and firs, and is present at both lower elevation sites. It was common over a six week period during mid-summer, and again in the early fall (Fig. 6).

In contrast, the three species of *Plagodis* are usually present in low numbers, and with limited flight periods (Fig. 7). The seasonality of *P. fervidaria* comprised early spring and mid-summer generations separated by an interval of eight weeks. The adult emerge of the other *Plagodis* species occurs within this interval, suggesting that their larval development in the second generation is completed within three or four weeks. All three species are known to feed on a range of hardwood trees.

Two species that are distributed over all sites, but more abundant at higher elevations, are the geometrids *Dysstroma citrata* (Fig. 8), and *D. truncata* (Fig. 9). The infrequent records of *D. citrata* are late summer and early fall, while *D. truncata* is abundant over the latter two months of summer, particularly at site 2. Both species may feed on herbs or tree species.

Two species of saturniid moths are present at the lower elevation sites, but only in low numbers (Fig. 10). They are of potential interest for long-term surveys because they represent of a group of moths that have in the past demonstrated apparent sensitivity to chemical pesticides. Some species have become locally extinct or greatly reduced in numbers due to pesticides or other environmental impacts. The adults are non-feeding (atrophied mouthparts) and because the light trap specimens are always in perfect condition, the seasonal records can be directly related to weather conditions at the time of collection. The larvae of both species are recorded feeding on a wide range of host trees.

In contrast to the saturniid moths, the fall hemlock looper *Lambdina fiscellaria* has a very broad flight period, and is present in considerable numbers Although a pest species in some areas of the northeastern United States and Canada, there is no indication at present that the numbers recorded on Mount Mansfield are responsible for specific levels of damage to trees. It is probable, although not confirmed, that the moth feeds on a range of hardwood species on Mount Mansfield.

Discussion

The Lepidoptera diversity patterns are only preliminary, particularly with respect to the micro-Lepidoptera which may be less effectively caught by the light traps. Even if they are attracted to the light, the plexiglass vanes may not be effective in disrupting the flight of these small moths. Long-term documentation will be necessary to confirm the current results, and other collections techniques may be desirable to survey those species not attracted to the lights. Some species of Noctuidae and various other families overwinter as adults, and are actively feeding in the spring and fall. Some species are rarely, if ever, attracted to lights, and best collected using bait (fermenting alcohol/sugar/fruit).

Long-term comparisons of light trap data may be most informative on species diversity and abundance for the macro-Lepidopteran groups Noctuidae, Geometridae, Notodontidae, Arctiidae, Saturniidae, Sphingidae, Lymantriidae Lasiocampidae, Drepanidae, and Limacodidae. These are now well documented for Mount Mansfield, and can be identified accurately by visual examination for most species. There are a few exceptions which require closer morphological examination, and the genus *Eupithecia*, in particular, will require further genitalic examination for a comprehensive listing of species.

Micro-Lepidoptera are unlikely to be intensively surveyed on a regular basis because they require greater resources than are available for this study. However, if it were practical, regular surveys of the Tortricidae would be desirable because this is one of the most diverse families of micro-Lepidoptera collected from the Mount Mansfield light traps, and it includes species that are known to feed on tree and shrub foliage, including some with pest status.

The seasonal patterns of Lepidoptera may be strongly influenced by weather patterns, particularly if the weather influences the number of moths attracted to the light traps. Casual observations suggest that cool and/or very wet (heavy rains) weather can reduce the number of moths. The limited sampling of one light trap per site and for only for one night per week may result in misleading patterns if the trap night coincides with poor weather. Replication and/or multiple sampling nights is desirable, but not feasible at present. In the future the seasonal periodicities of moths could be compared with both weather and tree phenology to develop a predictive model of insect activity and feeding.

Future Plans

The survey program in 1994 will continue for Lepidoptera and carabid beetles, while the canopy Hymenoptera and Diptera survey will be limited to May and June (period of early host-plant foliation). Long-term diversity and abundance trends will be examined by comparing the results of collections from 1991 to 1994.

The ecological and management significance of the Lepidoptera diversity requires information on host-plant associations. This information is currently being compiled from the literature and unpublished sources in cooperation with Dr D. F. Schweitzer of the Nature Conservancy. Documentation of host-plant associations will allow a more precise relationship to be identified for the prevalence of particular species, as well as estimating the significance of lepidopteran diversity in relation to vegetation structure and host-plant composition.

Acknowledgements

We are grateful for the continued support of Ross Bell (University of Vermont) and Bob Davidson (Carnegie Museum of Natural History) with identification of Carabidae and other Coleoptera. The identification of micro-lepidoptera was assisted by Mike Sabourin (South Burlington), with specialist confirmations contributed by a number of systematists at regional institutions. Data collection was assisted by Carlos Saltero (University of Vermont Research Program. Data processing and database entry was facilitated by David Barnes, pete Pfenning and Dave Marcaux (St Albans).

Figure 1. Comparison of species numbers and individuals for families of Lepidoptera collected at Proctor Maple Research Center (400 m) in 1993.

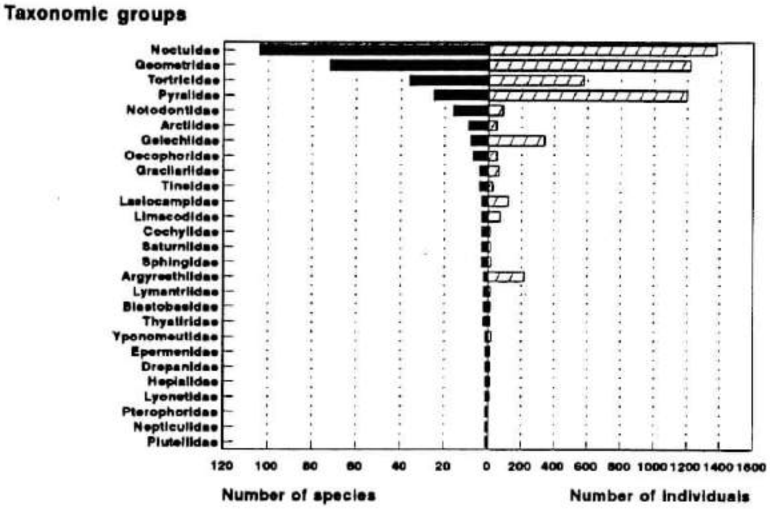

Figure 2. Comparison of species numbers and individuals for families of Lepidoptera collected at Underhill State Park (600 m) in 1993.

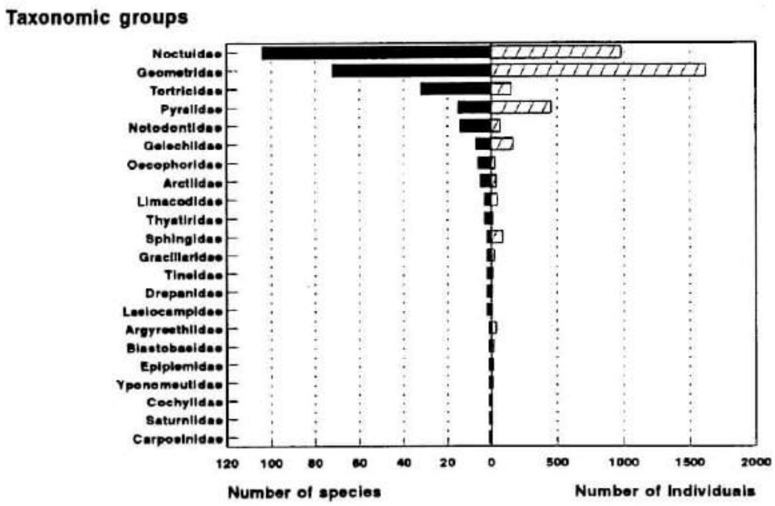

Figure 3. Comparison of species numbers and individuals for families of Lepidoptera collected at Mount Mansfield summit (1160 m) in 1993.

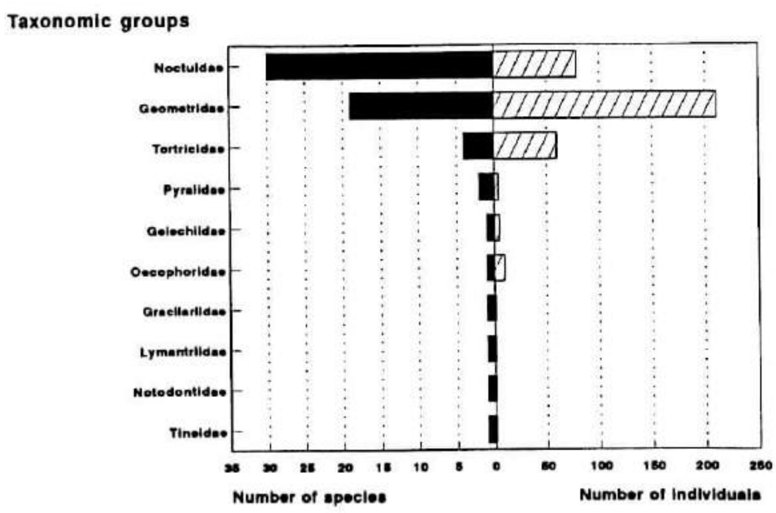

Figure 4. Seasonal collection (one trap night/week) of forest tent caterpillar (Malacosoma disstria) at Mount Mansfield sites 2 (Underhill State Park) and 3 (Proctor Maple Research Center).

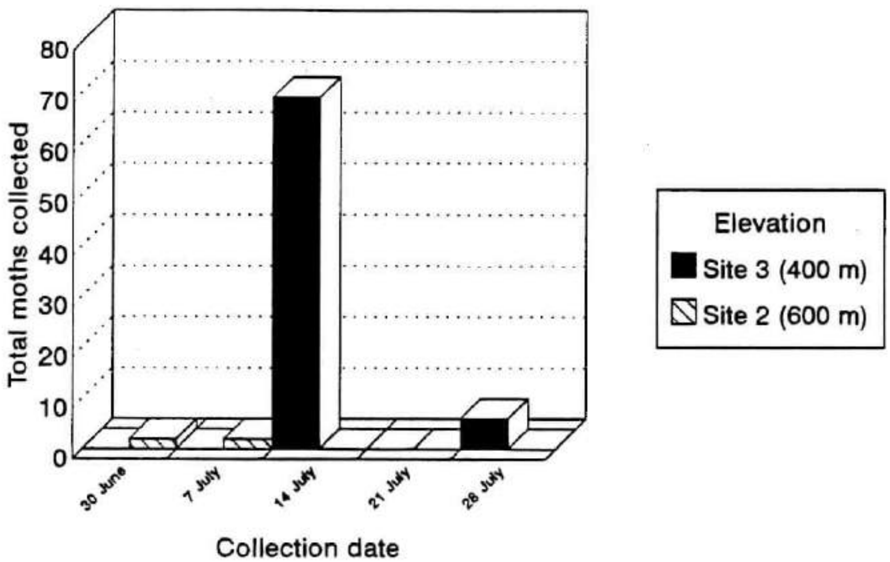

Figure 5. Seasonal collection (one trap night/week) of eastern tent caterpillar (Malacosoma americanum) at Mount Mansfield sites 2 (Underhill State Park) and 3 (Proctor Maple Research Center).

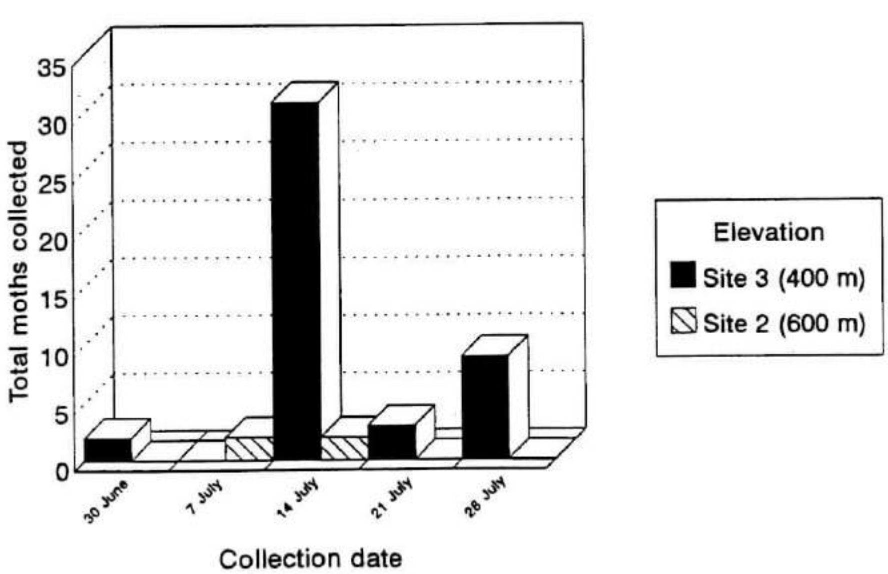

Figure 6. Seasonal collection (one trap night/week) of *Campaea perlata* (Geometridae) at Mount Mansfield sites 2 (Underhill State Park) and 3 (Proctor Maple Research Center).

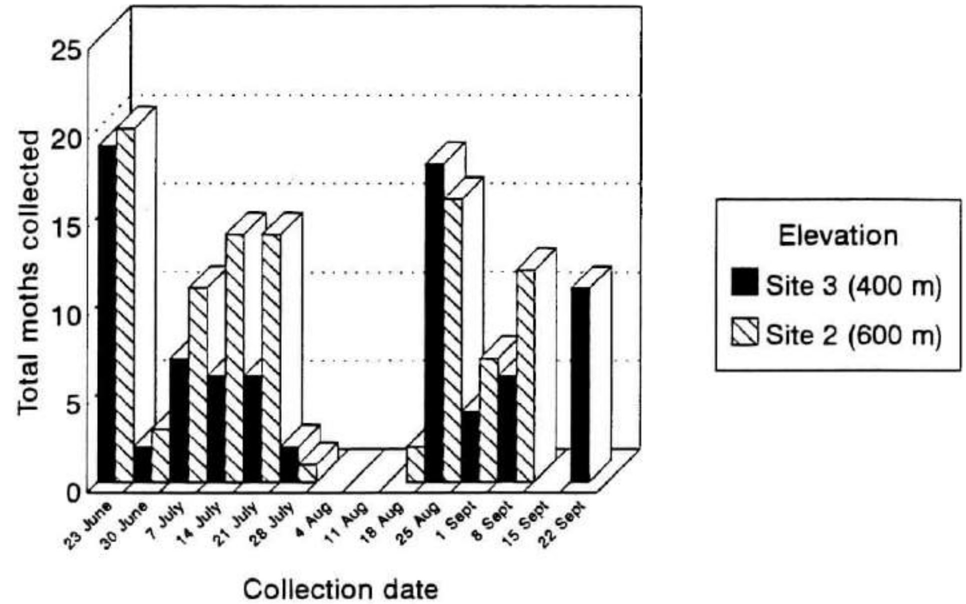

Figure 7. Seasonal collection (one trap night/week) of three *Plagodis* species (Geometridae) at Mount Mansfield. Records are combined for Underhill State Park and Proctor Maple Research Center.

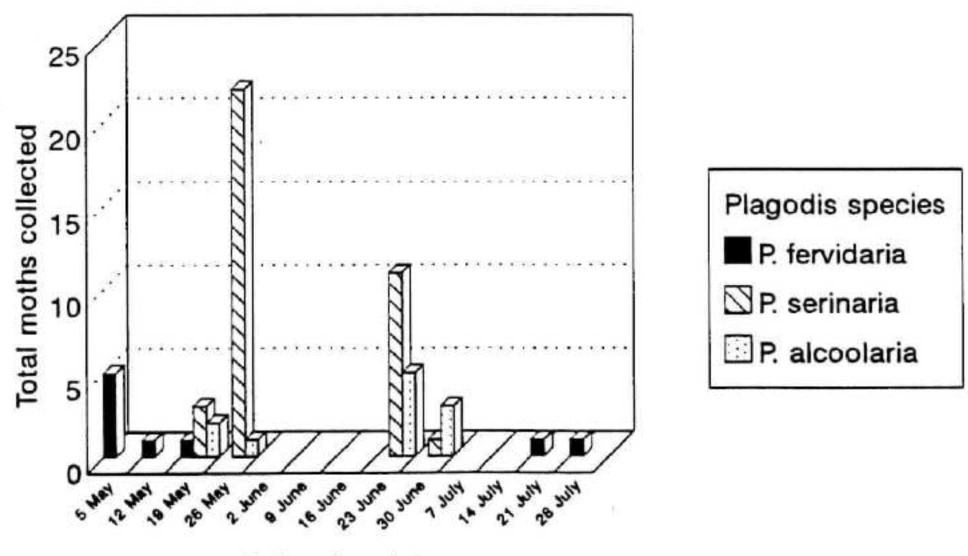

Figure 8. Seasonal collection (one trap night/week) of *Dysstroma citrata* (Geometridae) at Mount Mansfield sites 1 (sub-alpine fir forest), 2 (Underhill State Park) and 3 (Proctor Maple Research Center).

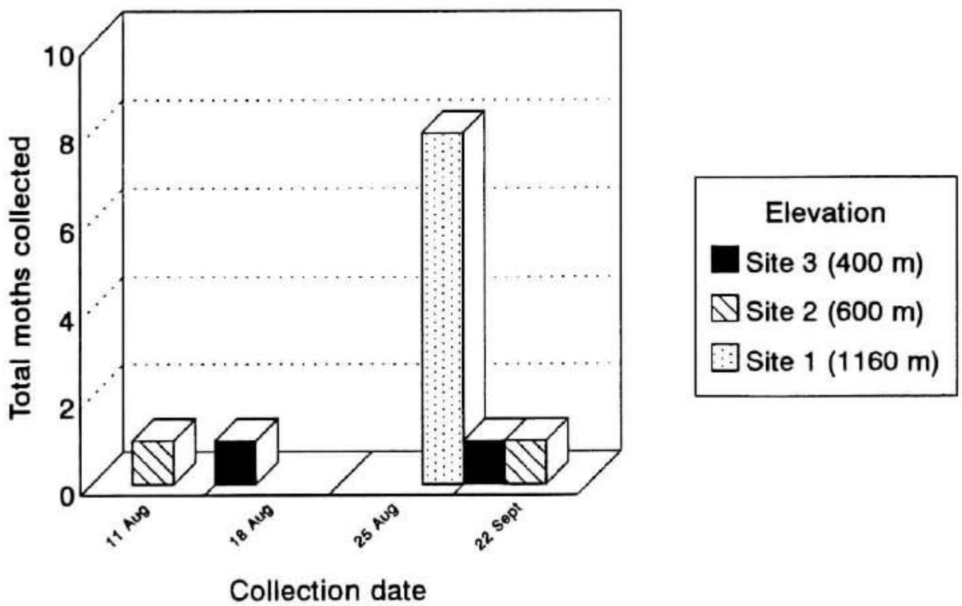

Figure 9. Seasonal collection (one trap night/week) of three *Dysstroma truncata* species (Geometridae) at Mount Mansfield sites 1 (sub-alpine fir forest), 2 (Underhill State Park) and 3 (Proctor Maple Research Center).

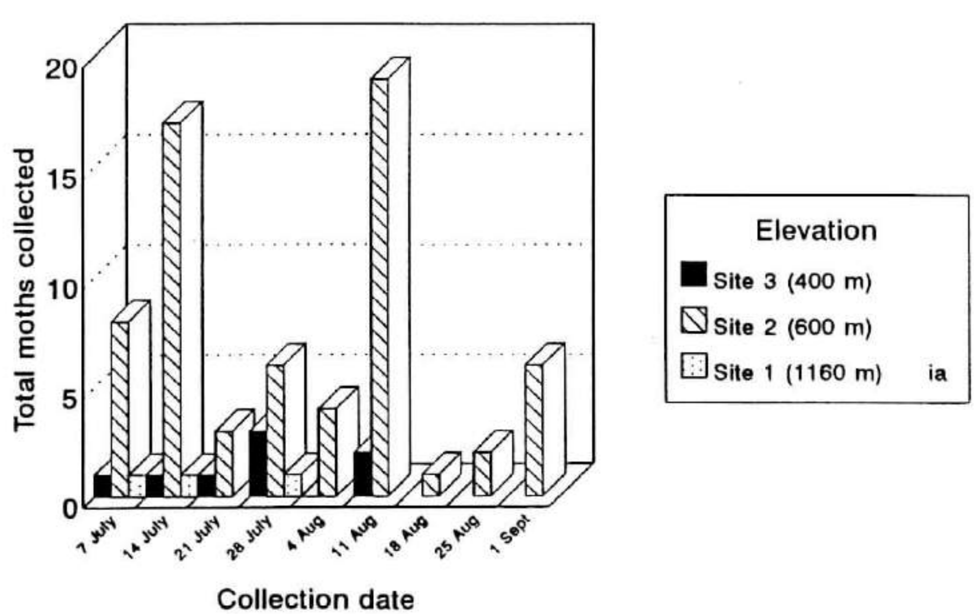

Figure 10. Seasonal collection (one trap night/week) of *Antheraea polyphemus* and *Actias luna* (Saturniidae) combined for site 2 (Underhill State Park) and 3 (Proctor Maple Research Center).

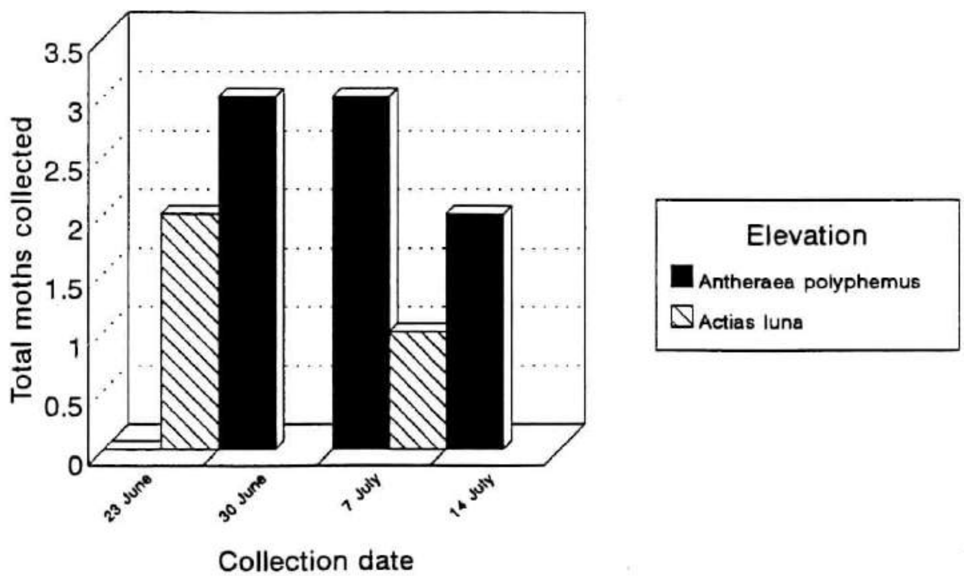

Figure 11. Seasonal collection (one trap night/week) of the fall hemlock looper *Lambdina fiscellaria* (Geometridae) at Mount Mansfield sites 2 (Underhill State Park) and 3 (Proctor Maple Research Center).

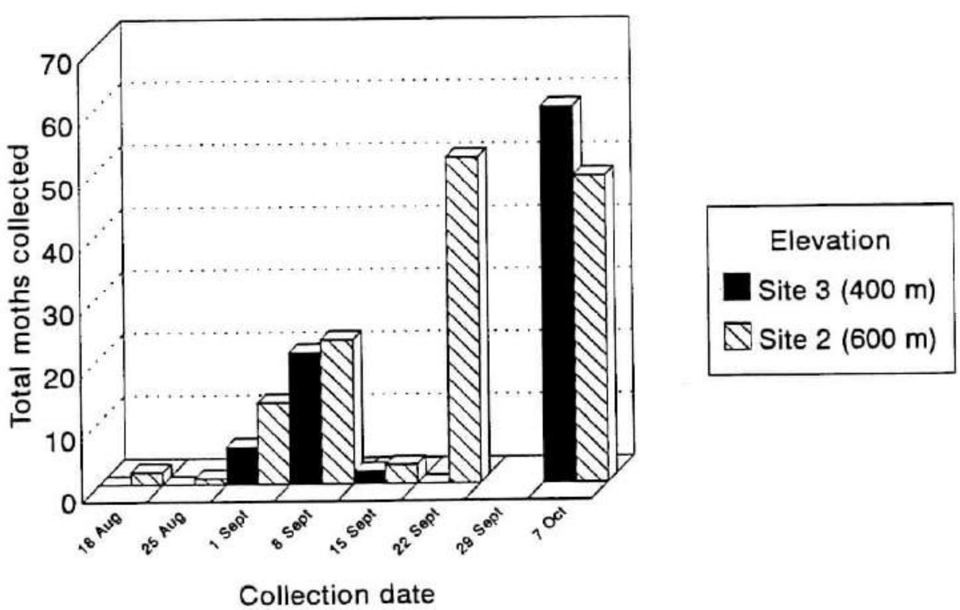

Table 1. Lepidoptera collected from light traps on Mount Mansfield summit (site 1 1160m), Underhill State Park (site 2 600m), and Proctor Maple Research Center (site 3 600m)

	Site		
	1	2	3
Arctiidae: Arctiinae			
Haploa lecontei (Guér-Meneville, 1832)		+	
Lophocampa maculata Harr., 1841		+	+
Phragmatobia assimilans Wlk., 1855		+	+
Phragmatobia fuliginosa (L., 1758)		+	
Spilosoma congrua Wlk., 1855		+	
Spilosoma virginica (F., 1798)		+	
Arctiidae: Ctenuchinae			
Ctenucha virginica (Esp., 1794)		+	
Arctiidae: Lithosiinae			
Clemensia albata Pack., 1864		+	+
Hypoprepia fucosa Hbn., 1827-1831			+
Argyresthiidae			
Argyresthia goedartella (L., 1758)			+
Argyresthia oreasella (Clem., 1860).		+	+
Blastobasidae			
Asaphocrita n.sp.		+	+
Hypatopa sp			+
Carposinidae			
Bondia cresentella (Wlsm., 1882)		+	+
Cochylidae			
Aethes atomosana Bsk., 1907			+
Cochylis dubitana (Hbn., 1799)		+	
Hysterosia hospes Wlsm., 1884			+
Thyraylia bunteana (Rob., 1869)	+		
Drepanidae			
Drepana arcuata Wlk., 1855.		+	+
Drepana bilineata (Pack., 1864)			+
Epermeniidae: Epermeniinae			
Epermenia ?albapunctella Bsk., 1908.			+

Table 1 continued

	Site 1	Site 2	Site 3
Epiplemidae			
Callizzia amorata Pack., 1856.	+		
Gelechiidae: Dichomeridinae			
Dichomeris punctipennella Clem., 1860		+	+
Dichomeris stependiaria (Braun, 1925)		+	
Trichotaphe bilobella (Zell., 1873)			+
Gelechiidae: Gelechiinae			
Chionodes continuella (Zell., 1839)		+	+
Chionodes mediofuscella (Clem., 1863)	+	+	
Chionodes obscurusella (Cham., 1872)	+	+	+
Coleotechnites quercivorella (Cham., 1872)		+	+
Filatima sp.1	+	+	
Pseudochelaria pennsylvanica Dietz, 1900		+	
Pseudotelphusa belangerella (Cham., 1875)		+	
Geometridae: Ennominae			
Anacamptodes ephyraria (Wlk., 1860)			+
Anagoga occiduaria (Wlk., 1861)	+	+	
Aethalura intertexta (Wlk., 1860)	+	+	
Besma endropiaria (G. & R., 1867)		+	+
Biston betularia (L., 1758)	+	+	
Cabera erythemaria Gn., 1857	+	+	
Campaea perlata (Gn., 1857)		+	+
Caripeta angustiorata (Wlk., 1863)	+		
Caripeta divisata Wlk., 1863	+	+	+
Ectropis crepuscularia (D. & S., 1775).	+	+	
Ennomos magnaria Gn., 1857			+
Euchlaena serrata (Drury, 1770)		+	+
Euchlaena irraria (B & McD., 1917)			+
Euchlaena tigrinaria (Gn., 1857)	+	+	
Eugonobapta nivosaria (Gn., 1857)		+	+
Eupithecia columbiata (Dyar, 1904)	+	+	+
Eutrapela clemataria (J.E., Smith. 1917)	+	+	
Homochlodes disconventa (Wlk., 1860)	+	+	
Homochlodes lactispargaria (Wlk., 1861).		+	+
Hypagyrtis piniata (Pack., 1870).	+	+	
Hypagyrtis unipunctata (Haw., 1809)		+	+
Iridopsis larvaria (Gn., 1857)		+	+
Itame anataria (Swett. 1913)		+	
Itame pustularia (Gn., 1857)		+	+
Lambdina fiscellaria (Gn., 1857)	+	+	

Table 1 continued

	Site 1	2	3
Lomographa glomeraria (Grt., 1881)		+	+
Lomographa vestaliata (Gn., 1857)			+
Lytrosis unitaria (H.-S., 1854)			+
Melanolophia canadaria (Gn., 1857)			+
Melanolophia signataria (Wlk., 1860).		+	+
Metanema inatomaria Gn., 1857	+	+	
Metarranthis angularia B. & McD., 1917		+	
Metarranthis hypocharia H.-S., 1854		+	
Nematocampa resistaria (H.-S., 1855)	+	+	
Nepytia canosaria (Wlk., 1863)		+	
Orthofidonia tinctaria (Wlk., 1860)		+	
Pero hubneraria (Gn., 1857)	+	+	+
Plagodis alcoolaria (Gn., 1857)	+	+	
Plagodis fervidaria H.-S., 1854.	+	+	
Plagodis serinaria H.-S., 1855	+	+	
Probole alienaria H.-S., 1855.		+	+
Probole amicaria (H.-S., 1855)	+		
Protoboarmia porcelaria (Gn., 1857)		+	+
Selenia kentaria (G. & R., 1867)	+	+	
Semiothisa aemulataria (Wlk., 1861)		+	+
Semiothisa bisignata (Wlk., 1866)	+	+	+
Semiothisa pinistrobata Fgn., 1972	+	+	+
Semiothisa ulserata (Pears., 1913)	+	+	
Sicya macularia (Harr., 1850)	+	+	+
Tetracis cachexiata Gn., 1857	+	+	
Xanthotype urticaria Swett, 1918	+	+	
Geometridae: Geometrinae			
Nemoria mimosaria (Gn., 1857)	+	+	
Geometridae: Larentiinae			
Acasis viridata (Pack., 1873)		+	
Anticlea vasiliata Gn., 1857.		+	+
Cladara atroliturata (Wlk., 1863)	+	+	
Cladara limitaria (Wlk., 1860).	+		
Dysstroma citrata (L., 1761)	+	+	+
Dysstroma hersiliata (Gn., 1857)	+	+	
Dystroma truncata (Hufn., 1767).	+	+	+
Ecliptopera silaceata (D. & S., 1875)		+	+
Epirrhoe alternata (Müller, 1764)	+	+	
Epirrita autumnata (Bkh., 1794)	+		+
Eulithis destinata (Mösch., 1860)	+		
Eulithis flavibrunneata (McD., 1943)	+		

Table 1 continued

	Site 1	2	3
Eulithis propulsata (Wlk., 1862)	+	+	
Euphyia unangulata intermediata (Gn., 1857)		+	+
Eupithecia absinthiata (Clerck, 1759)		+	
Heterophleps refusaria (Wlk., 1861)		+	+
Horisma intestinata (Gn., 1857)		+	+
Hydrelia inornata (Hulst, 1896)	+	+	
Hydria prunivorata (Fgn., 1955)	+	+	
Mesoleuca ruficillata (Gn., 1857)	+	+	
Orthonama obstipata (F., 1794)	+	+	
Orthonama centrostrigaria (Woll., 1858)		+	
Perizoma basaliata (Wlk., 1862)	+	+	+
Spargania magnioliata Gn., 1857			+
Stamnodes gibbicostata (Wlk., 1862)		+	+
Trichodezia albovittata (Gn., 1857)		+	
Venusia cambrica Curt., 1839	+	+	+
Venusia comptaria (Wlk., 1860)	+	+	
Xanthorhoe abrassaria (H.-S., 1856)	+		
Xanthorhoe ferrugata (Cl., 1759)		+	
Xanthorhoe iduata (Gn., 1857)	+	+	
Xanthorhoe labradorensis (Pack., 1867)	+	+	
Geometridae: Sterrhinae			
Cyclophora pendulinaria (Gn., 1857).		+	+
Pleuroprucha insulsaria (Gn., 1857)			+
Scopula limboundata (Haw., 1809)		+	+
Gracillariidae: Gracillariinae			
Caloptilia burgessiella (Zell., 1873)		+	+
Caloptilia coroniella (Clem., 1864)		+	+
Caloptilia serotinella (Ely, 1910)	+		+
Parornix geminatella (Pack., 1869)			+
Hepialdae			
Korscheltellus gracilis (Grt., 1864)		+	+
Incurvariidae: Icurvariinae			
Paraclemensia acerifoliella (Fitch, 1854)		+	
Lasiocampidae			
Malacosoma americanum (F., 1793).		+	+
Malacosoma disstria Hbn., 1820	+	+	

Table 1 continued		**Site**	
	1	**2**	**3**
Lasiocampidae: Macromphaliinae			
Tolype velleda Stoll., 1791			+
Limacodidae			
Packardia geminata (Pack., 1864)	+	+	
Tortricida pallida (H.S., 1854)		+	+
Tortricidia testacea (Pack., 1864)	+	+	
Lymantriidae: Orgyiinae			
Dasychira plagiata (Wlk., 1885)		+	
Orgyia definita Pack., 1864	+		+
Lyonetiidae			
Bucculatrix ainsliella Murt., 1905		+	
Nepticulidae: Nepticulinae			
Obrussa ochrefasciella Cham., 1873.	+	+	
Noctuidae: Acontiinae			
Leuconycta diphteroides (Gn., 1852)		+	
Lithacodia albidula (Gn., 1852)	+		
Lithacodia concinnimacula (Gn., 1852)	+	+	
Lithacodia muscosula (Gn., 1852)	+	+	
Maliattha synochitis (G. & R., 1868)		+	+
Pseudeustrotia carneola (Gn., 1852)		+	+
Noctuidae: Acronictinae			
Acronicta americana (Harr., 1841)		+	+
Acronicta fragilis (Gn., 1852)		+	+
Acronicta hasta Gn., 1852		+	
Acronicta impressa Wlk., 1856.		+	+
Acronicta innotata Gn., 1852		+	+
Acronicta retardata (Wlk. 1867)		+	
Acronicta tristis Sm., 1911		+	+
Noctuidae: Amphipyrinae			
Achatodes zeae (Harr., 1841)			+
Amphipoea americana (Speyer, 1875)	+		+
Amphipoea velata (Wlk., 1865)	+		
Amphipyra pyramidoides Gn., 1852	+	+	+
Amphipyra tragopoginis (Cl., 1759)		+	
Apamea dubitans (Wlk., 1856)	+		

Table 1 continued

	Site 1	2	3
Apamea amputatrix (Fitch, 1857)	+	+	
Apamea sordens (Hufn., 1766)		+	
Apamea vultuosa (Grt., 1875)		+	
Callopistria mollissima (Gn., 1852)		+	+
Chytonix palliatricula Gn., 1852	+	+	
Elaphria versicolor (Grt., 1875)	+	+	
Enargia decolor (Wlk., 1858)		+	
Euplexia benesimilis McD., 1922	+		
Hyppa xylinoides (Gn., 1852)			+
Ipimorpha pleonectusa Grt., 1873	+		
Magusa orbifera (Wlk., 1857)			+
Nedra ramosula (Gn., 1852)			+
Oligia crytora (Franc., 1950)		+	+
Oligia exhausta (Sm., 1903).		+	+
Oligia illocata (Wlk., 1857)	+	+	+
Oligia mactata (Gn., 1852)	+	+	+
Papaipema nepheleptema (Dyar, 1908)		+	
***Papaipema* sp.**	+		
Papaipema unimoda (Sm., 1894)	+	+	
Phlogophora iris Gn., 1852	+	+	
Phlogophora periculosa Gn., 1852	+	+	+
Psaphida rolandi Grt., 1874		+	
Spodoptera frugiperda (J. E. Smith)		+	+
Noctuidae: Catocalinae			
Catocala blandula Hulst, 1884		+	+
Catocola cerograma Gn., 1852		+	
Catocala sordida Grt., 1877			+
Catocala ultronia (Hbn., 1823)		+	
Catocala unijugata Wlk., 1858		+	
Ceratomia undulosa (Wlk., 1856).			+
Parallelia bistriaris Hbn., 1818		+	+
Zale galbanata (Morr., 1876).			+
Zale lunifera (Hbn., 1818)		+	
Zale minerea (Gn., 1852)	+	+	
Noctuidae: Cuculliinae			
Anathix ralla (G. & R., 1868)		+	+
Eupsilia morrisoni (Grt., 1874)	+		
Feralia comstocki (Grt., 1874)	+		
Lithophane baileyi Grt., 1877)		+	+
Lithophane fagina Morr., 1874		+	
Lithophane patefacta (Wlk., 1858)	+	+	

Table 1 continued

	Site 1	2	3
Metalepsis salicarum (Wlk., 1857)	+		
Pachypolia atricornis Grt., 1874.		+	+
Platypolia anceps (Steph., 1850)	+		
Sunira bicolorago (Gn., 1852)	+	+	+
Noctuidae: Hadeninae			
Achatia distincta Hbn., 1813		+	
Homorthodes furfurata (Grt., 1875).		+	+
Lacinopolia lorea (Gn., 1852)		+	+
Lacinipolia olivacea (Morr., 1874)	+	+	
Leucania insueta Gn., 1852			+
Melanchra adjuncta (Gn., 1852)	+		
Melanchra assimilans (Morr., 1874)		+	
Morrisonia confusa (Hbn., 1827-1831)	+	+	
Morrisonia evicta (Grt., 1873).	+		
Nephelodes minians Gn., 1852	+	+	+
Orthodes crenulata (Butler, 1890)	+		+
Orthodes cynica Gn., 1852	+	+	
Orthodes detracta (Wlk., 1857)	+	+	
Orthodes goodelli (Grt., 1875)			+
Orthosia revicta (Morr., 1876).	+		
Orthosia rubescens (Wlk., 1865).	+	+	
Polia imbrifera (Gn., 1852)	+	+	
Polia nimbosa Gn., 1852	+	+	+
Protorthodes oviduca (Gn., 1852)	+	+	
Pseudaletia unipuncta Haw., 1809	+		
Pseudothodes vecors (Gn., 1852).	+	+	
Spirameter lutra (Gn., 1852)			+
Tricholita signata (Wlk., 1860)		+	
Trichordestra lilacina (Harv., 1874)		+	
Noctuidae: Herminiinae			
Idia aemula (Hbn., 1813)	+	+	
Idia americalis (Gn., 1854)	+	+	
Idia **sp. (*coneisa*** of Forbes)		+	+
Idia lubricalis (Gey., 1832).			+
Idia rotundalis (Wlk., 1866)	+	+	+
Macrochilo absorptalis Wlk., 1859			+
Palthis angulalis (Hbn., 1796)		+	+
Phalaenophana pyramusalis (Wlk., 1859).		+	+
Phalaenostola eumelusalis (Wlk., 1859)	+	+	
Renia flavipunctalis (Gey., 1832)			+
Renia sobrialis (Wlk., 1859)		+	+

Table 1 continued

	Site 1	2	3
Zanclognatha cruralis (Gn., 1854)	+	+	
Zanclognatha laevigata (Grt., 1872)		+	+
Zanclognatha ochreipennis (Grt., 1872)	+	+	
Zanclognatha pedipilias (Gn., 1854)		+	+
Zanclognatha protumnusalis (Wlk., 1859)		+	+
Noctuidae: Hypeninae			
Bomolocha edictalis (Wlk., 1859)	+	+	
Bomolocha palparia (Wlk., 1861)	+	+	
Hypena humuli Harr. 1841		+	
Plathypena scabra (F., 1758)	+	+	+
Spargaloma sexpunctata Grt., 1873			+
Noctuidae: Hypenodinae			
Dyspyralis illocata Warren, 1891.		+	+
Hypenodes palustris Fgn., 1954)	+	+	+
Noctuidae: Noctuinae			
Abagrotis alternata (Grt., 1864)		+	
Anaplectoides prasina (D & S., 1775)	+	+	+
Anaplectoides pressus (Grt., 1874)		+	
Agrotis ipsilon (Hufn., 1766)			+
Agrotis venerabilis Wlk., 1857	+		
Aplectoides condita (Gn., 1852)		+	
Cerastis tenebrifera (Wlk., 1865)	+	+	
Cryptocala acadiensis (Bethune, 1870)	+	+	
Diarsia jucunda (Wlk., 1857)		+	+
Eueretagrotis perattenta (Grt., 1876)		+	+
Eueretagrotis attenta (Grt., 1874)		+	+
Eueretagrotis sigmoides (Gn., 1852)		+	+
Eurois astricta Morr., 1874.	+	+	+
Eurois occulta (L. 1758)	+		
Graphiphora auger haruspica (Grt., 1875)		+	+
Ochropleura plecta (L., 1761)		+	+
Polia purpurissata (Grt., 1864)			+
Spaelotis cladestina (Harr., 1862)	+		
Xestia bicarnea (Gn., 1852)		+	+
Xestia c-nigrum adela (Franc., 1980)		+	+
Xestia dolosa Franc., 1980	+	+	+
Xestia fabulosa Fgn., 1965	+		
Xestia mixta (Wlk., 1856).	+		
Xestia normaniana (Grt., 1874)	+	+	+
Xestia smithii (Snell., 1896)	+	+	

Table 1 continued	Site		
	1	2	3
Noctuidae: Nolinae			
Nola triquetrana (Fitch, 1856)		+	
Noctuidae: Pantheinae			
Colocasia flavicornis (Sm., 1884).	+	+	
Colocasia propinguilinea (Grt., 1873)		+	+
Raphia frater Grt., 1864	+		
Noctuidae: Plusiinae			
Anagrapha falcifera (Kby., 1873)	+		
Autographa ampla (Wlk., 1858)		+	
Diachrysia aeroiodes (Grt., 1864)	+	+	
Noctuidae: Rivulinae			
Rivula propinqualis Gn. 1854.		+	+
Noctuidae: Sarrothripinae			
Baileya opthalmica Gn., 1852			+
Notodontidae			
Clostera albosigma Fitch, 1856		+	
Dasylophia anguina (J. E. Smith, 1797)	+	+	
Dasylophia thyatiroides (Wlk., 1862)			+
Ellida caniplaga (Wlk., 1856)			+
Gluphisia lintneri (Grt., 1877)			+
Heterocampa biundata Wlk., 1855	+	+	
Heterocampa guttivitta (Wlk., 1855).	+	+	
Hyperaeschra georgica (H.-S., 1855)			+
Macrurocampa marthesia (Cram., 1780)		+	
Nadata gibbosa (J.E. Smith, 1797)	+	+	
Oligocentria semirufescens (Wlk., 1865)	+	+	
Peridea angulosa (J.E. Smith, 1797)			+
Peridea basitriens (Wlk., 1855)	+	+	
Peridea ferruginea (Pack., 1864)	+	+	+
Schizura ipomoeae Doubleday, 1841		+	+
Schizura leptinodes (Grt., 1864)	+		
Schizura unicornis (J.E.Smith, 1797)		+	+
Symmerista canicosta Franc., 1946		+	+
Symmerista leucitys Franc., 1946		+	+
Oecophoridae: Ethmiinae			
Machimia tentoriferella (Clem., 1860)	+	+	+

Table 1 continued

	Site 1	Site 2	Site 3
Pyralidae: Pyralinae			
Herculia olinalis (Gn., 1854)		+	
Hypsopygia costalis (F., 1775)		+	
Pyralis costiferalis Linnaeus, 1758		+	+
Pyralis disciferalis Dyar, 1908		+	+
Pyralidae: Pyraustinae			
Anageshna primordialis (Dyar, 1907)			+
Herpetogramma abdominalis (Zell., 1872)		+	+
Nascia acutella (Wlk., 1886)		+	+
Nomophila nearctica Mun., 1973		+	
Phlyctaenia coronata tertialis (Gn., 1854)		+	+
Pyralidae: Scopariinae			
Scoparia basalis Wlk., 1866.		+	+
Scoparia biplagialis Wlk., 1866	+	+	+
Saturniidae: Citheroniinae			
Dyrocampa rubicunda (F., 1793)		+	
Saturniidae: Saturniinae			
Agriphila vulgivagella (Clem., 1860)	+	+	+
Antheraea polyphemus (Cram., 1776)	+	+	
Actias luna (L., 1758)		+	+
Sesiidae: Sesiinae			
Synanthedon acerni (Clem., 1860)	+		
Sphingidae: Sphinginae			
Lapara bombycoides Wlk., 1856	+		
Pachysphinx modesta (Harr., 1839)			+
Paonias excaecatus (J. E. Smith, 1797)	+	+	
Paonias myops (J. E. Smith, 1797)			+
Thyatiridae: Thyatriinae			
Euthyatira pudens (Gn.)	+		
Habrosyne scripta (Gosse, 1840)	+	+	
Pseudothyatira cymatophoroides (Gn., 1852)		+	+
Tineidae			
Acrolophus morus (Grt., 1881)	+	+	+*
Amydria effrentella Clem., 1859		+	
Monopis dorsistrigella (Clem., 1859)			+

Table 1 continued	Site 1	2	3
Monopis spilotella Tengstrom, 1848.		+	
Niditinea fuscella (L., 1758)			+
Tortricidae: Olethreutinae			
Ancylis apicana (Wlk., 1866)			+
Ancylis comptana (Frölich, 1828)	+	+	
Ancylis fuscociliana (Clem., 1864)			+
Ancylis metamelana (Wlk., 1863)		+	
Catastega aceriella (Clem., 1861)		+	
Endopiza viteana Clam., 1860.	+		
Epinotia lindana (Fern., 1892)	+		
Epinotia rectiplicana (Wlsm., 1879)			+
Epinotia solandriana (L., 1758).		+	
Epinotia transmissana (Wlk., 1863)		+	
Epinotia trigonella (F., 1758)		+	+
Eucosma derelecta Heinr., 1929		+	+
Eucosma similana (Clem., 1860)	+		
Gretchena delicatana Heinr., 1923		+	+
Hulda impudens (Wlsm., 1884)	+		
Olethreutes appendicea (Zell., 1875)			+
Olethreutes astrologana (Zell., 1875)		+	
Olethreutes glaciana (Mösch., 1860)		+	+
Olethreutes nigrana (Heinr., 1923)			+
Olethreutes permundana (Clem., 1860)	+	+	
Olethreutes quadrifidus (Zell., 1875)		+	+
Olethreutes trinitana (McD., 1931)		+	+
Phaneta parmatana (Clem., 1860)	+		
Proteoteras aesculana Riley, 1881		+	
Proteoteras moffatiana Fern., 1905			+
Tanviva albolineana Kft., 1907	+	+	
Tortricidae: Tortricinae			
Acleris celiana (Rob., 1869)			+
Acleris chalybeana (Fern., 1882)		+	
Acleris logiana (Cl., 1759).	+	+	
Acleris maccana (Tr., 1835)			+
Acleris semiannula (Rob., 1869)	+		
Acleris subnivana (Wlk., 1863)	+	+	
Acleris variana Fern., 1886	+		+
Anopina ednana (Kft., 1907)		+	
Archips dissitana Grt., 1879		+	
Archips purpurana (Clem., 1865)	+	+	
Argyrotaenia mariana (Fern., 1882)		+	+

Table 1 continued

	Site 1	Site 2	Site 3
Argyrotaenia velutinana (Wlk., 1863)		+	
Choristoneura conflictana Wlk., 1863			+
Choristoneura pinus Free., 1953			
Choristoneura rosaceana (Harr., 1841)		+	
Clepsis melaleucana (Wlk., 1863)	+	+	
Clepsis persicana (Fitch, 1856)	+	+	+
Eulia ministrana (L., 1758)		+	+
Pandemis lamprosana (Rob., 1869)			+
Platynota idaeusalis (Wlk., 1859).	+	+	
Ptycholoma virescana (Clem., 1865)		+	+
Sparagonothis pettitana (Rob., 1869)		+	+
Sparganothis reticulatana (Clem., 1860).	+	+	
Syndemis afflictana (Wlk., 1863)		+	
Yponomeutidae			
Swammerdamia caesiella (Hbn., 1796)		+	+

POPULATION STUDIES OF BICKNELL'S THRUSH ON MT. MANSFIELD

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Abstract: Research on the demography and breeding ecology of Bicknell's (Gray-cheeked) Thrush in Mt. Mansfield's subalpine spruce-fir zone was continued in 1993. Studies were concentrated on a 8.6 ha plot established in 1992 at 1160-1200 m elevation. Intensive spot mapping of territorial males yielded similar density estimates of 40-55 breeding pairs/100 ha in both years. To examine questions of population stability, territory size, movements, site fidelity, territorial turnover, productivity, and survivorship, a concerted effort was made to capture and band breeding Bicknell's Thrushes. Using mist nets, a carved wooden thrush decoy, and tape recorded playbacks, 35 individuals (31 adults and 4 juveniles) were uniquely color-banded in 1992 and 1993 on or near the study plot. Four of the six birds banded on the plot in 1992 were confirmed to return in 1993. Limited nest searching in both years located two nests, one of which was successful in producing young. This marked population is planned to serve as a foundation for future long- and short-term research at the Mt. Mansfield site.

Work on Mt. Mansfield's Bicknell's Thrush population is part of a regional effort to assess the conservation status of this subspecies, which has recently been proposed for designation as a full species. Recent evidence suggests that Bicknell's Thrush has experienced breeding range contraction and population declines. Habitat deterioration has been documented on both its high elevation breeding grounds and on its Hispaniolan wintering grounds. In 1992 and 1993, the Vermont Institute of Natural Science (VINS) and the Manomet Bird Observatory (MBO) launched an investigation of the current population status of Bicknell's Thrush. A survey of 336 peaks in New York, Vermont, New Hampshire, Maine, and Massachusetts located Bicknell's Thrushes on 229 (68%). Of 67 surveyed peaks with known historical records of Bicknell's Thrush in the four states, birds were encountered on 55 (82%). Estimated populations ranged from only one or two on more than 80 peaks to as many as 250 pairs on Mt. Mansfield. While these results suggest that the distribution of Bicknell's Thrush in New England and New York has not undergone significant change, important questions remain about its overall population size and stability.

Anticipated plans for 1994 research on Mt. Mansfield include: 1) establishing an additional study plot in lower elevation spruce-fir forest; 2) obtaining density estimates on both plots; 3) uniquely color-banding all known pairs of Bicknell's Thrushes on each study plot; 4) searching for individual thrushes banded in 1992 and 1993; 5) obtaining productivity data on the upper elevation plot by locating and monitoring nests, and through combined mist-netting and observations of family groups; and 6) testing and evaluating several possible vegetation sampling schemes in order to develop a protocol for widespread use throughout the range of Bicknell's Thrush.

Lye Brook Area

Terrestrial Fauna

Preliminary Results of the Inventory and Monitoring of Amphibian Biodiversity in the Lye Brook Wilderness Region of the Green Mountain National Forest March-October, 1993

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Abstract

During our first field season at this site (April 28-Oct. 31), 6 field methods revealed 7 species of frog and 6 species of salamander. Three drift fences were built and local teams were selected and trained to run them. Three egg mass counting sites were also located. One partial set of baseline data has been gathered for long term monitoring purposes. The species inventory will be continued next spring but it is unlikely that we will discover any additional species. A comparison of inventory data from this site, Abbey pond, and Mt. Mansfield (all located within the Green Mountains) shows remarkable similarity. The species located at the three sites are identical, with the exception of *Rana catesbeiana* which is missing from Abbey pond (the site does not extend into the adjacent valley as do the other two sites). The most common salamander, *Notophthalmus viridescens*, and frog *Rana clamitans* are the same at Lye Brook and Abbey pond, I suspect due to the large amount of permanent water at both sites. The relative percentages of the other species differ between these two sites. The most notable differences being the higher percentages of stream salamanders; *Eurycea bisliniata*, *Gyrinophilus porphyriticus* and the toad *Bufo americanus* at Lye brook.

Introduction

This report is a summary of the efforts and results of work done in the first year of an initial 18 month study period in the Lye Brook Wilderness area of the Green Mountain National Forest. The intent of the study is to do an initial inventory of the amphibians located in the region and lay the ground work for the long-term monitoring of amphibian populations in the region. Concurrent with this effort is an initial inventory of another site within the main range of the Green Mountains at Abbey Pond outside of Middlebury VT. In this report I have also compared the inventory data from these two sites. In addition long-term monitoring continues in its third year at Mt. Mansfield, Underhill, Vermont.

This region is located in the towns of Manchester, Sunderland, Stratton and Winhall in Bennington County, Vermont. Most of the region consists of a plateau at about 2500 ft. in elevation. It has been logged heavily in the past, but is now protected. The plateau forest consists primarily of a mix of of northern hardwoods and conifers with many bogs, swamps, small lakes, beaver dams and old beaver meadows. The water bodies and the soils of the plateau tend to be acidic. The region drains primarily to the west, dropping in elevation to approximately 800 ft. in elevation. The west facing slopes hold a higher percentage of the northern hardwood forests and a number of fast moving streams. The high point of the region reaches close to 3000 ft.

Methods

At this site six different methods have been used to date.

Active searches are a concentrated effort in a predetermined area to locate amphibians in the leaf litter, under rocks and logs, within rotten logs or under bark. These searches usually are not effectively sustained for more than 1.5 hours.

Site checks are a less localized form of active search that includes time spent searching for and traveling between the best microhabitats.

Canoe searches are used when it it is easier to do a visual search of a lake or pond margin from the water than from the shore.

Drift fences are semi-permanent structures built to interrupt the feeding and migratory movements of amphibians on rainy nights or nights immediately after rains. They are constructed of 30 m lengths of aluminum flashing. Tangential with the flashing and buried flush with the ground surface are a series of cans and buckets that can be opened prior to evenings of expected amphibian activity. In addition traps that roughly resemble minnow traps made out of window screening are placed parallel to and abutting the fence. This method is the easiest to standardize and hence I feel it is the best method for reliable long-term monitoring. A copy of my drift fence protocol is available upon request from the author.

Night-time visits are made to selected sites in an effort to hear the calls of breeding and territorial anurans (frogs). They should be spread out to cover the full range of breeding seasons and weather conditions.

Night-time road searches are not possible at most remote sites. They involve driving a set route at a speed of ten to fifteen mph with the vehicle window open to hear calling anurans, and eyes on the road and road margins to see amphibians crossing the route. The method can be very effective in roaded areas.

Accidental discoveries are often made while employing a method not intended to locate that specific species or scouting or working at a site. Individuals located accidentally are identified as such in the data base and in the figures.

None of these methods alone will survey the complete range of amphibians possible in an area. A combination of these methods must be employed in an initial inventory effort. In tables 1-4 at the end of this report I have broken down the results and amount of effort by method.

Overview of the Results and Work Effort for the 1993 Field Season

During the first year of this inventory project, 6 salamander species and 7 frog species were located in or near the Lye Brook Wilderness region of the Green Mountain National Forest. Field teams visited ~28 sites in the region and located 564 individuals of 13 species. In addition, 91 egg masses, 20 choruses of breeding frogs and a variety of amphibian larvae were identified. Aside from scouting and building drift fences, data were gathered on 22 different days, using 6 different methods, producing a total of 55 data gathering efforts between the dates of April 28th and October 31st, 1993.

When the raw data are examined using all methods combined, including all metamorphosed individuals (no eggs or larvae) and not including chorusing data, the following percentages are generated;*

Caudates (Salamanders);

Notophthalmus viridescens	Eastern newt	53%
Eurycea bislineata	Two-lined salamander	20%
Plethodon cinereus	Redback salamander	18%
Gyrinophilus porphyriticus	Spring salamander	6%
Ambystoma maculatum	Spotted salamander	2%
Desmognathus fuscus	Dusky salamander	2%

Anurans (Frogs);

Rana clamitans	Green frog	48%
Bufo americanus	American toad	23%
Rana sylvatica	Wood frog	12%
Pseudacris crucifer	Spring peeper	12%
Rana palustris	Pickerel frog	4%
Hyla versicolor	Gray tree frog	.5%
Rana catesbeiana	Bullfrog	.5%

Though not purposefully sought, one snake species was also located;

Thamnophis sirtalis Common Garter snake

It is important to keep in mind that these percentages are only a rough indicator of the relative abundance of the species in this wilderness area. They are effected by the relative amounts of effort spent using the different methods. In addition, the time of year during which each method was used, the specific sites surveyed and the weather conditions also have an effect on which species are most likely to be located. For example, I expect that spring peeper and spotted salamander will be found in larger numbers next spring using the drift fences that were built this season. I have tried to show clearly in the figures included later in this report, the results relative to the method, time of year, number of sites and amount of effort. For the purposes of long-term monitoring, results need to be compared between the same methods and sites, sampled during the same mix of times, in similar weather conditions and standardized for the amount of effort.

In addition to the above data gathering efforts, the field teams located sites for and installed three drift fences that are designed to be used as long-term monitoring sites as well as inventory devices. Two of these sites are located on the high plateau south of the wilderness area boundary. A field team of faculty from the Stratton Mt. School has been trained to open and check both fences as well as record the data. The third fence is located at an elevation of close to 800 feet in the extreme northwest corner of the region within the National Forest but just outside of the wilderness area. Due to the large size of the region a separate team of teachers and students from the Burr and Burton Seminary has been trained to open and record data from this fence. In order to effectively use drift fences for monitoring, an individual (or group of individuals) needs to be continually on call to make trips to open the fences when the right environmental conditions exist. I was fortunate to find reliable and interested individuals who live in the vicinity. Although I presently have one adult and a group of students for this fence, I am still looking for a second adult. I now have data from essentially one half of the field season from these fences and will have a full years data by the conclusion of this contract in July of next year.

Of the many potential breeding sites visited, three sites have been designated for long-term monitoring of egg masses. Egg masses of *Rana sylvatica* (Wood Frog) and *Ambystoma maculatum* (Spotted salamander) have been located at these sites. These species are both early spring breeders with obvious and easily identified egg masses. I refer to these sights as Benson Pond, North Alder Dam and Kelly Stand Dam. They are all associated with beaver dams or in beaver meadows, although the Benson Pond site is adjacent to what is apparently a man made permanent pond. At these sites I will standardize a protocol and begin gathering data this spring. I have not located sites that meet the criteria of a classic vernal pool in this area. I am not totally satisfied with the sites I have chosen. Because they are associated with beaver dams or meadows they may be subject to manipulation and change over time. If I locate more appropriate sites I will relocate the egg mass counts.

As a result of the need for the long-term monitoring sites to be readily accessible from April through October under a variety of weather conditions, they have been located outside of the wilderness area boundaries, however my inventory efforts sampled a wide variety of sites inside the wilderness area and I feel that the sites selected are representative of the habitats within.

The location of the drift fences, and proposed sites for long-term egg mass counts are shown in figures 1 and 2. Maps of the total area surveyed have been forwarded to the GMNF.

* *Notophthalmus viridescens* (Eastern Newt) were sometimes found in large numbers while we were counting egg masses, building drift fences or using a method designed to locate a different species. Occasionally these were entered simply as "many" in the database. Each reference to "many "was counted as 10 individuals in the data analysis. I believe this is a conservative treatment of these entries.

Brief Discussion of the Results to Date

The overall diversity found at this site fits well with a pattern that is beginning to emerge as a result of our work at a variety of sites through out the western half of the state. Keeping in mind that comparable data from other Vermont sites were not available until the beginning of my efforts in 1988, a clearer picture of the expected diversity at any given site will continue to emerge as I examine the results of my efforts at more sites. However, based on my recent efforts at Abbey Pond and Mt. Mansfield the species located at this site are what I would have expected given the location of the site along the main range of the Green Mts., the age and mix of tree species, the pH of the soils and the amount of permanent and semi-permanent water available.

The species list generated so far is almost identical to that of the two other central Green Mountain sites where I have fairly complete data sets (Mt. Mansfield and Abbey Pond). However, the proportions of each species differ. Keep in mind that I have a different balance of methods used at this point in the inventory.

There are approximately 22 species of amphibian reported in Vermont. Many of these are either very rare, localized in other regions of the state, or found in habitat types which were not found in this region. As stated above the diversity at this site is very similar to that found at the two other Green Mountain sites I have studied. However, compared to sites outside of the Green Mts., but still in west central Vermont, this site has less diversity of both reptile and amphibian species. Whether this is a result of the decreased buffering capacity of the bedrock, habitat types, elevation or other direct or indirect effects of a change in microclimate is not yet clear.

Species that appear to be absent from this site, but have been located in Addison, Rutland or Bennington counties in recent years are;

Amphibians Missing

Ambystoma jeffersonianum	Jefferson salamander
Ambystoma laterale	Blue-spotted salamander
Hemidactylium scutatum	Four-toed salamander
Necturus maculosus	Mudpuppy
Rana pipiens	Leopard frog

Of these species *Necturus maculosus* (Mudpuppy) would be expected primarily in Lake Champlain and its major tributaries, hence not at this site. Although I am just beginning to get a picture of the distribution within the state of most of these species, I would have suspected the absence of some of them from this site based on an emerging picture of preference for habitat types which are not represented in this region. Habitats missing and some of the species possibly associated with them include; deep and permanent water bodies with extensive vegetation at low elevations (Leopard frog), flood plains with vernal pools and surrounding woods (Blue-spotted salamander), or oak-hickory ridges with semipermanent pools of neutral pH (Jefferson salamander). Their absence however was by no means certain and one or more of them may yet be located here in the next field season. The absence of *Hemidactylium scutatum* (Four-toed salamander) and *Ambystoma jeffersonianum* and *laterale* (Jefferson and Blue-spotted salamanders) from this, the third Green Mountain site I have surveyed, is very interesting. It suggests that they are entirely limited in distribution to foot hills and floodplains. I had thought that if I was to locate them at all in the Green Mountains, it might be on the west flank of the mountains in lower elevation hardwood forests. Clearly most of this region is not that type of woodland, but I did locate one of the drift fence and egg mass sites at only 800 feet in elevation, on the extreme western edge of this region. In addition I performed site checks and active searches along the western border. It is in this area that I located the one and only *Rana catesbeiana* (Bullfrog), calling in the pond near the access to Lye Brook Falls. If some of the other "foothill" and lowland species, are later found in the wilderness, I would expect to find them along the western border of the area. In fact I located one of the *Ambystoma* hybrids (*jeffersonianum x laterale*) in the Batten Kill valley less than 1 km west of the wilderness area. Also in this adjacent valley area are higher numbers of Bullfrogs and Gray tree frogs. I located only one individual of *Hyla crucifer* (Gray tree frog) within the survey area. In fact I never heard it at all, but my younger (better ears?) field assistants claim to have heard one, when we were at Branch pond one evening. I suspect that I will find more Gray tree frogs next spring. It is difficult to locate them, other than by call, during night-time visits. To complicate matters they call primarily in May and June on warm humid nights often before thunder showers. I will make an effort to spend a few nights in the woods this coming summer under those conditions to see if they are indeed in the survey area.

The amphibian species listed below have been located in Vermont but not in Bennington county. Hence their absence from this site is not remarkable.

Pseudacris triseriata	Northern Chorus frog
Rana septentrionalis	Mink frog

The Northern chorus frog has only been located on Grand Isle as part of an extended range reaching into the Lake Champlain Valley from the north and west. It is not known from any other site within Vermont, nor has it been relocated in recent years on Grand Isle.

The Mink frog would have been a remote possibility at this site. It is a northern species that is frequently found within the belt of northern conifers. However it appears that its range does not reach this far south in Vermont although the habitat and local climate appear to be suitable.

Comparisons

The most responsible comparison that can be made at this point between Lye Brook and Abbey Pond involves balancing the relative effort of three methods; drift fences, site checks and active searches. For example if the amount of person-hours spent in active searches at Lye Brook was half that spent at Abbey pond, the amphibian numbers should be doubled for that method before they are compared. Once the figures for each method are standardized (active searches x 2, site checks x 1.7 and fence-nights x 1.23) they can then be combined and compared. If this is done the following figures are generated.

	Lye Brook		Abbey Pond	
Caudates (Salamanders)				
Eastern newt	436	49%	583	61%
Two-lined salamander	202	23%	70	7%
Redback salamander	152	17%	140	15%
Spring salamander	59	7%	2	.2%
Spotted salamander	20	2%	59	6%
Dusky salamander	19	2%	102	11%
Total	888	100%	956	~100%
Anurans (Frogs);				
Green frog	104	49%	114	53%
American toad	40	19%	20	9%
Wood frog	28	13%	54	25%
Spring peeper	26	12%	22	10%
Pickerel frog	13	6%	6	3%
Gray tree frog	0	0%	1	.5%
Bullfrog	0	0%	0	0%
Total	211	~100%	217	~100%

the reason that they usually breed in temporary ponds where fish can not survive. However they do breed very successfully in permanent and semipermanent ponds that do not hold predators. If fish are introduced to these ponds, the fish would be expected to have a greater impact on those species who are not generally found with them. *Rana clamitans* on the other hand are frequently found in lakes, ponds and streams with fish populations. Hence, the natural presence or introduction of fish to these ponds, may have helped to increase the relative abundance of Green frogs relative to Wood frogs. Unlike Abbey pond the second most abundant frog so far at this site is *Bufo americanus* (American toad). Why this species is also more abundant than the Wood frog, I don't yet have a clue. Equally perplexing are the low numbers of the Spotted salamander and the Dusky salamander relative to Abbey Pond. At this point I would venture that the numbers of Spotted salamanders will balance out to some extent after the spring season. In the case of the Dusky on the other hand I have had only limited success in locating breeding sites in the Lye Brook Wilderness.

It is also very interesting to compare the relative abundances of *Eurycea bislineata* (Two-lined salamander) at Lye Brook and Abbey pond. At Lye Brook it makes up 23% of the salamanders found. It is second in abundance only to the Eastern newt. While at Abbey pond, it makes up only 7% and ranks fourth in abundance. Unlike the toad situation, it is fairly easy to come up with a logical hypothesis that might well explain this difference. Once one moves off the central plateau of the Lye Brook Wilderness area, there are many fast well oxygenated brooks and streams. This is not the case at Abbey pond. The survey area at Abbey pond contains only one short section of this habitat type. These streams are the favored habitat of this salamander. This hypothesis is further supported by the increase in relative abundance of *Gyrinophilus porphyriticus* (Spring salamander). At Abbey pond it is the least most common salamander at only .2% while at Lye brook it comprises 7% and is the 4th most abundant. This large stream predator is also found in the same habitat type. However it is slightly premature to discuss apparent proportions before the spring field season. In addition comparisons between two large regions, although useful, are less reliable in showing small proportional differences than comparisons between the same sites over time.

Future Plans

Diseased Organisms

At the Abbey Pond site over the course of the field season I located amphibians which appeared to be suffering from three different diseases.

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Rana sylvatica metamorphs were found on two occasions with one of the rear legs undeveloped. *Notophthalmus viridescens* adults were located with large light colored crippling growths on their bodies and on a few occasions emaciated individuals were located. At this site I have seen only one of the emaciated newts, one adult newt dying with no external signs of disease and a few dead adults. I have obtained permits from the state, and made the necessary arrangements with an out of state laboratory to determine the causes of these problems on any "diseased" specimens I locate next field season. At present there is little evidence of these problems at Lye Brook. However I will now be looking for them at this site as well as Abbey Pond and others.

Long-term Monitoring Methods

The methods I originally intended to use at this site on an annual basis for long-term monitoring were drift fences and egg mass counts only. Structures are in place, sites chosen and field workers trained to continue the monitoring beyond this contract period. These two methods will be effective in monitoring a wide variety of amphibians at this site, but not all. As a result of the high numbers of stream salamanders and streams located at this site, a third method could be employed if funding permits. Active searches along three predetermined stretches of stream could be run. These searches would give us data on the Two-lined and Spring salamanders which were surprisingly abundant at this site. Protocol could be easily developed to standardize these counts. Periodic inventories using the total range of methods are still recommended. The first years monitoring data will be included in next falls report.

Context

As stated in the introduction this site will become one of three long-term monitoring sites located within the Green Mountains of Vermont. In addition the current inventory work at these and many other sites in Vermont is helping us to understand distribution patterns of amphibians throughout Vermont and the factors which may determine them. To date a great deal has been learned. The data gathered at these sites have been used in a preliminary set of maps showing the known distribution of amphibians and reptiles in Vermont.

Acknowledgments

In addition to the author, a number of other individuals were tremendously valuable in the gathering of data in this region. Catherine

Herzog served as a field assistant for the duration of the field season. Timothy Bernard, a Middlebury College student assisted over the summer, supported by a grant from the Howard Hughes Medical Institute. Faculty from the Stratton Mountain School are monitoring the upper two drift fences under the direction of Lee Petty. Students and faculty from the Burr and Burton Seminary are monitoring the low elevation fence under the supervision of Tom Hopkins.

Thanks are also due to Dr. Steve Trombulak of Middlebury College for the use of his lab and equipment as well as his continued support and guidance.

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Table 1

A Summary of Field Efforts in the Lye Brook Region, 1993

Month	Active Searches	Canoe Searches	Drift-fence nights	Night Visits	Night Road Searches	Site Checks	Accidental Disc's.	Visitation Days
April	29			28		28,29		2
May	12,27	11		11	11	11,26	11,12	4
June	16			16		17	16,17	2
July	8,9			1,8		1,2,8,9	2,27*	4
August				4				1
September			9,18,19			14	14	4
October	12		13,17, 21,22				12,31*	5
Total # of times each method was used	14	2	7 nights, 3 fences, 13 fence nights	7	1	18		55 data gathering efforts, on 22 days
# of Sites	12	1	3	5	1 Route	16	10	28*** Sites
Significant Units**	~30 Person-hours	2 Canoe-hours	4 Nights Upper Fences (2), 5 Nights Lower Fence	4 hours	1 Route at ~12 km	50 Person-hours at 16 Sites		

* not counted as a data gathering day (drift fence building or maintenance),

** hours rounded to the nearest quarter-hour,

*** more than one method was used at most sites, hence this number is not the sum of the this row

Table 2

Salamanders Located in the Lye Brook Region, 1993

Species	Active Searches	Canoe Searches	Drift Fences	Night Visits	Night Road Searches	Site Checks	Accidental Discoveries	Totals	% of All Caudates
Ambystoma maculatum **Spotted Salamander**	4 egg masses	11 egg masses	10		4	21 egg masses	18 egg masses	**14** **54 egg masses**	**2%**
Desmognathus fuscus **Dusky Salamander**	6					4	1	**11**	**2%**
Eurycea bislineata **Two-lined Salamander**	65		1			42 6 egg masses	2	**110** **6 egg masses**	**20%**
Gyrinophilus porphyriticus **Spring Salamander**	14					18		**32**	**6%**
Notophthalmus viridescens **Eastern Newt**	117	10+	51	20+	1	82+	17+	**298+**	**53%**
Plethodon cinereus **Redback Salamander**	26		22			43	8	**99**	**18%**
# of Species	6	2	4	1	2	6	5	**6**	
# Individuals	228	10+	84	20+	5	189	28	**564**	
# Egg Masses	4	11				27	18	60	
% of Caudates	100%	33%	67%	17%	33%	100%	83%	100%	

Table 3

Frogs Located in the Lye Brook Region, 1993

Species	Active Searches	Canoe Searches	Drift Fence Nights	Night-time Visits	Night-time Road Searches	Site Checks	Acci-dental Disc's.	Totals	% of All Frogs
Bufo americanus **American Toad**	4		1	3 2 choruses	13 1 chorus	18 1 tadpole site	7	**46 3 choruses 1 tadpole site**	**23%**
Hyla versicolor **Gray Tree Frog**				1 ?				**1 ?**	**.5%**
Pseudacris crucifer **Spring Peeper**	7	1		6 3 choruses	2 10 choruses	7	1 1 chorus	**24 14 choruses**	**12%**
Rana catesbeiana **Bullfrog**				1				**1**	**.5%**
Rana clamitans **Green Frog**	18	6		20 2 choruses	2	40	10	**96 2 choruses**	**48%**
Rana palustris **Pickerel Frog**	3					4	1	**8**	**4%**
Rana sylvatica **Wood Frog**	4	4 egg masses	4	5	2	9 1 chorus 25 egg masses	2 egg masses	**24 1 chorus 31 egg masses**	**12%**

Table 4

Totals for Frogs

Species	Active Searches	Canoe Searches	Drift Fence Nights	Night-time Visits	Night-time Road Searches	Site Checks	Accidental Discoveries	Totals
# of Species	5	3	2	6	4	5	5	7
# Individuals	36	7	5	36	19	78	19	200
# of Egg Masses		4				25	2	31
# of Choruses				7	11	1	1	20
# Tadpole Sites						1		1
% of All Frogs	71%	43%	29%	86%	57%	71%	71%	100%

Combined Totals for all Amphibians

# of Species	11	5	6	7	6	11	10	13
# Individuals	264	17+	89	56+	24	267	47	764
# of Egg Masses	4	15				52	20	91
# of Choruses				7	11	1	1	20
# Tadpole sites						1		1
% of All Amphibian Species	85%	38%	46%	54%	46%	85%	77%	100%

Reptiles Located in the Lye Brook Region, 1993

Thamnophis sirtalis Common Garter Snake	3					5	3	11

Drift Fence and Egg Mass Survey Locations

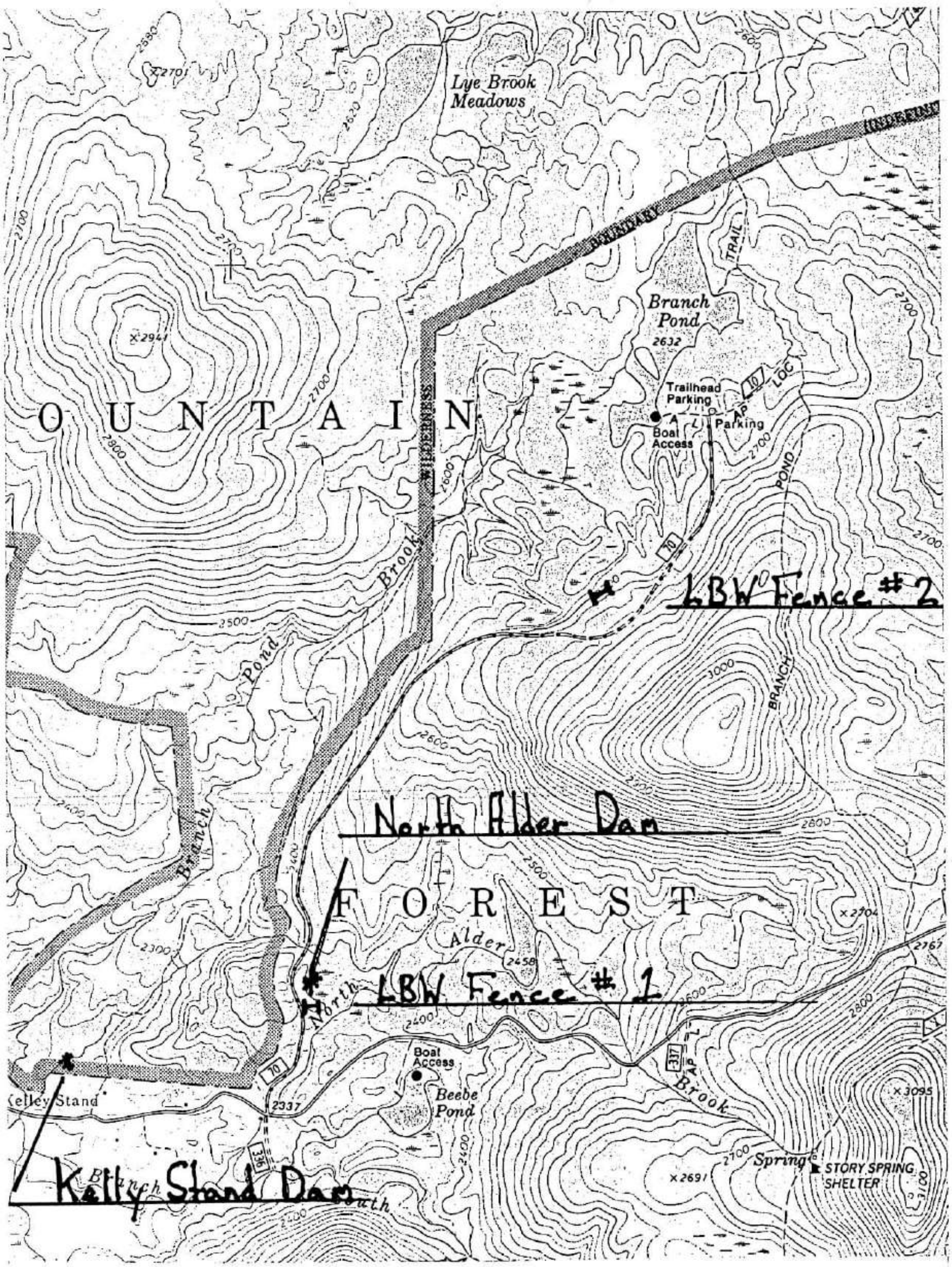
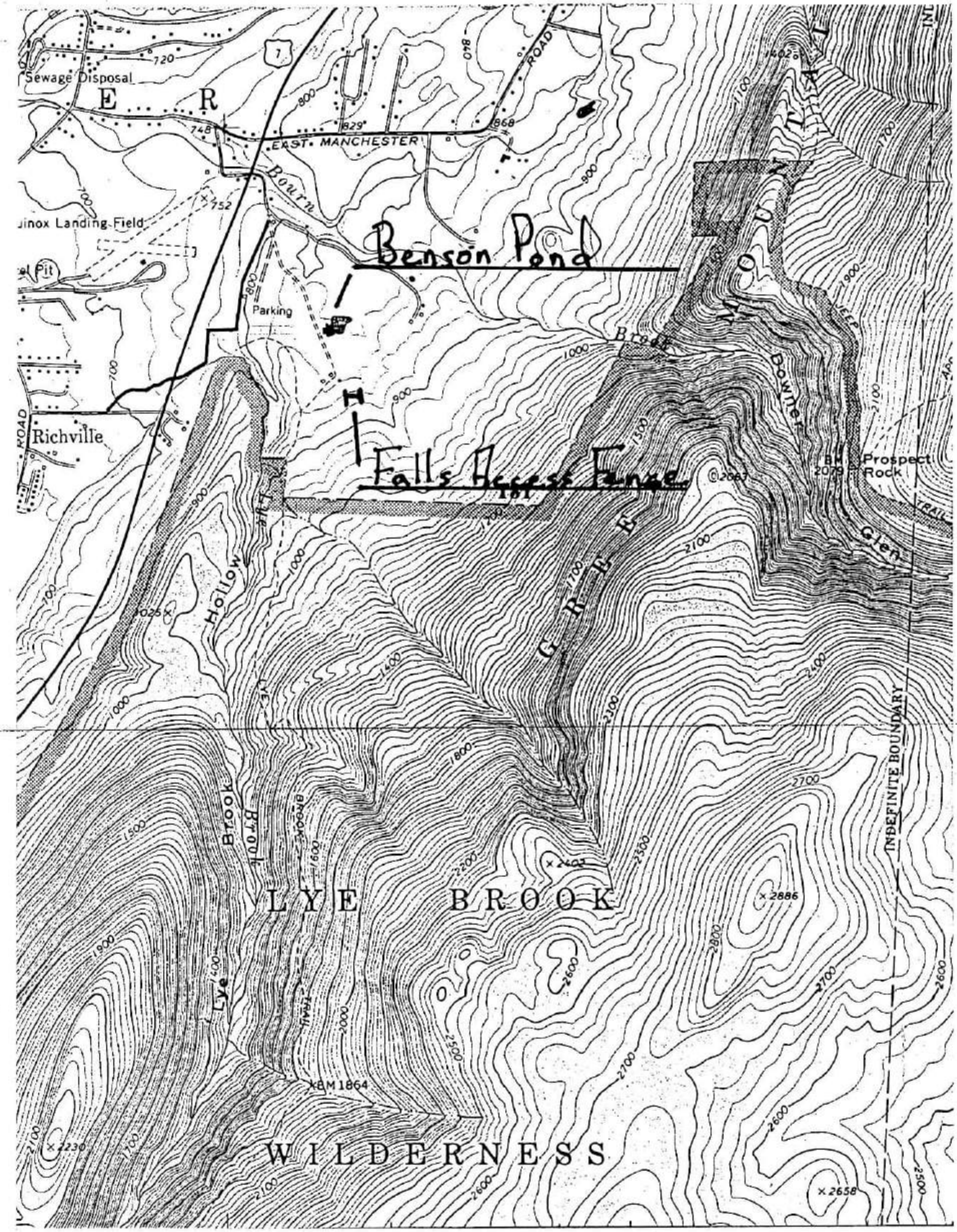


Figure 2

Drift Fence and Egg Mass Survey Locations



Lye Brook Area

Terrestrial Flora

EVALUATION OF OZONE DAMAGE TO VEGETATION ON THE LYE BROOK WILDERNESS IN 1993

SURVEY REPORT

MAY 1994

Prepared By:

James T. O'Brien, USDA Forest Service
Forest Health Protection, Durham Field Office

UNITED STATES DEPARTMENT
OF AGRICULTURE

Forest Service

Northeastern Area

Evaluation of Ozone Damage to Vegetation on the Lye Brook Wilderness in 1993

Survey Report

April 1994

Prepared by: James T. O'Brien, Plant Pathologist, Forest Health Protection, P.O. Box 640, Durham, NH 03824

Cooperators: William Manning, University of Massachussetts and Richard Poirot, Vermont Air Pollution Control

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ABSTRACT

An evaluation of ozone damage to vegetation in Lye Brook Wilderness is conducted annually to help the Green Mountain National Forest meet the requirements of the Clean Air Act. The objectives of the evaluations are (1) to determine if symptoms of ozone injury are present on ozone sensitive species on Lye Brook Wilderness and if so, to quantify the extent and intensity of the injury, and (2) to relate the occurrence of symptoms found in the Wilderness to ozone concentrations recorded nearby. To these ends, sensitive vegetation within the Wilderness, primarily black cherry and white ash trees and blackberry brambles, have been examined for ozone injury since 1988. Ozone data have been obtained from the State monitor at Bennington (low elevation) and, since 1989, the Forest Service monitor on Mount Equinox (high elevation).

In 1993, ozone concentrations in the vicinity of the Wilderness were generally moderate; the "average daily peak concentration" during the growing season was, at both elevations, 56 ppb - close to the 1988-92 mean. The second highest hourly average concentration - the value used for PSD (Prevention of Significant Deterioration) purposes - was 110 ppb at Bennington and 102 ppb on Mt. Equinox. The "red line" value, a second highest hourly average concentration of 120 ppb, was not reached in 1993.

In 1993, symptoms of ozone injury to plants on the Wilderness were not often found and not pronounced when they were found. No injury was found on either of the 2 white ash trees sampled, and injury was found on only 3 of the 18 black cherry trees. None of the blackberry canes on the six blackberry plots examined was injured, making 1993 the first year since the surveys were begun in 1988 that no blackberry plants were injured.

In the evaluations so far, plant injury and ozone concentrations have been fairly well correlated, though not as closely as might be expected. In 1993, for example, it is believed that the dry weather of that summer prevented much of the injury by causing the plants' stomata to close. The plants did not absorb the dose they would have if there had been no drought.

INTRODUCTION

Under provisions of the Clean Air Act amendments of 1977, the Forest Service is responsible for the protection of "Class I" wilderness areas from the adverse effects of air pollution. In 1987, personnel of the National Forest System requested assistance from Forest Health Protection in evaluating the effect of ozone on the vegetation of the Lye Brook Wilderness in Vermont. Since then the Wilderness has been surveyed annually for symptoms of ozone injury, and the injury related to ozone concentrations recorded at nearby monitors. Herein is a report of the 1993 findings, and comparisons with the findings of previous years.

OBJECTIVES

The objectives of the 1993 evaluation were, as in previous years, (1) to determine if symptoms of ozone injury were present on ozone sensitive species on Lye Brook Wilderness, and if so, to quantify the extent and intensity of the injury, and (2) to relate the occurrence of symptoms found in the Wilderness to ozone concentrations recorded nearby.

METHODS

Ozone concentrations

In the same manner as for the reports of previous years, computer printouts of one-hour average ozone concentrations recorded April through October 1993 at Bennington, Vermont (elevation 244 m), were obtained from Richard Poirot of the Vermont Air Pollution Control Agency. Records from the monitor on Mt. Equinox (elevation 625 m), which operated June through August 1993, were compared with the Bennington data, and both sources of information were used to estimate the ozone levels to which the vegetation on Lye Brook Wilderness was subjected. Dr. William Manning of the University of Massachusetts, cooperating with the Forest Service, oversaw activities at the Mt. Equinox site.[1]

The second highest one-hour average concentration has been chosen as the ozone parameter relevant to the Forest Service's PSD (Prevention of Significant Deterioration) process for the protection of the air quality of the wildernesses of Region 9 (Adams and others, 1991). The "green line" (concentrations sufficiently low that impacts on wilderness values are not expected) was set at 80 ppb; the "red line" (concentrations sufficiently high that impacts on wilderness values are predicted) at 120 ppb. The "yellow zone" (effects uncertain) is between 80 and 120 ppb.

Tree group and plot establishment

In 1992, the species of ozone-sensitive plants that were closely examined for symptoms of ozone injury were white ash (*Fraximus americana* L.), black cherry (*Prunus serotina* Ehrh.), and blackberry (mostly *Rubus vermontanus* Blanch.). Usually the same trees or clones (blackberries) were examined in 1988 through 1992.

[1] A third cooperator was the Carthusian Foundation of Arlington, VT. The Foundation provided the site and access to electric power.

In 1993, only 2 white ash and 18 black cherry trees were sampled, compared to 14 ash and 25 cherry trees in 1991 and 1992. A tree climber could not be used to collect samples from tall trees, as was done in previous years, because of rain. Thus it was necessary to use pole pruners to obtain all tree samples, and the crowns of most tall trees could not be reached. The white ashes and two of the black cherries that were sampled are located along the jeep road on the northern edge of the Wilderness. The 16 smaller black cherry trees, in Groups 6,7, and 8, are located at the opening at the east end of the jeep road (4 trees), near Kelley Stand at the southernmost part of the Wilderness (9 trees), and near the north end of the Lye Brook Trail (3 trees).

Six blackberry clones in the eastern portion of the Wilderness, where blackberry canes growing in the open can be found, were sampled in 1993. To prevent sampling a plant twice, temporary plots containing 10 canes each - 5 first year canes (primocanes) and 5 second year canes (floricanes) - were established in each clone.

The locations of the blackberry plots and tree groups are shown in Figure 1.

Injury ratings

From 1988 to 1992, nearly all the injury found on the plants examined consisted of a purple stippling or discoloration of the leaves. Very little dead tissue was found. Thus it was this purple discoloration that was searched for and, when found, rated in 1993.

Two methods of classifying and rating injured foliage, in order to quantify the injury and permit comparisons from year to year, were used in 1993: (1) A five class system - the way foliage was classified and rated in surveys of the Wilderness since 1988. This was to allow comparison of 1993 injury with that of previous years. (2) An eight class system - the way samples are classified in National Park Service surveys. The latter method standardizes procedures in the eastern United States.

The five class system combines the percentage of injured leaves on the plant or branch and the intensity of damage on the 10 most severely injured leaves. Both of these are on a scale of 0 to 4 as follows:

0 = No injury
1 = Trace (1 to 5 percent)
2 = Light (6 to 25 percent)
3 = Moderate (26 to 50 percent)
4 = Heavy (greater than 50 percent)

The classes were multiplied for the index rating. For example, a plant with 20 percent of its leaves injured, the heaviest of which averaged 4 percent, would be rated 2 (2 x 1). The most severe injury possible would be 16 (4 x 4).

The eight class system is the modified Horsfall-Barrett system, a system that takes advantage of the fact that an observer can discern small differences when injury is light, but gradually loses this ability as injury approaches 50 percent. The observer rates 30 leaves on each of three terminal shoots from near the top of a tree, or the oldest 30 leaves on a smaller plant. The injury on each leaf is classified thusly: 0 (0), 1 (1-3 percent), 2 (4-6 percent), 3 (7-12 percent), 4 (13-25 percent), 5 (26-50 percent), 6 (51-75 percent), and 7 (76 percent or greater). The classes are averaged for a rating of the plant.

Figure 1. Map of Lye Brook Wilderness, Green Mountain National Forest, Vermont, showing locations of vegetation examined for ozone injury. (Scale 1:62800).

RESULTS

Ozone concentrations in 1993

Table 1 shows that for most of the parameters computed, ozone concentrations recorded at Bennington, in 1993, were in the low to moderate range when compared to previous years. (Overall and 7 hour averages, because they are not significant with regard to plant injury, are presented in Appendix Table 1.)

The "average daily peak concentrations" for 1993 was 56 ppb - about the mean of the years 1988 through 1992. The number of hours during which May-August concentrations were 80 ppb or higher was 51 at Bennington in 1993 (Table 1), which is the third lowest of the years 1988-93.

On Mt. Equinox, the number of hours during which June-August concentrations were 80 ppb or higher was 40 in 1993, compared to 54 in 1992, 121 in 1991, and about 46 in 1990. The count for 1989 was only 17, but concentrations were high in May of that year. The Mt. Equinox monitor is usually not in operation in May.

As in most years, in 1993 the number of hours, June-August, during which concentrations exceeded 50 ppb was greater on Mt. Equinox than at Bennington - 428 vs. 348 (owing to the nighttime "scavaging" of ozone at low elevations, Bennington averages about 100 hours fewer than Mt. Equinox). For Mt. Equinox 428 is a low total, compared with 484 in 1992, 614 in 1991, and 446 in 1990.

The second highest one-hour average concentrations (in ppb) for 1987 through 1993 are as follows:

	1987	1988	1989	1990	1991	1992	1993
Bennington	95	125	101	107	118	94	110
Mt. Equinox	--	--	100	96	123	103	102

Symptoms on black cherry and white ash

Symptoms of ozone injury were found on the two black cherry trees examined along the jeep road. One of these, tree 1 of group 3, when rated by the five class system, had an injury index of 4.7; by the eight class system, 1.8. Symptoms on the other black cherry along the jeep road, tree 1 of group 4, were found on a single leaf and were very faint, so no rating was possible. No symptoms were found on the two white ashes examined. Of the 16 black cherries in groups not along the jeep road (groups 6-8), only one, tree 3 (PB 347) of group 6, had symptoms. Oddly, only the foliage of a single lower branch was affected. That branch was rated 8 by the five class system and 1.2 by the eight class system.

Symptoms on blackberry

None of the 60 blackberry canes examined in the six clones surveyed had symptoms of ozone injury in 1993.

Table 2. Comparison of 1988 through 1993 data on high concentrations from the ozone monitor at Bennington, Vermont. (Missing data 6/26-7/2/93 filled in with Mt. Equinox data.)

		APR	MAY	JUN	JUL	AUG	SEP	OCT	7 MONTH MEAN/TOTAL	MAY-AUG MEAN/TOTAL
Average daily peaks (ppb)	1988	49	63	66	71	64	47	38	57	66
	1989	55	63	56	59	48	47	45	53	56
	1990	51	53	61	55	50	49	39	51	55
	1991	57	60	59	56	53	45	40	53	57
	1992	61	55	58	47	44	46	38	50	51
	1993	47	55	55	52	60	46	53	53	56
Number hours >50 ppb	1988	55	218	161	207	197	61	43	942	783
	1989	170	268	131	148	66	69	56	908	613
	1990	109	145	150	137	96	84	42	763	528
	1991	160	176	117	108	99	66	49	775	500
	1992	214	142	180	42	43	26	11	658	407
	1993	83	126	114	89	145	57	122	736	474
Percent hours >50 ppb	1988	9	37	31	32	29	9	6	21	32
	1989	25	39	19	21	10	10	8	19	23
	1990	17	20	23	19	15	12	6	16	20
	1991	23	25	17	16	14	10	7	16	18
	1992	32	20	26	6	6	4	2	14	15
	1993	12	18	17	12	20	8	17	15	17
Number hours ≥ 80 ppb[1]	1988	2	26	59	65	42	2	0	196	192
	1989	0	13	13	13	0	1	0	40	39
	1990	12	4	33	17	5	1	0	72	59
	1991	0	12	47	28	18	0	0	105	105
	1992	21	4	24	0	0	0	0	49	28
	1993	7	0	29	9	13	0	0	58	51
Percent hours ≥ 80 ppb	1988	0.3	4.4	10.8	9.4	6.1	0.3	0.0	4.4	7.7
	1989	0.0	1.9	1.9	1.9	0.0	0.2	0.0	0.9	1.4
	1990	1.9	0.6	5.1	2.4	0.8	0.2	0.0	1.5	2.2
	1991	0.0	1.7	6.8	4.1	2.6	0.0	0.0	2.2	3.8
	1992	3.2	0.6	3.6	0.0	0.0	0.0	0.0	1.0	1.0
	1993	1.0	0.0	4.2	1.3	1.8	0.0	0.0	1.2	1.8

[1]Levels ≥ 80 ppb occurred on 35 days in 1988; 9 in 1989; 14 in 1990; 19 in 1991; 8 in 1992; and 11 in 1993.

DISCUSSION

The ozone concentrations that occurred in 1993 appear to be those for a typical or average year - or perhaps below average (Table 1 and Appendix Table 1). The 'red line', a second-highest concentration of 120 ppb was not reached; in fact that concentration has been reached in only 2 of the 7 years in which monitoring was conducted. Nevertheless, some injury to vegetation has occurred each year and 1993 was no exception. The ratings given both the trees that were rated reflect the fact that many of the leaves were affected but they were only lightly injured. One of these, tree 1 of group 3, is known to be quite sensitive, having shown injury every year since 1988 except 1992.

That injury was slight was indicated also by the absence of injury to blackberry plants. At least some blackberries were injured every previous year since 1988, even in 1992, a year of low concentrations. It was because of the low concentrations that injury to vegetation was light in 1992. In 1993, in contrast, concentrations were high enough to cause injury, but even less injury occurred. Dr. Manning, who examined vegetation near the monitor throughout the summer of 1993, thinks the hot, dry weather conditions that occurred during that summer protected the plants by causing the stomata to close. The closing of the stomata is the means by which a plant limits water loss through transpiration, and inadvertently the plant shuts out ozone at the same time.

FUTURE PLANS

Plans are to continue the ozone concentration monitoring indefinitely, in order to discern long term trends in ozone concentrations. Though presently the Forest Service monitor on Mt. Equinox cannot be available for the entire growing season, it should be more relevant to the Wilderness than the State monitor at Bennington because it is closer, both geographically and in elevation. Perhaps eventually the Mt. Equinox monitor can be replaced with a solar-powered unit at EPA's recently installed CASTNET (Clean Air Status and Trends NETwork) site about 700 m SW of Kelley Stand at an elevation of about 700 m. That site is even closer to the Wilderness.

Another vegetation survey is planned for 1994, and perhaps surveys should be continued one or two years beyond that. By that time, we should have enough information to estimate what concentration level should "trigger" a survey. That is, a survey would be conducted only when concentrations, and meteorological conditions, are such that significant injury is likely. At this writing, the May concentrations look as if they may indicate the later appearance of symptoms. In the years 1988, 1989, and 1991 symptoms were widespread and intensive, and those are the years when May concentrations were highest. That correlation may be only a coincidence, but the matter bears watching in future years.

REFERENCES

Adams, Mary Beth; Nichols, Dale S.; Federer, C. Anthony; Jensen, Keith F.; Parrott, Harry. 1991. Screening Procedure to Evaluate Effects of Air Pollution on Eastern Region Wildernesses Cited as Class I Air Quality Areas. Gen. Tech. Rep. NE-151. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 33 p.

APPENDIX

Appendix Table 1. Comparison of 1988-93 overall and 7-hour (0900-1600) average ozone concentrations at Bennington, VT (Missing data 6/26-7/2/93 filled in with Mt. Equinox data).

		APR	MAY	JUN	JUL	AUG	SEP	OCT	7 MONTH MEAN	MAY-AUG MEAN
Overall average (ppb)	1988	38	43	44	44	38	27	26	37	42
	1989	43	46	37	35	30	27	28	35	37
	1990	39	40	41	34	30	28	25	34	36
	1991	42	38	35	35	30	25	26	33	34
	1992	47	41	43	35	32	35	27	37	38
	1993	35	37	37	32	35	33	41	36	35
7 hr ave (0900-1600) (ppb)	1988	42	55	59	61	51	39	32	48	56
	1989	50	55	45	47	43	37	37	45	48
	1990	45	47	50	47	44	42	33	44	47
	1991	50	47	47	45	42	35	32	43	45
	1992	54	46	48	36	36	36	31	41	42
	1993	46	45	46	42	49	37	48	45	46

PROGRESS REPORT

LICHENS AND AIR QUALITY IN THE LYE BROOK WILDERNESS OF GREEN MT. NATIONAL FOREST.

Clifford M. Wetmore

This project was to assess the air quality of the Lye Brook Wilderness by using lichens as indicators and to prepare a species list of the lichens found in the wilderness area.

Three weeks were spent in the wilderness in August, 1993. Over 550 lichen collections were obtained at 18 localities. These collections will provide the species list and the distributions of the species most sensitive to sulfur dioxide. At four localities additional material of four species was collected for elemental analysis.

Most of the lichens collected have been identified and deposited in the Univ. of Minnesota Herbarium. The preliminary species list includes 127 species. The elemental analysis material has been cleaned and analyzed but the results have not been compiled.

The project will be completed and the report prepared by September, 1994.