Vermont Forest Ecosystem Monitoring

(formerly Vermont Monitoring Cooperative)

Annual Report for 1995

Sandra Wilmot and Timothy Scherbatskoy
(Editors)

The VForEM is Vermont's Cooperative Forest Ecosystem Monitoring and Research Program, administered by VForEM, Inc., in partnership with the Vermont Department of Forests, Parks & Recreation, the University of Vermont, and the Green Mountain National Forest.

Additional financial support has been received from the USDA Forest Service, Northeastern Area State and Private Forestry, and Northeast Forest Experiment Station.

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TERRESTRIAL FLORA

Introduction

The purpose of the VForEM annual report is to document results from studies conducted at the two VForEM sites at Mount Mansfield and the Lye Brook Area for the calendar year. Cooperators working at the two study sites are invited to submit their findings (preliminary or otherwise) for the year in a form that is easily understood by non-experts with an interest in forested ecosystems. It is hoped that this publication will stimulate an exchange of information and ideas and promote cooperation in expanding our understanding of forested ecosystems in Vermont.

This document begins with an overview of program highlights for 1995, then proceeds to specific study results. Results are organized by the type of information collected (atmospheric, flora, fauna, etc.), and within each type are articles from studies conducted at both Mount Mansfield and the Lye Brook Area sites.

A centralized data management structure was initiated in 1995 with the hiring of a full-time VForEM Data Manager. Current and historical data and metadata began to be standardized and stored in the VForEM Data Library, and cataloged in a VForEM Card Catalog for easy retrieval. Data requests can be accomplished through the Data Manager, with the goal of eventually having data, metadata and reports available through the VForEM web site on the internet (http://mole.uvm.edu/vmc).

A VForEM Data Integration Workshop for cooperators was held in January. The goal was to better define what integration means, how to accomplish data integration, and what process and products VForEM participants would be interested in developing. One outcome of the meeting was a plan to produce a Data Integration Report that would use VForEM data to illustrate methods of integration. The Data Manager would be responsible for conducting analysis and working with cooperators to complete a variety of integration projects. This report would provide a stepping stone towards producing more comprehensive result-oriented reports.

The Annual Cooperators Meeting in March featured presentation of results by cooperators and two concurrent workshops. One workshop focused on data integration to address ecosystem management needs. The second workshop provided an opportunity to develop research needs that could be addressed in a VForEM Forest Management Study.

Outreach activities were numerous this year. The Management Team of the Agency of Natural Resources, a group largely concerned with natural resource management and policy, met with VForEM Monitoring and Research Directors to learn of mutually beneficial opportunities between our groups. The Chief of the USDA Forest Service, Dr. Jack Ward Thomas, visited the Mount Mansfield site and received a presentation on our program as well as a site tour. VForEM participated in a Vermont Weather Group, to promote the exchange of information and resources between those groups collecting weather data, and groups interested in using it. A day-long Information Session on VForEM was offered at the Proctor Maple Research Center for environmental groups, educators, local community and municipal employees, forest industry, legislators and others. This session condensed research results into highlights that were pertinent and digestible to the groups attending. VForEM (VMC) was featured at a meeting of the Center for Research on Vermont at UVM, with a presentation on "Vermont Monitoring Cooperative: Keeping Track of Vermont's Natural Environment". A VForEM newsletter was initiated in April. The major thrust of the newsletter was to advertise data available, present enticing applications that could be accomplished with VForEM data, and provide a forum for information exchange.

Media coverage focused on high elevations. First, a focused look at the forest song bird monitoring ongoing on Mount Mansfield by the Vermont Institute of Science. Later, a fall foliage article of the high recreational use at summit of the mountain, and the potential impacts to the alpine ecosystem. Both articles emphasized the need for long-term monitoring of "natural" ecosystems as well as those with human disturbance.

VForEM Cooperators aided in the development of air resource data needs as they participated in a USDA Forest Service initiative to determine "Air Resource Spatial Data Needs and Visibility Thresholds". This workshop focused on Class I Wilderness Areas, like Lye Brook, and their need to protect air quality related values.

VForEM Cooperators also united to participate in the Agency of Natural Resources "Environment 1996" publication. This annual publication attempts to document the status and trends in Vermont's natural resources. This issue focused on biodiversity, ecosystems and ecosystem management.

In regards to creating a more unified, well defined program, we initiated a draft Memorandum of Understanding between the State Agency of Natural Resources, the University of Vermont, the USDA Forest Service Green Mountain National Forest, Northeastern Area State and Private Forestry, and Northeast Forest Experiment Station. This document will provide an clear understanding of how truly cooperative this program is, with each partner playing a crucial role in program implementation.

Atmospheric

Deposition and ecosystem processing of atmospheric mercury in the Lake Champlain basin
- 1995 -

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University of Vermont School of Natural Resources

ABSTRACT

Deposition and ecosystem processing of atmospheric mercury (Hg) in the Lake Champlain basin have been studied in cooperation with the University of Michigan Air Quality Laboratory since December, 1992 at the VMC Air Quality Monitoring site in Underhill Center, VT (400 m elevation). Daily wet-only precipitation, weekly 24 hr vapor and particulate air samples, stream water and snowmelt have been analyzed for total Hg by cold vapor atomic fluorescence spectrometry (CVAFS). Further details of methods and objectives can be found in previous reports. Reported here is a brief update on findings through the end of 1995.

Between December 1992 and December 1995, total Hg concentration in precipitation ranged from 1.2 to 59 ng/L, with a mean of 9.5 ng/L, and with the highest concentrations generally occurring during the summer months (Fig. 1). Total annual Hg deposition in precipitation averaged 8.3 $\mu g/m^2$ (83 mg/ha) during this period (Fig. 2). Combined wet and dry deposition of Hg, using vapor phase estimated dry deposition, was 14.9 $\mu g/m^2$ for 1993, 13.6 $\mu g/m^2$ for 1994, and 14.3 $\mu g/m^2$ for 1995, with the greatest deposition rates in the summer months (Fig. 3). Vapor phase Hg ranged from 0.5 to 6.9 ng/m^3, with a mean of 1.74 ng/m^3, and without much seasonal variation (Fig. 4). We have not yet independently confirmed the accuracy of the one extreme measurement (6.9 ng/m^3 on 14 July 1995). Particulate phase Hg ranged from 1 to 43 pg/m^3, with a mean of 10 pg/m^3, and with the highest concentrations occurring in the winter months (Fig. 5).

During 1995, total Hg concentrations in stream-water continued to be monitored in Nettle Brook, a small stream draining an 11 ha mixed hardwood gauged catchment in the Stevensville Brook area. Hg concentrations were 1 to 3 ng/L during base flow conditions, and reached 79 ng/L at peak flow during spring snowmelt in 1994. Stream flow and Hg concentration during spring snowmelt in 1995, however, were much lower than 1994, resulting in substantially smaller stream export of Hg (Fig. 6). The relationship between Hg input in atmospheric deposition and stream Hg export in Nettle Brook is shown in Table 1. A large proportion of the Hg deposition input appears to be retained by the catchment, with only 10-24% being exported in stream water. The fate of this retained Hg (accumulation or volatilization) is unknown at this time.

ACKNOWLEDGMENTS

Primary financial support for this work was from grants from the NOAA Air Resources Lab and the US EPA OAQPS Great Waters Program under the Lake Champlain Special Designation Act of 1990, the Lake Champlain Research Consortium, and the Vermont Air Pollution Control Division. We also wish to acknowledge the assistance and support of the University of Vermont Proctor Maple Research Center, where much of this work was conducted, and the very able assistance of Joanne Cummings and Carl Waite, as well as the other cooperators listed below. This study was undertaken in cooperation with the Vermont Monitoring Cooperative.

COOPERATORS

University of Vermont: Joanne Cummings, Carl Waite, Rinda Gordon
Proctor Maple Research Center: Melvin Tyree, Sumner Williams
University of Michigan: Jerry Keeler, Anne Rea
NOAA Air Resources Laboratory: Richard Artz
VT ANR DEC Air Pollution Control Program: Rich Poirot

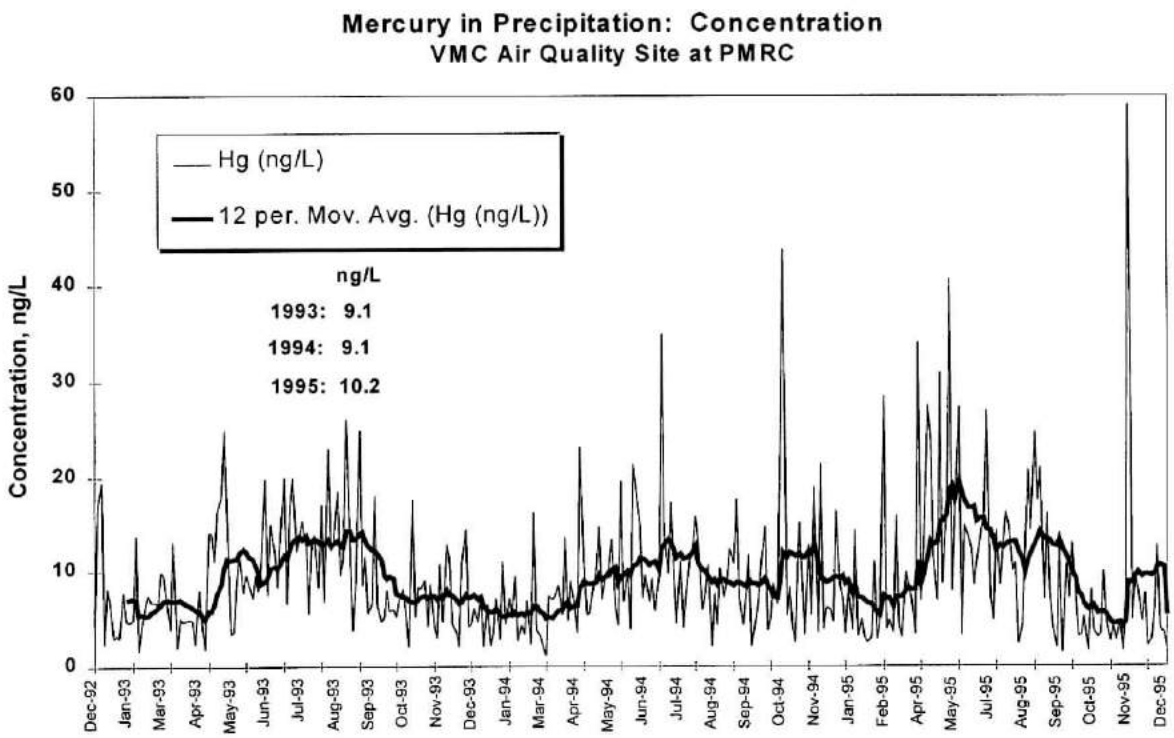

Figure 1. Event precipitation Hg concentrations and running mean, 1992 - 1995.

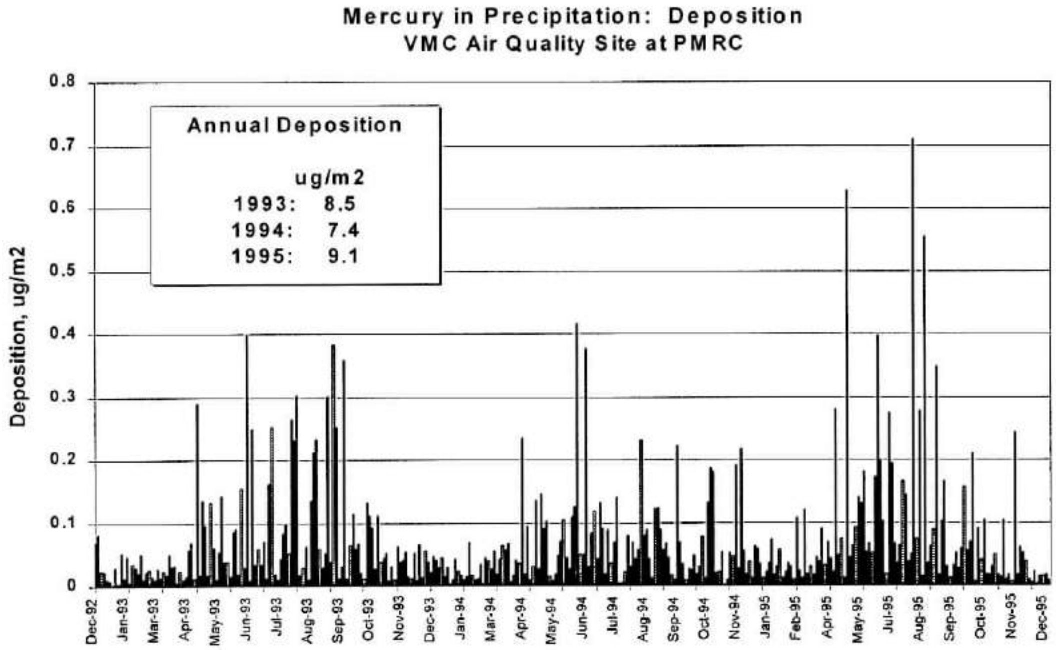

Figure 2. Event precipitation Hg deposition, 1992 -1995.

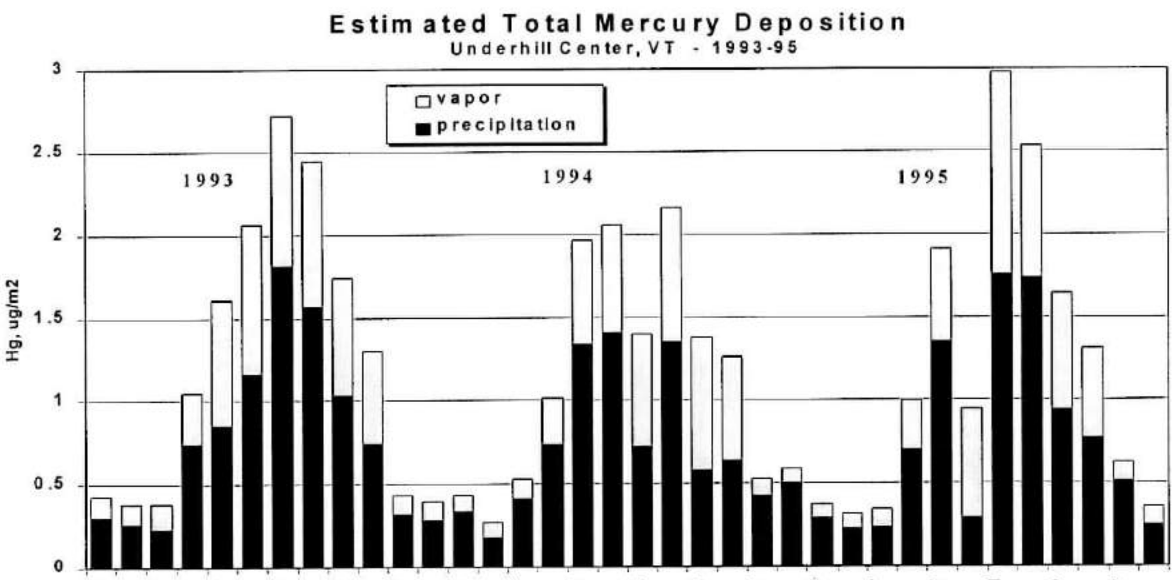

Figure 3. Monthly total wet and estimated dry (vapor) deposition, 1992 - 1995.

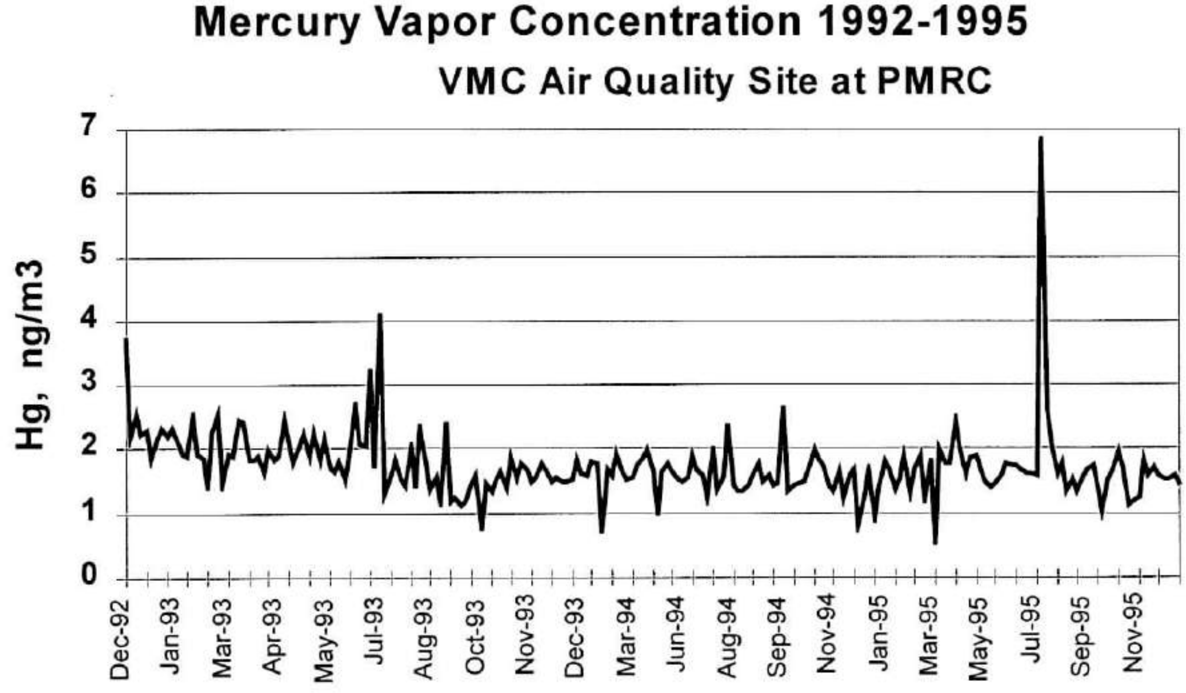

Figure 4. Weekly vapor Hg concentrations, 1992 - 1995.

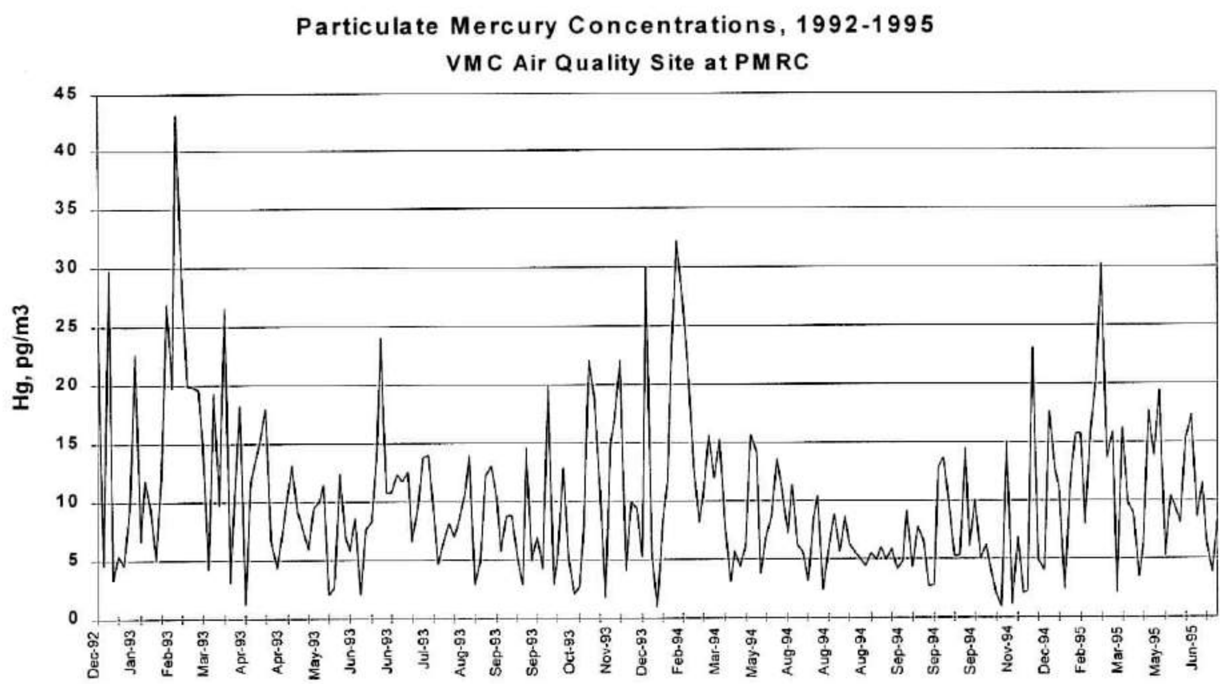

Figure 5. Weekly particulate Hg concentrations, 1992 - 1995.

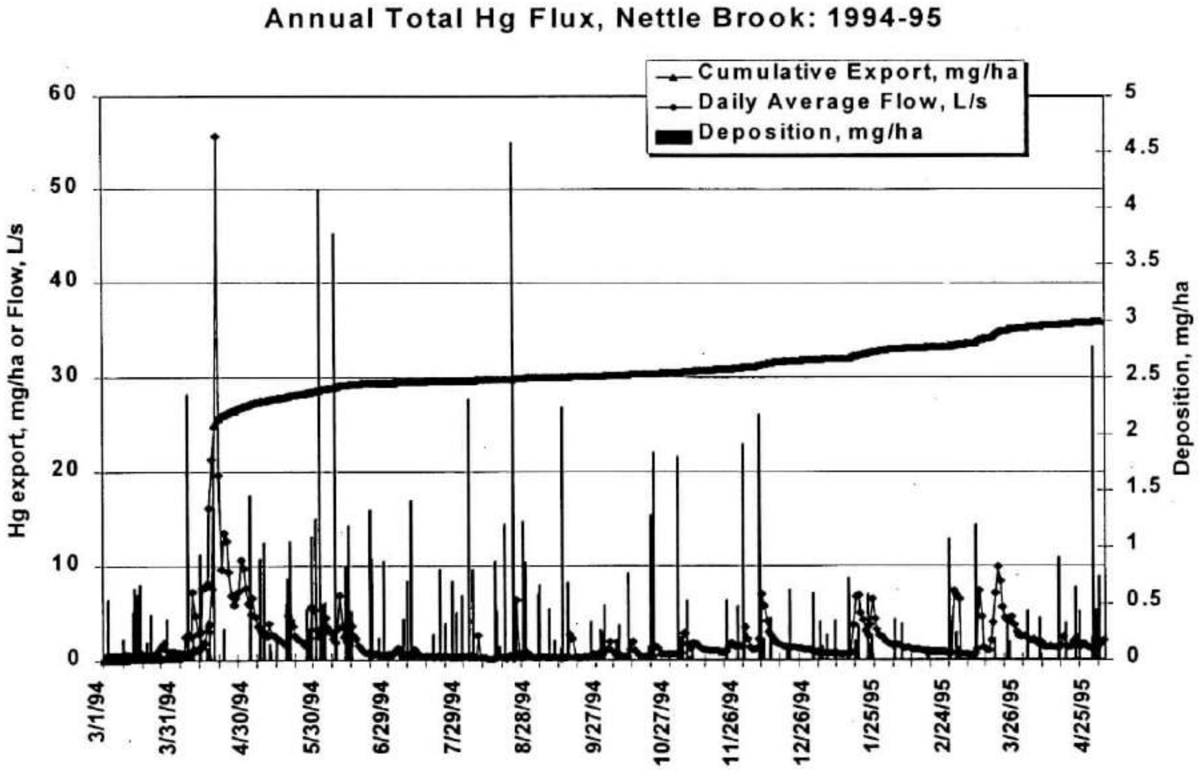

Figure 6. Cumulative stream export of Hg from Nettle Brook catchment, stream flow and precipitation Hg deposition, 1994 - 1995.

Table 1. Nettle Brook Hg Input / Output

Wet & Dry Deposition Inputs, 1994-95:	**280 mg/ha**		
1994:	***134***		
1995:	***146***		
Stream Export, ... 1994-95:	**44 mg/ha**		
1994:	***30***		
1995:	***14***		
Net Retention in Catchment, 1994-95:	**236 mg/ha**	**(84%)**	
1994:	***104***		***(76%)***
1995:	***132***		***(91%)***

MEASUREMENT OF ENVIRONMENTAL AND POLLUTANT GRADIENTS

IN THE FOREST CANOPY

1995

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Cooperators:

Deane Wang and Joanne Cummings, UVM School of Natural Resources
David Ellsworth, Brookhaven National Laboratory, Upton, L.I., NY

ABSTRACT

From January to December 1995 meteorology and ozone (O_3) data were continuously collected at five elevations (0.5, 7.5, 12, 16, and 24 m above the ground) from the VMC research tower at the Proctor Maple Research Center in Underhill, VT. In 1995, we did few new analyses of meteorological data and have no new results to report. We hope to examine these data more thoroughly in 1996 and report new results at that time. Examination of O_3 data for 1995 revealed a similar pattern to that observed in 1992-94. As in previous years, O_3 concentrations generally increase with height in the canopy, but the largest and only significant difference occurred between 0.5 m (just above the forest floor) and all other elevations, with O_3 levels being lowest at 0.5 m. On average, over the entire sampling season (mid April-mid September), O_3 concentrations were 26% lower at 0.5 than at 24 m, compared to 23% and 21% lower in 1994 and 1993, respectively. This reduction in O_3 concentration just above the forest floor may result from inadequate mixing of air due to a boundary layer effect and lower air velocities at this level or the physical or chemical destruction of O_3. Number of hours of O_3 exposure at threshold concentrations of $\geq$60, $\geq$70, $\geq$80, $\geq$90, and $\geq$100 ppb during June, July, and August were tabulated for 1995, as previously done in 1993 and 1994. As in 1994, it was found that the total number of hours of exposure at the two lower concentrations ($\geq$60, and $\geq$70 ppb) continued to decrease from the previous year, averaging a 24% reduction in number of hours of exposure at the four upper elevations (7.5, 12, 16, and 24 m). The number of hours of exposure at $\geq$80 ppb increased by an average of 12 hours at the four upper elevations in 1995 from 1994, but remained 55% lower than 1993 numbers. When averaged over the entire season, O_3 concentrations in 1995 were similar to those in 1993 at all elevations. However, 1994 concentrations were 10% lower than than those in 1993 and 1995, and this reduction was consistent across all canopy heights. Examination of average seasonal diurnal patterns for 1995 revealed that O_3 concentrations reached a daily low in early morning (around 7:00 AM) and maximum levels from midday to early afternoon and again shortly before midnight.

Meteorological and Deposition Chemistry Monitoring -1995-

Joanne Cummings and Timothy Scherbatskoy
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COOPERATORS:

UVM Proctor Maple Research Center (PMRC), National Atmospheric Deposition Program (NADP), US Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), VT Department of Environmental Conservation (DEC), WCAX-TV staff at Mt. Mansfield transmitter station, Green Mountain National Forest, EPA AREAL Laboratory, University of Michigan Air Quality Laboratory (UMAQL).

ABSTRACT:

Continuous monitoring of meteorological, wet and dry deposition chemistry has been conducted at the VForEM Mt. Mansfield and Lye Brook sites. The 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 collection of basic meteorological data, precipitation chemistry monitoring, and dry deposition monitoring programs.

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 projects are discussed elsewhere in the Annual Report.

The National Atmospheric Deposition Program, operating at PMRC since 1984 and at Bennington, VT since 1981, provides weekly analysis of major ions in precipitation. The Atmospheric Integrated Research Monitoring Network (AIRMoN), established in January of 1993, provides similar data on a daily basis. The Dry Deposition Inferential Measurement system, started mid-year in 1992, provides weekly data on dry deposition of nitrogen (HNO3 vapor, NO3 particulate) and sulfur (SO2 vapor and SO4 particulate). In addition, atmospheric mercury monitoring in precipitation, gaseous and aerosol phases has operated at PMRC since 1993. The Vermont Acid Precipitation Monitoring Program (VAPMP) provides daily precipitation pH since 1980 at the Mt. Mansfield summit, and since 1983 at the PMRC site.

Eight years of meteorological data collection at the PMRC, from June of 1988 to December of 1995, has enabled VForEM to begin to develop a long term record of continuous weather monitoring. An analysis of this record is included in this report, with comparisons of precipitation, growing degree days, and temperature variables.

OBJECTIVES:

Continuous monitoring, at the VForEM Mt. Mansfield and Lye Brook sites, of meteorological variables and the chemistry of precipitation and dry deposition. Summary of representative data from the chemical deposition monitoring programs.

METHODS:

Several monitoring stations and programs were operated at sites in Underhill Center.

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 VForEM Mt. Mansfield site located at the Proctor Maple Research Center. This station has remote (modem) access and has been in continuous operation since June of 1988. Data are updated continuously and are archived electronically. Data are available from the VForEM Data Manager or the Site Operator at the PMRC. Station supervision is by Tim Scherbatskoy; operations and maintenance are by Joanne Cummings and Carl Waite. Additional meteorological data are collected at the forest canopy research tower and in the Stevensville Brook watershed; these provide continuous monitoring at within-forest sites. Although not reported here, these data are available from the VForEM data manager.

In 1995, the long term meteorological record (1988 to 1995) was consolidated. This now provides a convenient long term data set, and is being used for the study of trends of variables such as precipitation, growing degree days and temperature. Each year of data was standardized into spreadsheet format, and missing temperature data were supplied using regression calculations with the Mt. Mansfield temperature data. This method was used to determine the probablity of temperature values at PMRC based on values from Mt.Mansfield. Belfort rain gage amounts at the PMRC site were used to supply missing precipitation data.

The National Weather Service (NWS) under NOAA supervises a second weather station at the WCAX-TV transmitter station near the nose of Mt. Mansfield. This station is 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. These data are being used in other VForEM studies to develop statewide meteorological and deposition maps. VForEM 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 available from VForEM in Voyager format for the period 1954-1995.

2. Precipitation Chemistry -

The NADP/NTN (National Atmospheric Deposition Program/National Trends Network) has maintained a site at the air quality monitoring station at the PMRC since 1984, and another site near Bennington, VT, since 1981. Weekly collection of precipitation for chemical analysis is performed at these sites. 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, Mg, K, Na, NH4, NO3, Cl, SO4, and PO4. During January of 1995, the NADP site at PMRC was visited by Richard Shores of the Research Triangle Institute, contracted by NADP to observe collection and handling procedures of the NADP samples, and to check site equipment for proper functioning.

In September of 1995, an intercomparison NADP collection program was initiated at the PMRC site. Collocated collectors are a part of the quality assurance program sponsored by the NADP Coordination Office in Fort Collins, Colorado. An Aerochem Metrics wet/dry collector identical to the collector at the PMRC site, and a Belfort raingage dedicated to that collector were installed by Mark Nilles of the NADP Coordination Office. The colocated collector will function for one year in a comparison study on the accuracy and precision of the collector and raingage.

This station has been in operation since 1984, and is part of a national network of over 200 stations including one other station at Bennington. Data are available from theVMC 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.

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 nine wet deposition sites, and fourteen dry deposition sites in the network, located in the eastern U.S. Sites other than the Proctor Center which have collocated NADP/NTN and NADP/AIRMoN collectors are: Bondville, Illinois; Oakridge, Tennessee; and State College, Pennsylvania. Except for being an event based sampling program, it follows the protocol and measures the variables of the NADP/NTN program; the sampler is located at the Air Quality site at PMRC. Station operation is by Joanne Cummings with supervision by Tim Scherbatskoy. The AIRMoN station was installed in December of 1992. Data for the 1995 sample period for both NADP/NTN and NADP/AIRMoN can be accessed on the NADP web page. The address of the web page is HTTP://NADP.NREL.COLOSTATE.EDU/NADP/. Data can be accessed by contacting the VForEM data manager also.

A comparison of pH, sulfate deposition and nitrate deposition for the Underhill NADP (VT99) site and the Bennington, VT NADP site (VT01) was undertaken. Eleven years of annual deposition data were compared to discover trends and variations between the two sites. A brief discussion of these findings is provided in the following pages.

3. Dry Deposition -

The Dry Deposition Inferential Measurement program was started in August 1992 at the forest canopy research tower at the PMRC. This monitoring program uses filterpacks to collect continuous weekly samples of dry deposition of sulfur (SO2 vapor, SO4 particulate) and nitrogen (HNO3 vapor, NO3 particulate), 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 in this forested ecosystem. This station is one of fourteen stations in the NOAA network in the eastern U.S.; the data collected are comparable to other dry deposition monitoring programs in the U.S. operated by the EPA. The equipment is located above the forest canopy at 22 meters 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 VForEM quarterly.

RESULTS and DISCUSSION:

1. Basic Meterology:

Figure 1 on the following pages graphically displays the monthly summaries for maximum and minimum temperatures and precipitation. The Y-scales for these graphs varies from month to month. Table 1 shows monthly summaries in text form. The mean temperatures columns are designated "A" and "B" because the means are calculated with two different methods. Mean temperature A is the arithmetic average of the daily means for the month, or the addition of daily mean values for the month, divided by the number of days in the month with values. Mean temperature B is the midpoint average, calculated by adding the highest mean and the lowest mean for the day and dividing by two. The National Weather Service uses the mean temperature B method. Growing degree days are calculated by adding the degrees above freezing for a day to the next day's above freezing value. A cumulative number of degrees above zero is derived. Days when the temperature does not go above freezing are given a zero value.

Upon examination of the weather data for 1995, unusually warm temperatures occured for twelve days in January of 1995, and snow pack melted. During December of 1995, snow fall as precipitation occurred for twenty five days during the month.

Eight years of temperature and precipitation data were graphed for comparison on the following pages. Figure 2 shows 1988 to 1995 annual maximum and minimum temperatures along with preciptation totals for each year. In Figure 3, January and July temperatures and precipitation for the eight year period were graphed. The meteorological station at the PMRC began collecting data in June of 1988, therefore data is only available for a six month period in 1988. In 1991, the largest range of temperatures occured, and in December the coldest temperture for the period, -40 degrees centigrade was recorded. There are not enough data to discern any regional trends in annual temperature and precipitation, but information on year to year variations can assist researchers in interpreting other ecological data on insect populations, forest health, growth rates, nutrient cycling, air pollution, etc.

2. Precipitation Chemistry:

NADP published a booklet of maps of the United States, with concentrations and deposition rates for ions analyzed by the Central Analytical Laboratory in Champaign, Illinois. Figure 4, Map A shows the 1995 pH values from field measurements. Map B and C related deposition of sulfate and nitrate to regional areas of the US, and Map D contains total precipitation for 1995. The maps make obvious the fact that north central and north eastern parts of the US experience lower pH values, and higher deposition of sulfates and nitrates. NADP maintains two sites in Vermont, one in Underhill and another in Bennington, in the region of the Lye Brook Wilderness Area. Continued monitoring of atmospheric deposition is enabling researchers to look at regional trends, and observe changes which may occur over time as a result of the Clean Air Act policies.

NADP data from the Underhill (VT99) and Bennington (VT01) sites were compared in an attempt to discover relationships or differences in deposition from the southern and northern parts of Vermont. The protocols for both sites are the same, as with all 191 sites across the country. Figure 5, Charts A, B and C graphically display comparisons of pH, sufate and nitrate deposition. Chart D shows annual precipitation amounts for each site. Annual volume weighted average pH was generally lower for the Bennington site, except for 1993. Since deposition is a function of precipitation amount and concentration, however, climate plays an important role. Examination of annual average sulfate deposition at Bennington may or may not be declining, suggesting that sulfur reduction mandates by the 1990 Clean Air Act Ammendments are or are not affecting precipitation chemistry in southern Vermont. Annual variation in nitrate deposition does not appear to show any trend over this time period at either site.

In order to evaluate the effects of chemical deposition on a local or regional scale, more data must be collected. NAPAP (National Acidic Precipitation Assessment Program) chose a time scale of thirty years to ascertain reductions in atmospheric sulfur inputs, and for the chemical composition of affected surface waters bodies to reach equilibrium with reduced loads. The need to include natural variation in climate with deposition data requires sufficient time to characterize the variability, and to evidence changes. However, these data are valuable now for cooperators researching and monitoring forest health indicator species, nutrient cycling, habitat loss, etc.

On a regional scale, the 1996 progress report of the US-Canada Air Quality Agreement states that there is evidence of a decrease in wet sulfur deposition. It is correlated with sulfate emissions reductions, mainly from coal burning industries using low sulfur coal. Nitrate deposition and precipitation acidity shows no consistent change, however. There also is evidence that calcium and magnesium concentrations in precipitation have declined, contributing to the continued acidification of precipitation, and reduced input of these important nutrients to ecosystems. A U.S. report using the Regional Acid Deposition Model predicts most of the northeast US and lower Canada will experience a 30% or greater reduction in total sulfur deposition by 2010. Results from field experiments and modeling studies indicate that continued nitrate deposition at the current levels could result in an erosion of the benefits of sulfur emissions controls. Figure 6 shows graphs of expected trends in sulfate and nitrate emissions to the year 2010.

The 1996 Progress Report used data from the NADP/NTN and NADP/AIRMoN Networks, and the CASTNET Network in the US. Canada's largest monitoring network is known as CAPMoN (Canada Air and Precipitation Monitoring Network).

3. Dry Deposition:

Figure 7 displays the data collected for the Dry Deposition Inferential Monitoring Program (DDIM) at the PMRC forest research tower from 1992 to November of 1995. No analysis of trends or relationships for this project has been completed at this time. Below zero values on the chart indicate times when the station was not operating.

FUNDING SOURCES:

1. NADP/NTN - United States Geologic Survey (USGS)
2. AIRMoN - National Oceanic and Atmospheric Administration (NOAA)
3. Meteorology station at the PMRC Air Quality Site - Vermont Forest Ecosystem Monitoring, Inc. (VForEM)
4. Dry Deposition Inferential Monitoring Project - NOAA

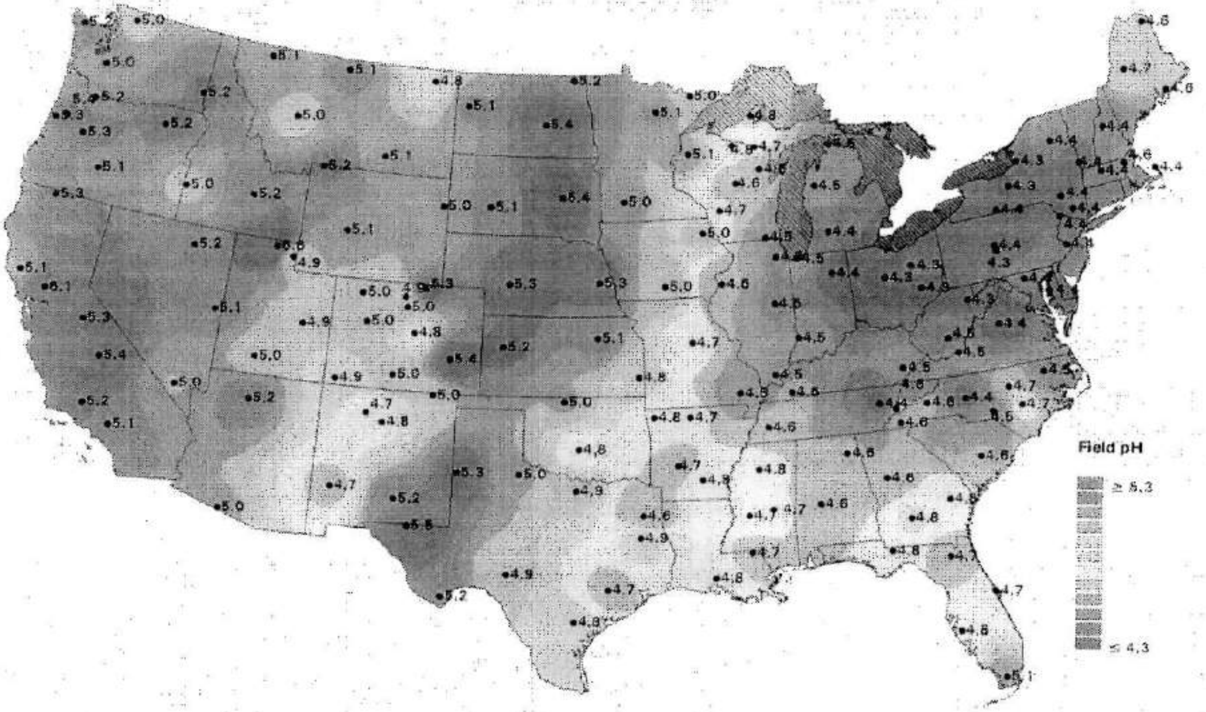
REFERENCES:

United States - Canada Air Quality Agreement. Progress Report 1996. International Joint Commission, 1250 23rd Street, NW, Suite 100, Washington, D.C.

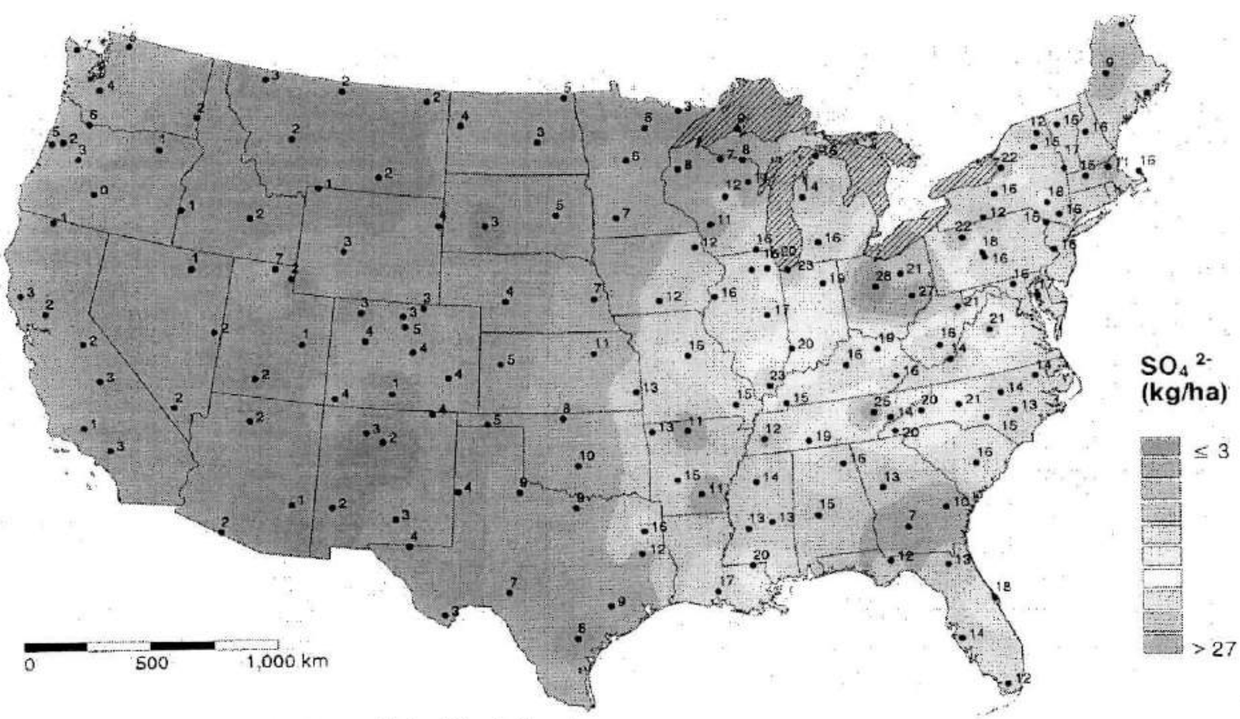
National Atmospheric Deposition Program/National Trends Network. 1996. NADP/NTN Wet Deposition in the United States 1995. Natural Resources Ecology Laboratory, Colorado State University, Fort Collins, CO.

Figure 4. 1995 NADP Wet Deposition Maps

Map A. Hydrogen Ion Concentrations as pH (from field measurements)



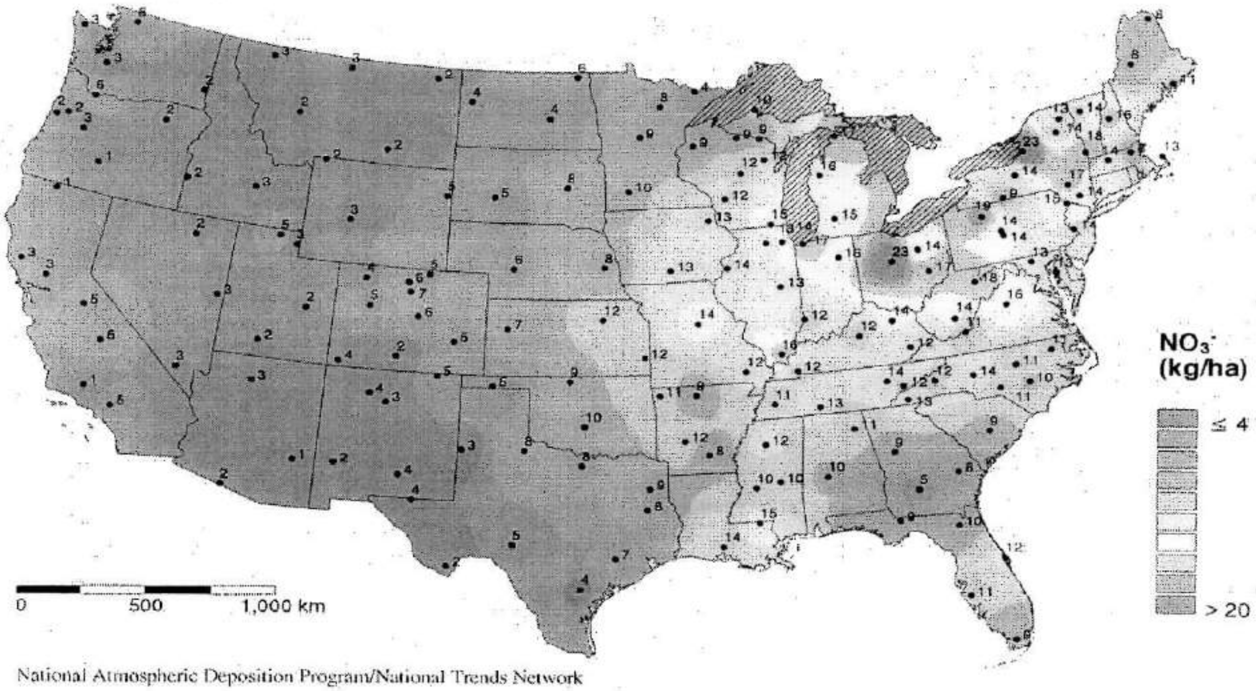
Map B. Sulfate Ion Deposition



National Atmospheric Deposition Program/National Trends Network

Figure 4. (cont'd) 1995 NADP Wet Deposition Maps

Map C. Nitrate Ion Deposition



Map D. Total Precipitation for 1995

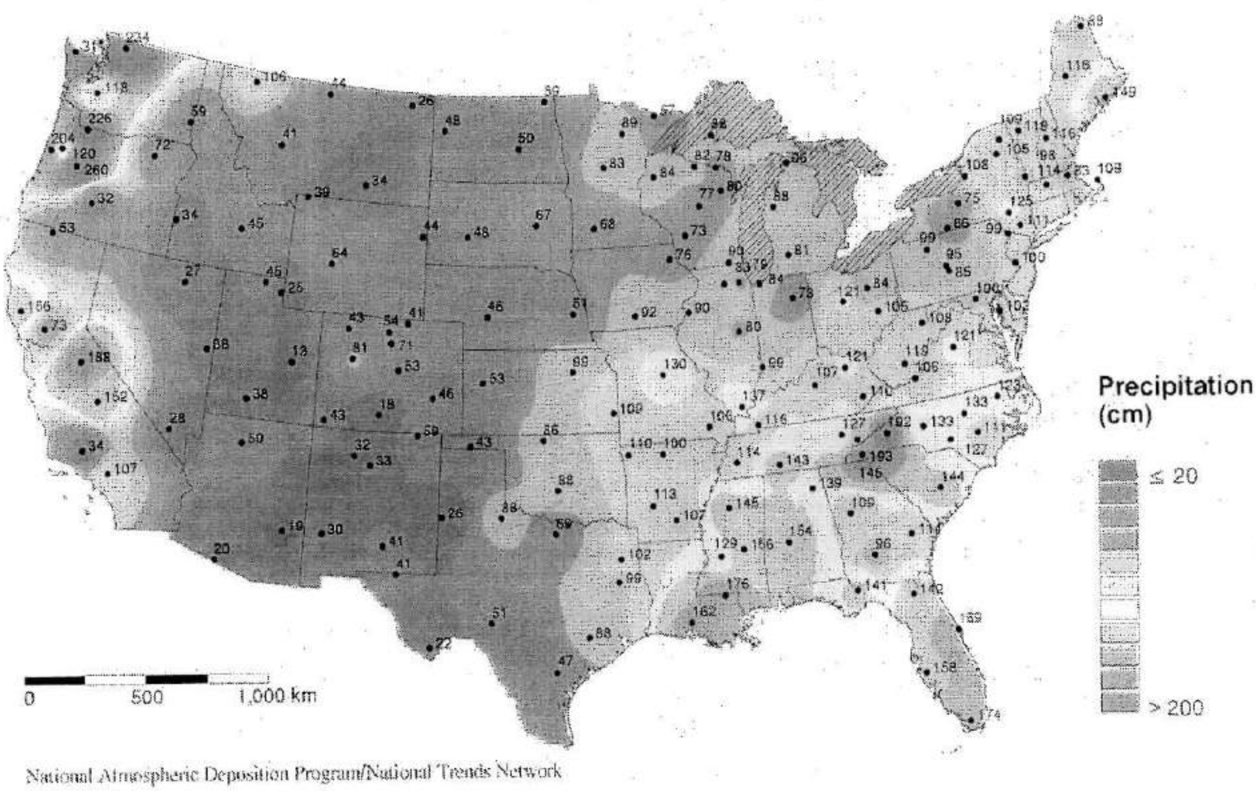


Figure 5. Comparison of Underhill and Bennington NADP Data, 1988 to 1995 - pH and Sulfate Deposition

Chart A. Annual Volume-Weighted Average pH

1984 to 1995 - Underhill, VT and Bennington, VT

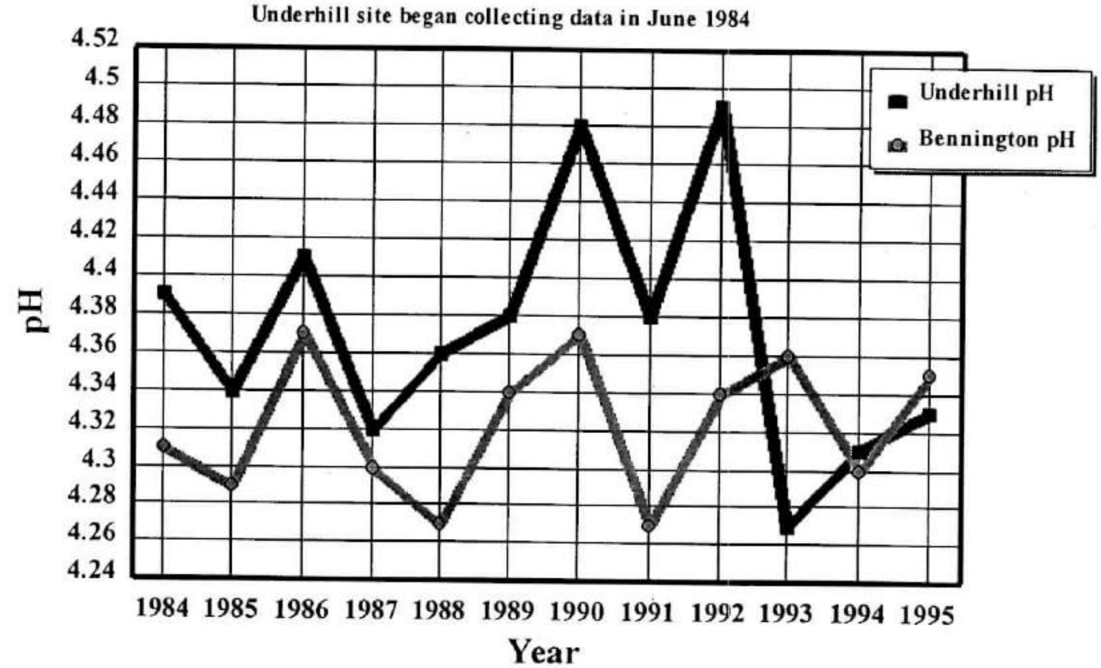


Chart B. Sulfate Deposition - 1984 to 1995

Underhill, Vt and Bennington, VT

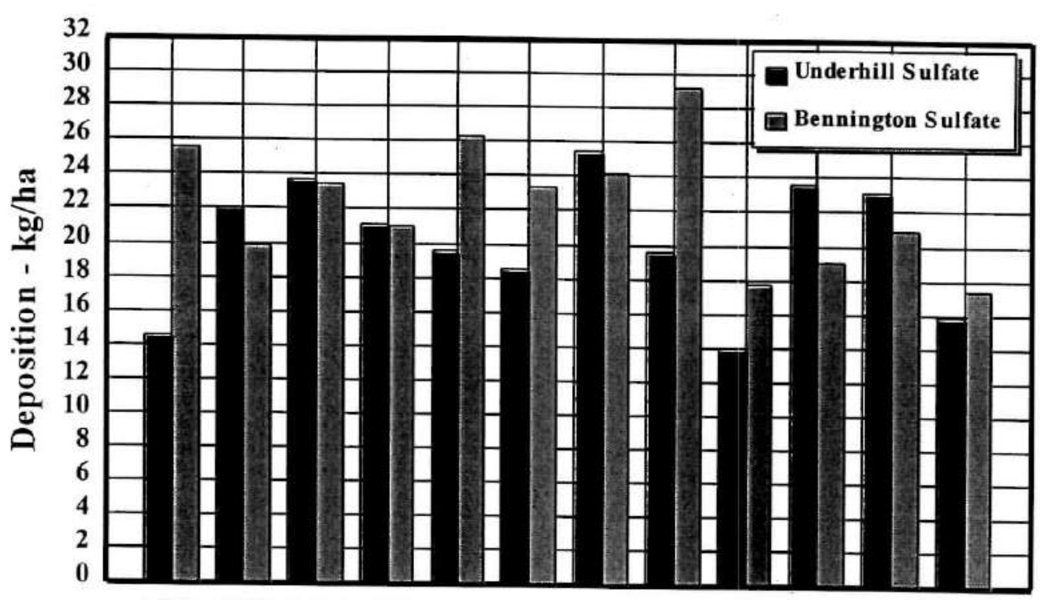


Figure 5. Comparison of Underhill and Bennington NADP Data, 1984 to 1995 - Nitrate Deposition and Precipitation

Chart C. Nitrate Deposition - 1984 to 1995

Underhill, Vt and Bennington, VT

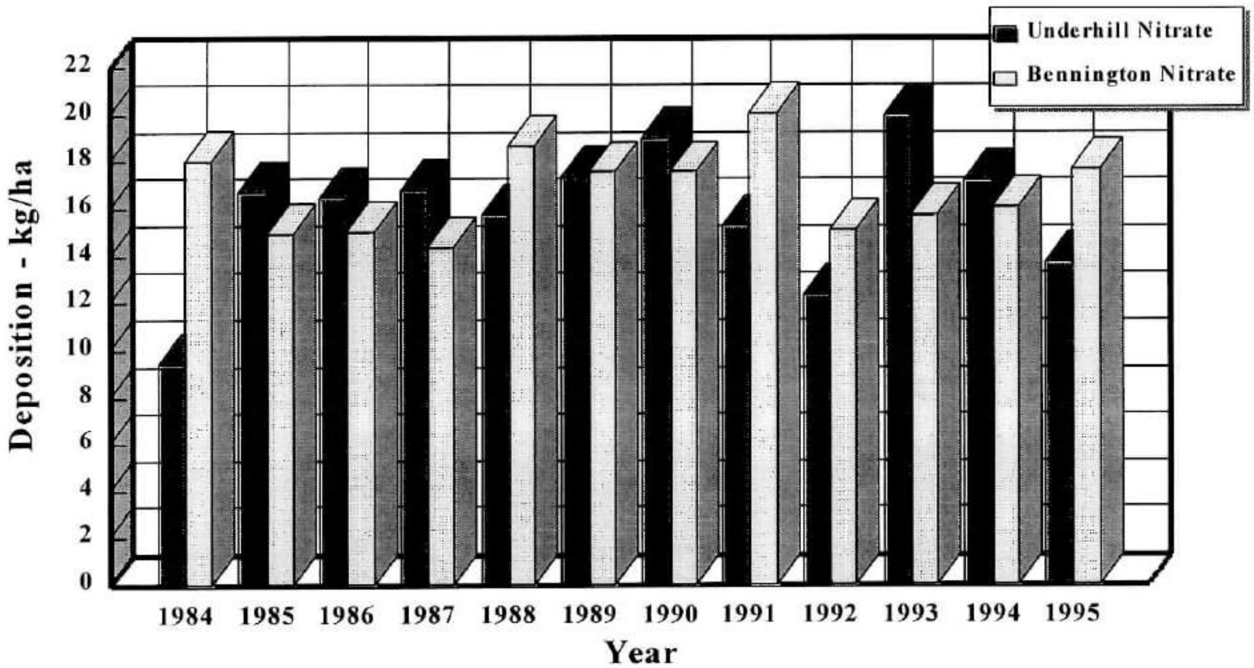


Chart D. Underhill and Bennington Annual Precipitation from NADP Data - 1984 to 1995

Underhill site began collecting data in June of 1984

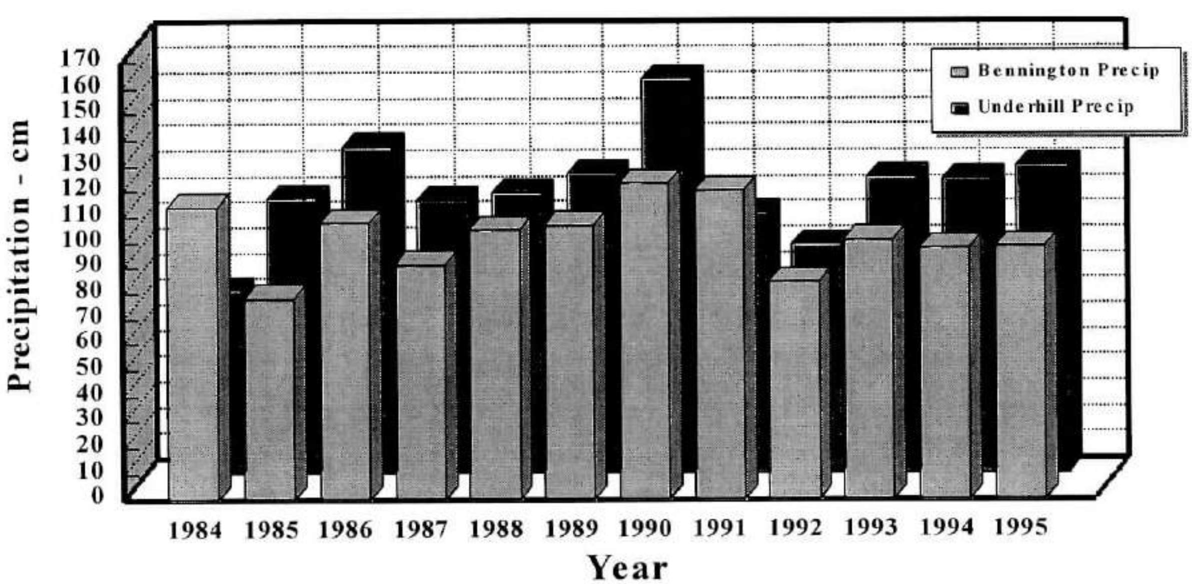
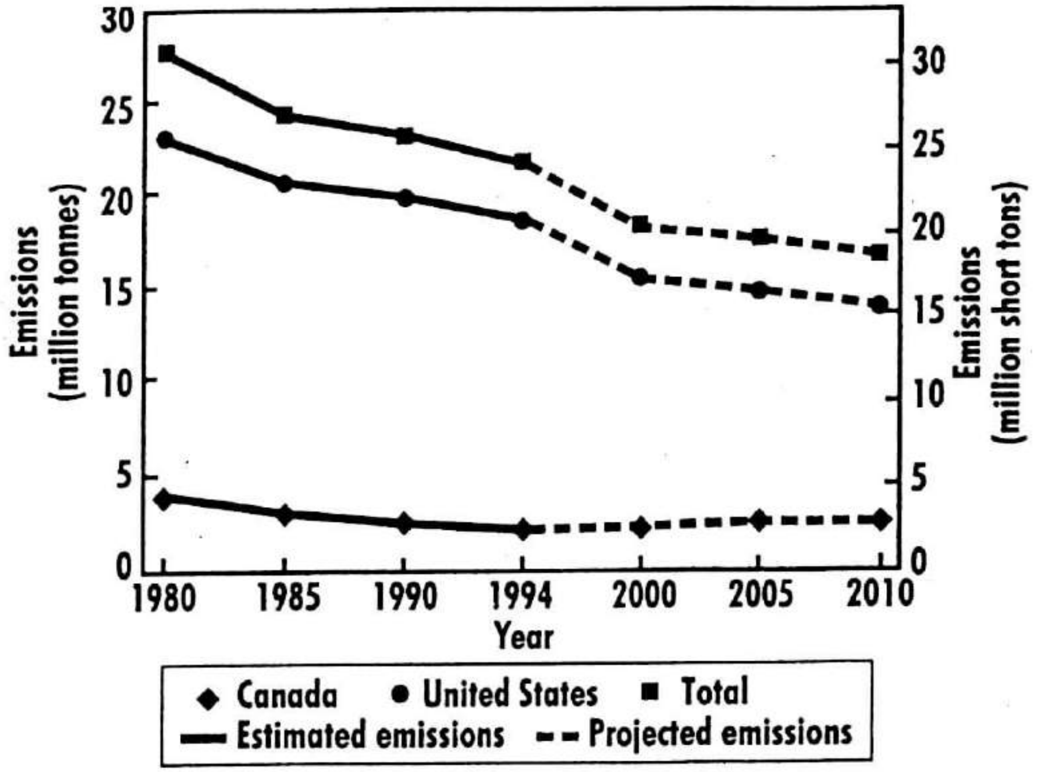
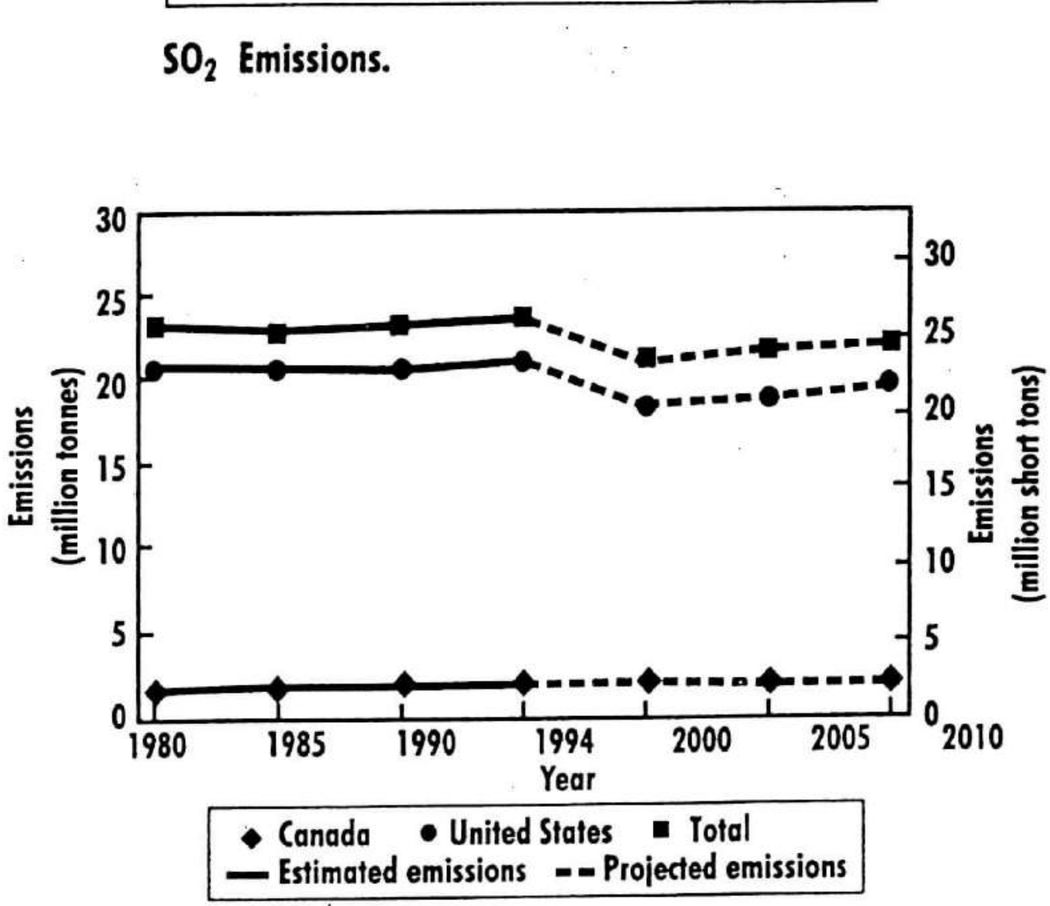


Figure 6. Emissions Estimates for Sulfate and Nitrate in the U.S.A. and Canada, 1980 to 2010



SO_2 Emissions.



NO_x Emissions.

Figure 7. Dry Deposition at the PMRC Forest Tower
December 10, 1994 to November 14, 1995

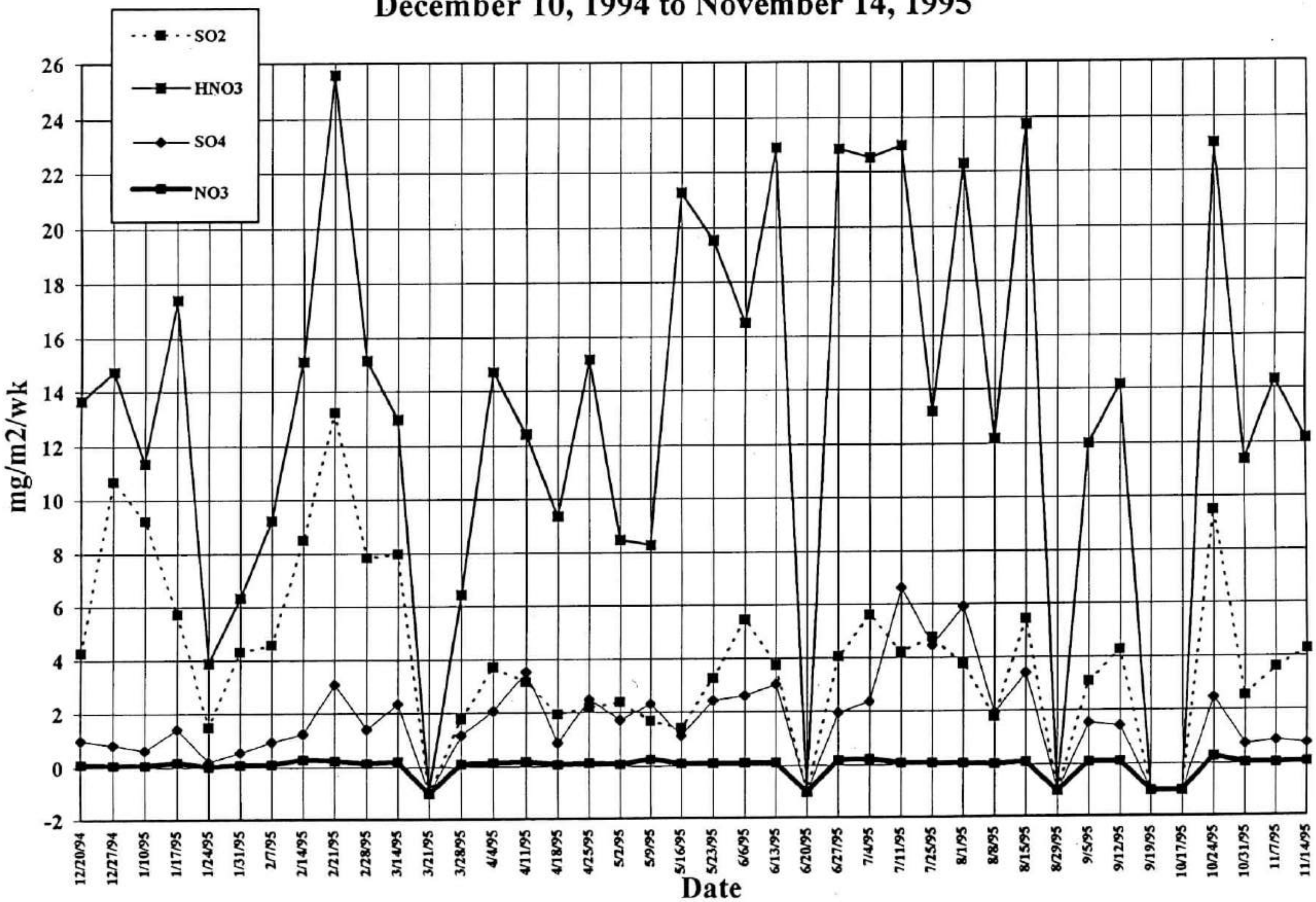


Figure 1. PMRC Monthly Maximum, MinimumTemperatures and Preciptation Data, January to December 1995

(Note: Y-Scales vary from month to month)

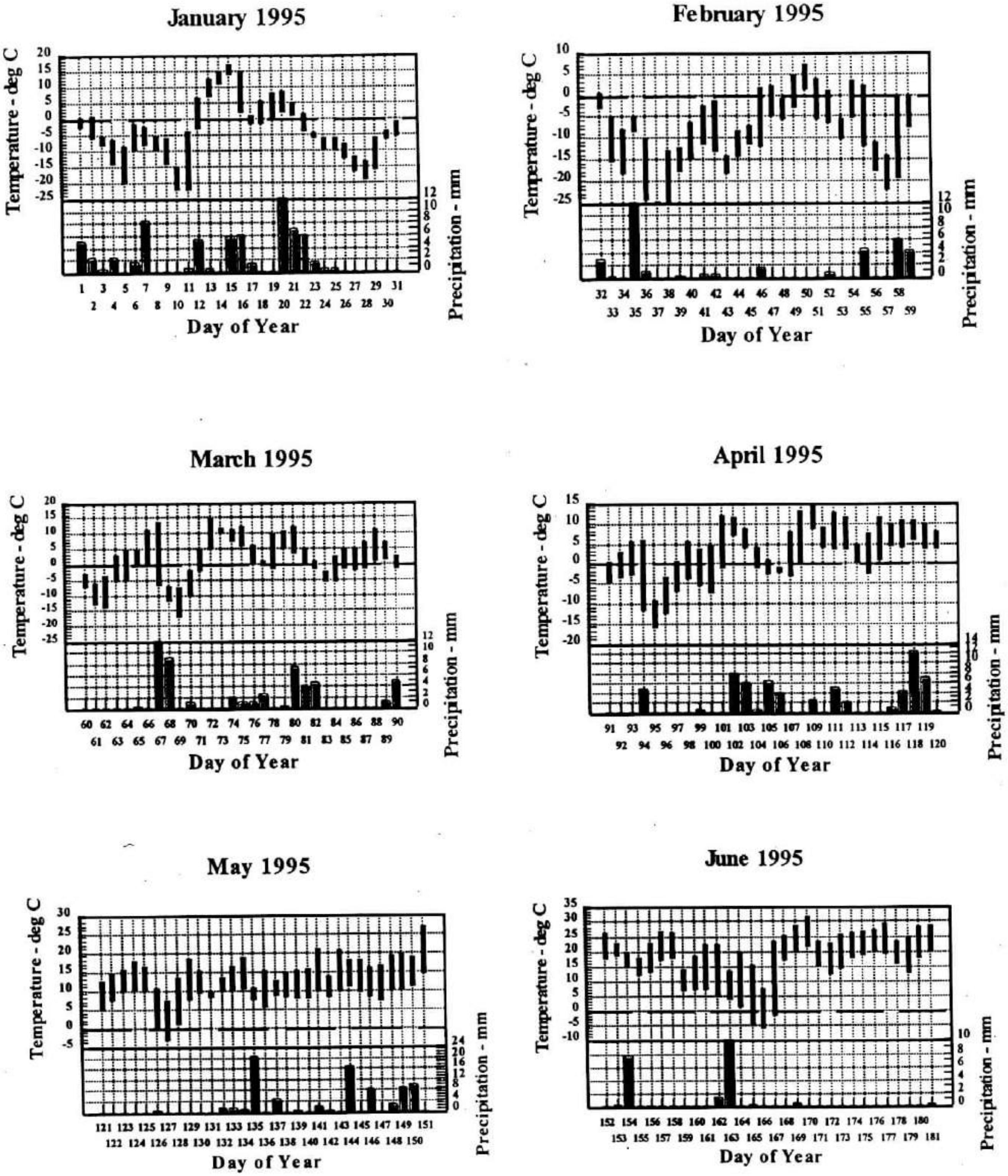
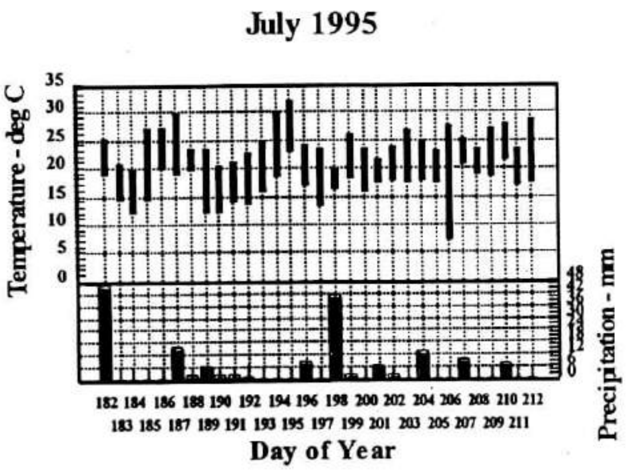
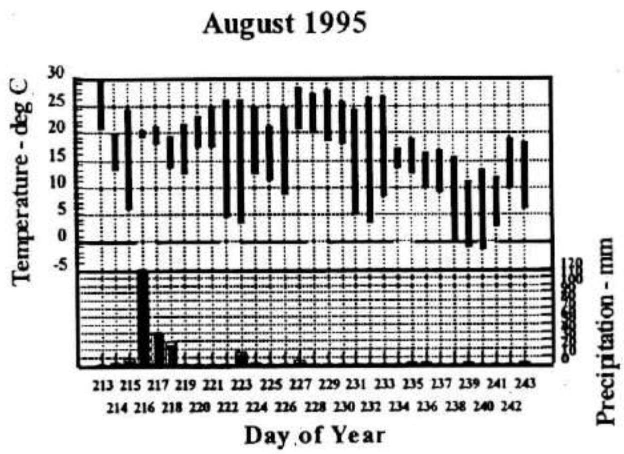
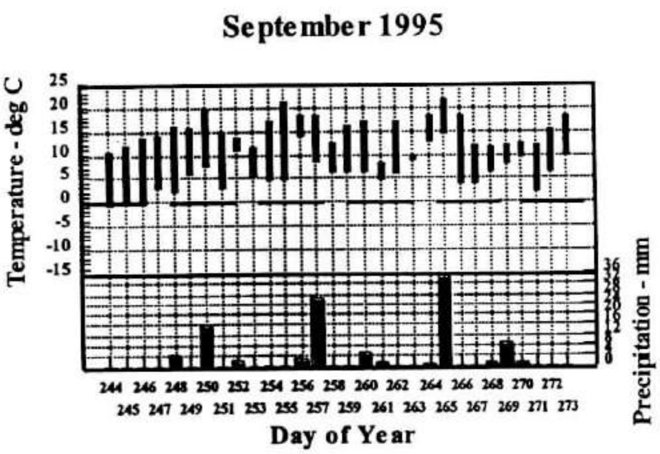


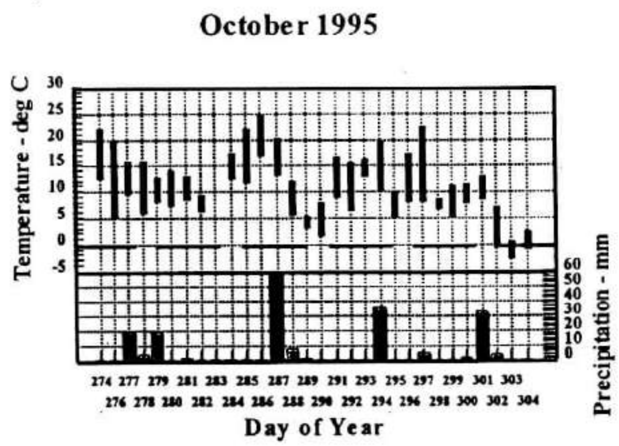
Figure 1. (cont'd) PMRC Monthly Maximum, Minimum Temperatures and Precipitation, January to December 1995

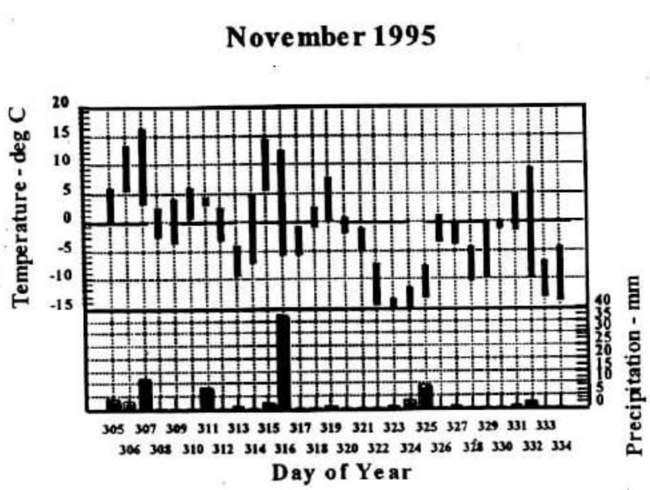
(Note: Y-Scales vary from month to month)











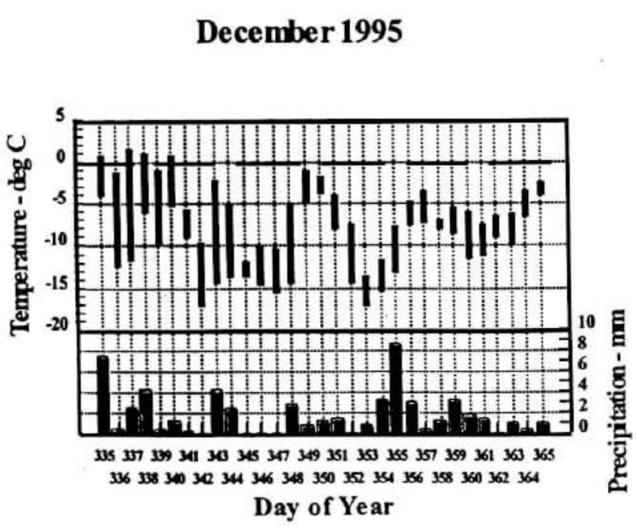


Table 1. PMRC Weather Data Summaries - January to May 1995

	Barometic Pressure	Mean Wind Direction	Wind Direction Deviation	Mean Wind Speed	Max. Wind Speed	Max. Temp.	Min. Temp.	Mean Temp. A	Mean Temp. B	Growing Degree Day	Mean Dew Point	Mean Relative Humidity	Precip-itation
	mb	deg	deg	m/s	m/s	deg C	deg C	deg C	deg C	deg C	deg C	%	mm
1995 Annual													
Mean	963	189	32.1	1.9	3.3	10.0	1.8	5.7	5.6	7.6	-2.1	61.1	3.1
Max	979	341	66.2	5.7	8.1	32.1	22.7	26.5	27.4	26.5	18.9	276.6	119.4
Min	935	76	19	0.5	1.2	-24.7	-28.3	-26.3	-26.5	0	-33.7	9.6	0
Sum										2727.2			1134.0
January													
Mean	955	203	28.9	2.0	3.4	-0.5	-7.1	-3.6	-3.8	2.2	-9.9	60.5	2.2
Max	970	341	61.4	4.9	7.1	17.1	13.6	15.4	15.3	15.4	7.2	84.5	16
Min	940	130	19	0.8	1.6	-14.9	-22.5	-18.2	-18.5	0	-26.6	24.9	0
Sum										67.2			69.6
February													
Mean	958	205	28.2	2.4	4.2	-4.4	-13.0	-8.6	-8.7	0.3	-16.3	51.7	1.3
Max	977	307	42.1	4	6.3	7.1	1	4	4.1	4	-4.8	73.4	12.7
Min	935	118	21	1.2	2.1	-24.7	-28.3	-26.3	-26.5	0	-33.7	33.8	0
Sum										9.3			35.2
March													
Mean	959	193	27.4	1.9	3.3	4.7	-2.9	1.0	0.9	3.2	-7.5	52.8	1.9
Max	977	333	37.5	3.7	6.1	14.9	9.7	11	10.8	11	0.9	75.8	21.3
Min	942	105	19.2	0.9	1.6	-7.9	-17.3	-12.2	-12.6	0	-22.5	26.8	0
Sum										98.8			60.2
April													
Mean	962	213	28.2	2.3	4.1	6.5	-1.4	2.7	2.5	4.1	-7.5	46.4	2.1
Max	979	325	38.9	5.7	7.5	14	8.4	10.7	11.2	10.7	1.6	66.2	12.2
Min	944	118	20.5	1	2.1	-9.4	-16.2	-12.4	-12.8	0	-25	22.8	0
Sum										123.1			64.2
May													
Mean	963	189	32.5	2.0	3.5	15.9	7.9	12.0	11.9	12.0	-1.6	40.9	2.5
Max	975	327	44	4	6.2	26.7	14.2	20	20.4	20	9	68.5	20.1
Min	953	127	22.6	1.1	1.9	7.2	-3.3	2.2	2	2.9	-13	17.3	0
Sum										371.4			76.3

Table 1 . (cont'd) PMRC Weather Data Summary - June to December 1995

	Barometric Pressure	Mean Wind Direction	Wind Direction Deviation	Mean Wind Speed	Max. Wind Speed	Max. Temp.	Min. Temp.	Mean Temp. A	Mean Temp. B	Growing Degree Day	Mean Dew Point	Mean Relative Humidity	Precip-itation
	mb	deg	deg	m/s	m/s	deg C	deg C	deg C	deg C	deg C	deg C	%	mm
June													
Mean	967	171	34.2	1.4	2.6	23.0	12.1	17.2	17.6	17.4	5.5	56.7	0.8
Max	977	247	54.6	1.8	3.7	31.8	21.5	25.9	26.6	25.9	13.4	162.8	13
Min	954	141	22.9	1.1	1.7	7.7	-6.2	-0.7	0.8	1.4	-2	24.3	0
Sum										521.3			23.3
July													
Mean	965	174	36.6	1.4	2.8	24.7	16.4	20.4	20.5	20.4	13.3	65.7	5.2
Max	973	263	66.2	2	4.2	32.1	22.7	26.5	27.4	26.5	17.8	83.1	45.7
Min	957	136	23.2	0.9	1.6	19.6	7.2	14.9	15.7	14.9	7.3	43.5	0
Sum										632.5			161.9
August													
Mean	967	181	37.2	1.4	2.5	21.6	9.8	16.3	15.7	16.3	11.6	79.2	6.9
Max	974	304	51.7	2.8	4.4	29.3	20.6	24.6	24.9	24.6	18.9	125.2	119.4
Min	959	94	24.1	0.7	1.4	11.1	-1.7	5.6	4.9	5.7	4.1	48.4	0
Sum										440.8			187.2
September													
Mean	969	179	38.3	1.4	2.6	15.2	1.3	7.0	7.1	6.3	-0.3	89.9	3.4
Max	978	282	61.4	2.1	3.8	21.4	13.7	16.7	16.1	16.7	13	276.6	34.5
Min	959	128	25.3	0.6	1.4	8.2	-11.3	-13.2	-14.9	0	-21.5	9.6	0
Sum										189.3			101.8
October													
Mean	964	189	33.6	2.1	3.7	13.5	6.8	8.5	8.8	7.3	-4.4	54.5	6.2
Max	976	274	65.3	4.6	8.1	24.6	16.7	19.9	20.6	19.9	11.5	88	58.7
Mini	948	142	21.4	0.7	1.4	0.8	-3.1	-24.9	-17.9	0	-19.3	14.8	0
Sum										218.8			186.7
November													
Mean	963	194	28.0	2.2	3.9	3.4	-3.7	-0.3	-0.2	2.0	-5.5	66.8	2.7
Max	978	319	42.1	4.1	7.1	16.2	5.2	10.8	9.7	10.8	6.1	93.9	37.1
Min	947	128	21.6	0.7	1.3	-7.1	-14.1	-10.1	-10.2	0	-15.6	47.4	0
Sum										54			72.3
December													
Mean	958	173	31.3	1.8	3.2	-5.1	-10.5	-7.8	-7.8	0.0	-12.0	70.5	1.8
Max	973	318	45.6	3.4	6.7	1.6	-3.9	-1.2	-1.6	0.4	-5.1	88	8.6
Min	944	76	22	0.5	1.2	-13.5	-17.3	-15.4	-15.4	0	-20.6	49.9	0
Sum										0.7			56.2

Figure 2. PMRC Long Term Annual Meteorological Record, 1988 to 1995: Comparison of Temperature and Precipitation

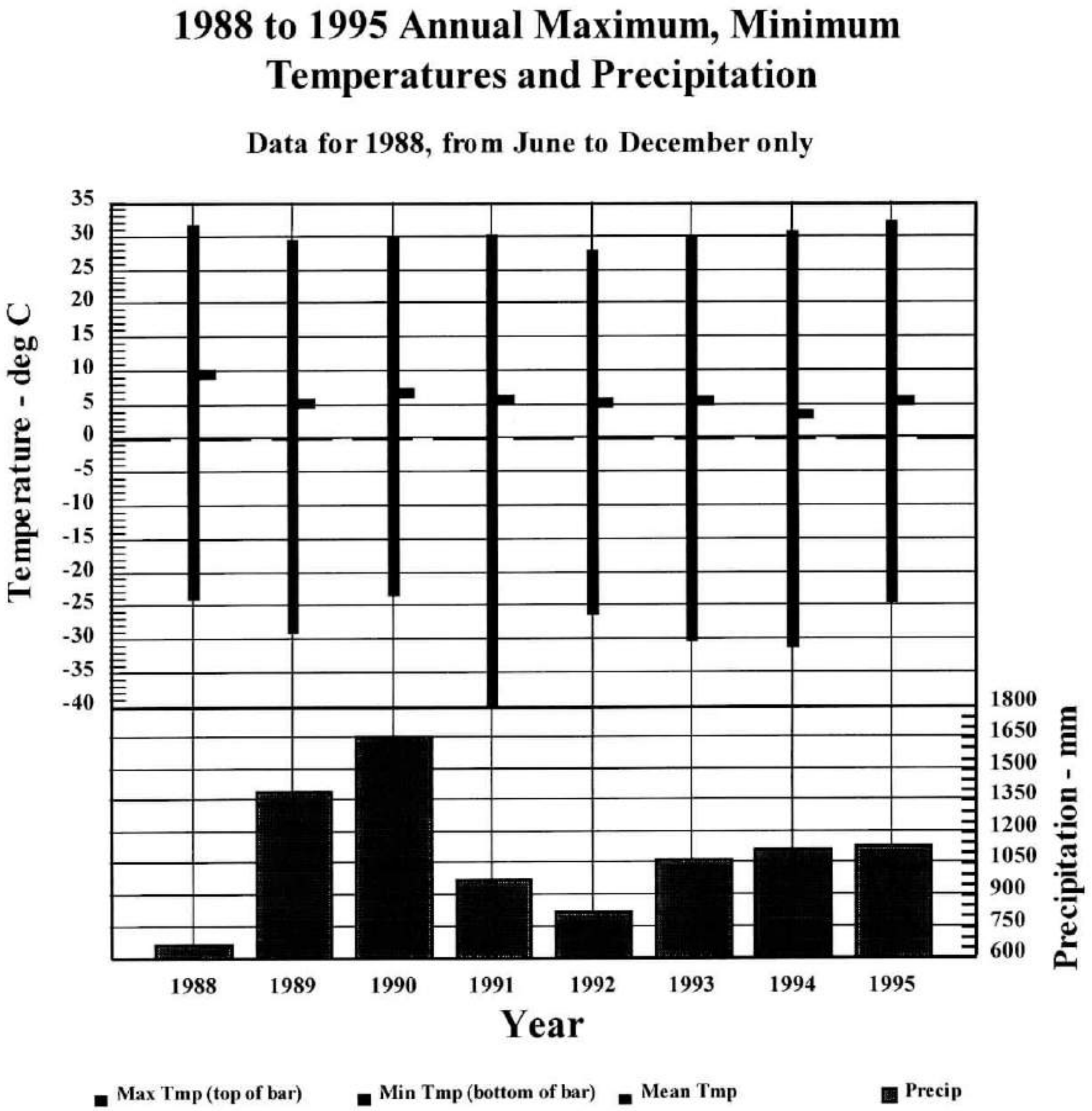
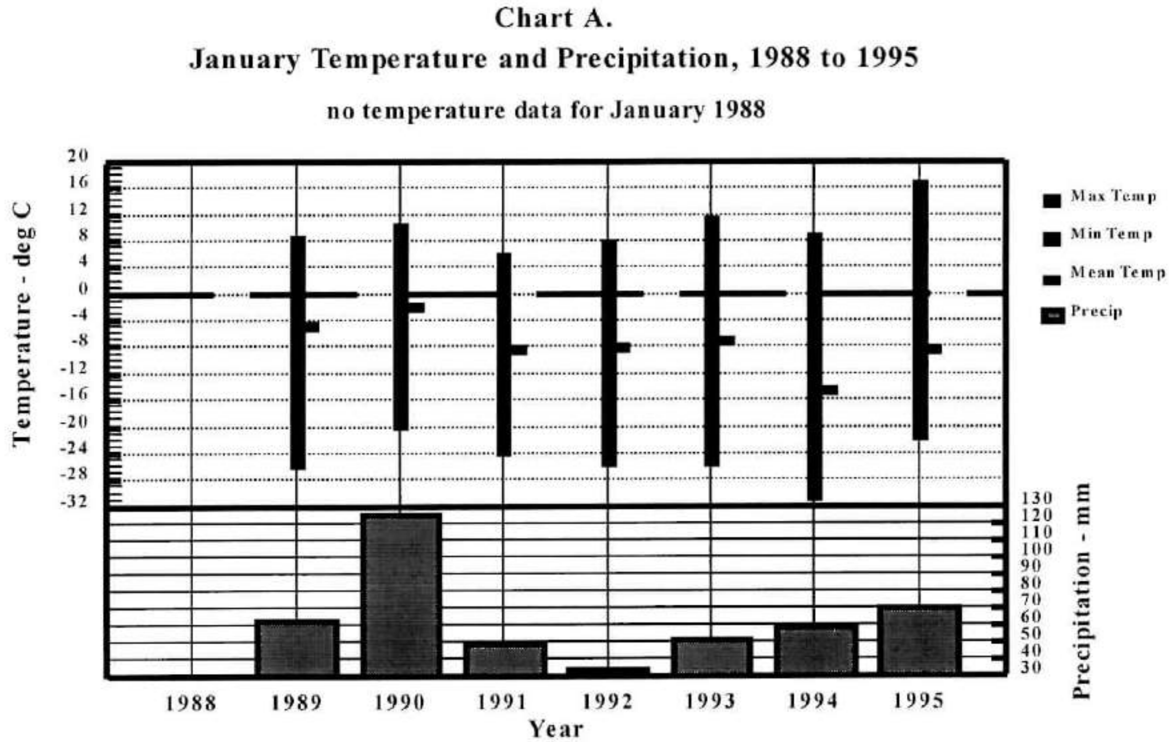
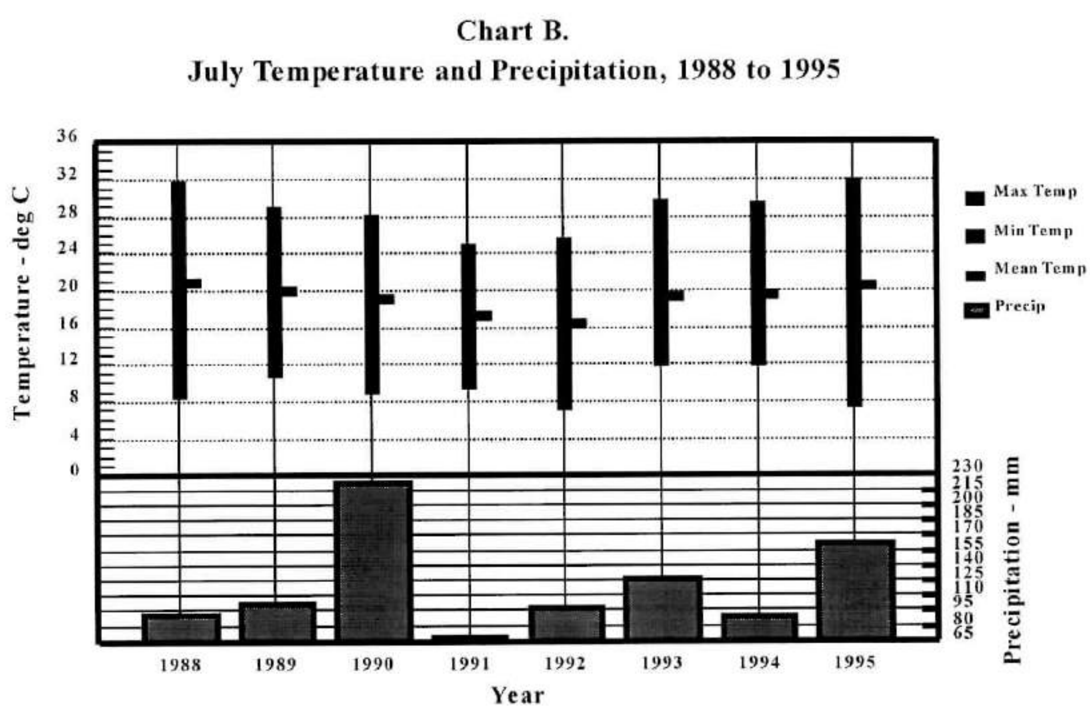


Figure 3. PMRC Long Term Annual Summary: January and July Temperature and Precipitation - 1988 to 1995





Lye Brook Wilderness CASTNET Site
Meteorological and Deposition Chemistry Monitoring
-1995 -

Joanne Cummings and Timothy Scherbatskoy
School of Natural Resources, University of Vermont

Cooperators: Green Mountain National Forest (Nancy Burt), EPA AREAL (Ralph Baumgardner)

Abstract:
Continuous monitoring of meteorology and wet and dry deposition chemistry has been conducted at the Vermont Forest Ecosystem Monitoring (VForEM) Lye Brook Wilderness site. The U.S. EPA, in cooperation with the Green Mountain National Forest and VForEM, established a CASTNET (Clean Air Status and Trends Network) site at the Lye Brook Wilderness research area (729m), in southwestern Vermont. The monitoring activities began January 1, 1994. The site is managed by Environmental Science and Engineering, Inc. (ESE, Inc.) in Durham, North Carolina, under contract from the EPA-CASTNET AREAL Laboratory. This project provides continuous, site specific air quality data on meteorology, dry deposition of SO2, HNO3, particle sulfate, nitrate, ammonium, wet deposition of major ions, and hourly average ozone concentrations. The site was established to research the effects of air pollution on the Air Quality Related Values (AQRV's) of this Class I Wilderness Area. Data from this project are available from the VForEM Data Manager.

Methods:

1. **Basic Meteorology** - The site includes a continuous meteorological monitoring station for ambient temperature at 2 and 10 m, and relative humidity, surface wetness, precipitation, wind speed and direction and solar radiation at 10 m. Meteorological data for 1995 are complete with the exception of November, when the site was off-line, so two years of data (1994-1995) are now archived.

2. **Precipitation Chemistry** - Precipitation is collected on a weekly basis using an AerochemMetrics wet-only collector. Samples are analyzed for major ions, acidity, pH and conductivity. The results of the analysis are comparable with other regional and national sites such as the NADP network.

3. **Dry Deposition** - Dry deposition monitoring at the site consists of continuous weekly sampling for SO_2, HNO_3 vapor, particulate sulfate, nitrate and ammonium. The results of this research are comparable with other regional and national sites, including the EPA National Dry Deposition Network and fourteen sites in the NOAA AIRMon (DDIM) program.

Significant Findings:
No analysis of trends has been completed at this time.

SOIL TEMPERATURE GRADIENTS IN A NORTHERN

HARDWOOD FOREST

1995

Carl Waite and Tim Scherbatskoy
School of Natural Resources
University of Vermont

Cooperators:

Deane Wang and Joanne Cummings, UVM School of Natural Resources

ABSTRACT

A study was initiated in January 1993 to continuously monitor soil temperature at several depths in a northern hardwood forest in Underhill, VT. In 1993-95 treatments applied to these plots were designed to examine the effects of snow cover on soil temperature. Overall seasonal trends were similar in all three years, with soil temperatures increasing with increasing soil depth during fall and winter, and decreasing with increasing depth in spring and summer. During winter, soil temperatures in snow-free plots were more responsive to ambient air temperature than those in snow-covered plots, and were consistently 1 to 5° C (1993), 3 to 9° C (1994), and 0.5 to 2.5° C (1995) lower than those at corresponding depths in snow-covered plots. Winter 1995 differed from the two previous seasons because, in addition to soils not freezing at -30 cm when snow was present, soil did not freeze at this depth when snow was absent. Soil temperatures at -15 cm in snow-covered plots remained above freezing until early March, while temperatures at -5 cm remained slightly above freezing in early winter and slightly below in the late winter. In snow-free plots, 1995 soil temperatures reached lows of 0.5, -1, and -3° C at depths of -30, -15, and -5 cm, respectively. In contrast, 1994 soil temperatures at all subsurface depths (-30, -15, and -5 cm), in snow-covered plots, remained above freezing throughout winter, while in 1993, only at -30 cm was soil temperature consistently above freezing. When a continuous snow pack >30 cm develops in December, it appears that soil temperatures tend to stay above freezing even at depths as shallow as -5 cm. When averaged over all three years, below freezing temperatures (1 February-15 April) occurred only 0.33% of the time at -30 cm when snow was present, but 61% of the time when snow was absent.

INTRODUCTION

In January 1993 a study was initiated to continuously monitor soil temperatures at several depths within a northern hardwood forest. This monitoring provides basic information on soil temperature gradients within the forest and addresses questions about the frequency of freezing in the forest soil rooting zone. This instrumentation allows us to add soil temperature information, under a variety of environmental conditions, to the ever-increasing database being generated at the tower site.

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,

2. examine the effects of snow cover on soil temperature at various depths,

3. quantify the number of hours of subfreezing soil temperatures at various depths during winter and examine the frequency of freeze-thaw cycles, and

4. relate meteorological variables such as ambient temperature to soil temperature.

METHODS

On 15 January 1993 soil thermocouples were installed in two sets of paired, m^2 plots located near the VMC canopy research tower at the Proctor Maple Research Center in Underhill, VT. Thermocouples were installed within the upper rooting zone at 2 cm above and 5, 15, and 30 cm below the soil surface (2, -5, -15, and -30 cm). The paired-plot approach allows treatment of one plot in each pair while maintaining the second plot as a control. For a further description of these thermocouples, details of installation, or data collection procedures, please see 1993 or 1994 VMC Annual Reports.

Treatments of snow-covered vs. snow-free plots were continued in 1995, as in 1993-94, to continue 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 second plot was kept free of snow throughout winter. Average snow depths on all plots were measured and recorded and snow was cleared from snow-free plots after each snowfall.

A problem with the data collection system for one set of plots was discovered during 1995, making data collected from this pair of plots suspect. Therefore, only data from one pair of plots are included in this report. The exclusion of data from one set of paired plots altered the experimental design so that analysis of variance no longer could be used to detect significant differences among treatments.

RESULTS

In 1995 overall seasonal trends in soil temperature were similar to those found in 1993 and 1994. Soil temperature generally increased with depth during fall and winter and decreased with depth in spring and summer (Fig. 1). Soil temperatures at all three subsurface depths came into equilibrium with air temperature near the soil surface in mid April, (four weeks later than in 1994 and two weeks later than in 1993) and again in early September (similar in timing to 1994 and two weeks earlier than in 1993). These times, when no temperature gradients are present, 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 mid April, then continued to increase at a slower rate until mid July, although soil temperatures at -15 and -30 cm continued to increase until August. Soil temperatures then began to decrease gradually from mid July-August through mid October and then more rapidly through November. Average monthly soil temperatures fluctuated by 15 ^{o} C over the season at -30 cm and 18^{o} C at -5 cm.

The first snowfall of the 1994-95 season occurred on 8 December 1994, but unlike the 1993-94 winter season, snow cover was completely lost during a thaw in mid January and snow never accumulated to a depth greater than 43 cm. In fact, only during two brief periods in February and March did snow depth on snow plots exceed 30 cm (Fig. 2). During the January thaw event, ambient temperatures reached 16^{o} C and remained above freezing for nearly 10 days (Fig. 3). Despite the lack of continuous snow cover and a maximum snow depth of 43 cm, slightly less than 60% of 1993 and 1994 maximum totals (75 and 72 cm, respectively), soil temperatures in snow-free plots were generally more responsive to ambient air temperature than those in snow-covered plots. This was particularly true at shallower depths (-5 and -15 cm), although differences were less dramatic than in previous years (Fig. 3 and 4). With the exception of upward trends in mid January, temperatures at all subsurface soil depths in both treatments generally decrease throughout winter until reaching seasonal lows in March and April.

Specific results show that average daily temperatures of soil at -30 cm in both snow-covered and snow-free plots remained above freezing throughout the entire period (December 1994 to mid April 1995) and averaged 2.2^{o} C in both treatments (Fig. 4). Soil temperatures at -30 cm in snow-covered and snow-free plots ranged from 0.1 (early March) to 5^{o} C (during the January thaw) above freezing. During some periods of the winter, soil temperature at -30 cm in snow-free plots were actually slightly warmer than those in snow-covered plots, but differences were probably not statistically different. At -15 cm in snow-covered plots, soil temperatures remained above freezing (averaging 1.3^{o} C; reaching 5.5^{o} C during the January thaw) until early March when temperatures dipped slightly below freezing (reaching -0.1^{o} C). In snow-free plots at -15 cm, soil temperatures approached freezing in mid January, just prior to the January thaw, rose to

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.

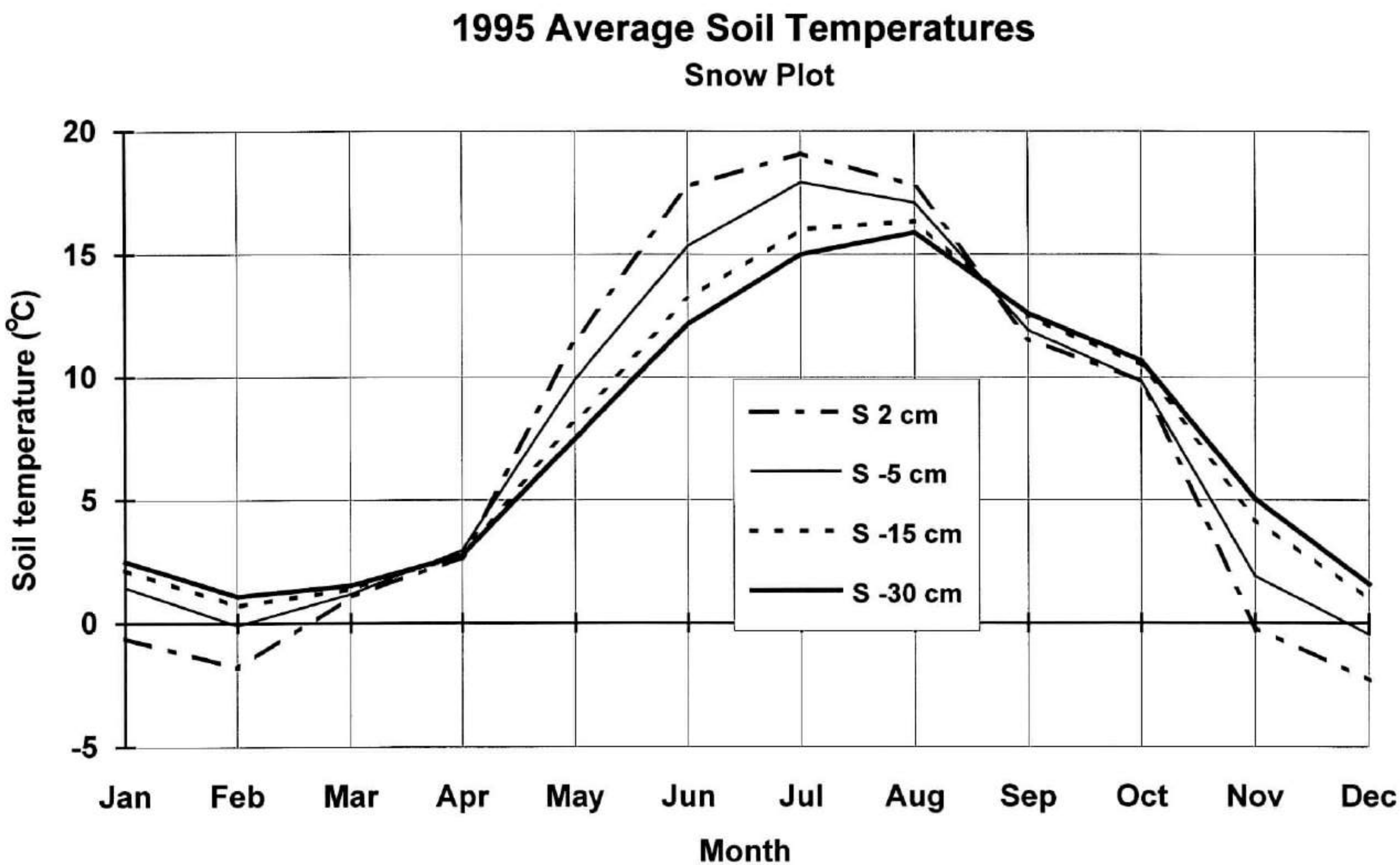


Figure 2. Average snow depth and average daily soil temperature for snow-covered (snow) and snow-free plots from 1 December 1994 to 15 April 1995 measured in a northern hardwood forest stand at the Proctor Maple Research Center in Underhill, VT.

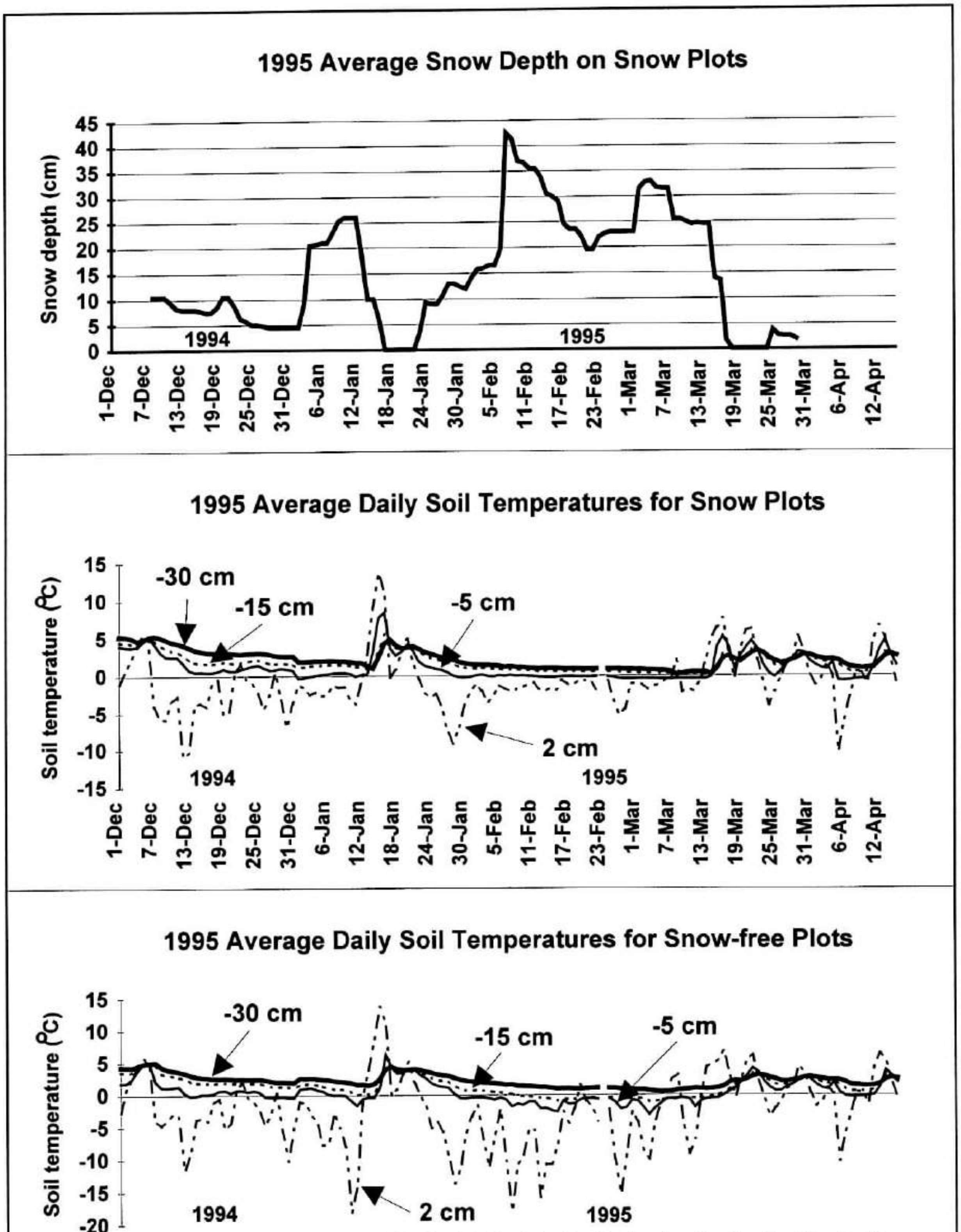


Figure 3. Average daily soil temperature measured 2 cm above and 5, 15, and 30 cm below the soil surface and ambient air temperature measured at 7.5 m above the forest floor, during January 1995, in a northern hardwood stand at the Proctor Maple Research Center in Underhill, VT.

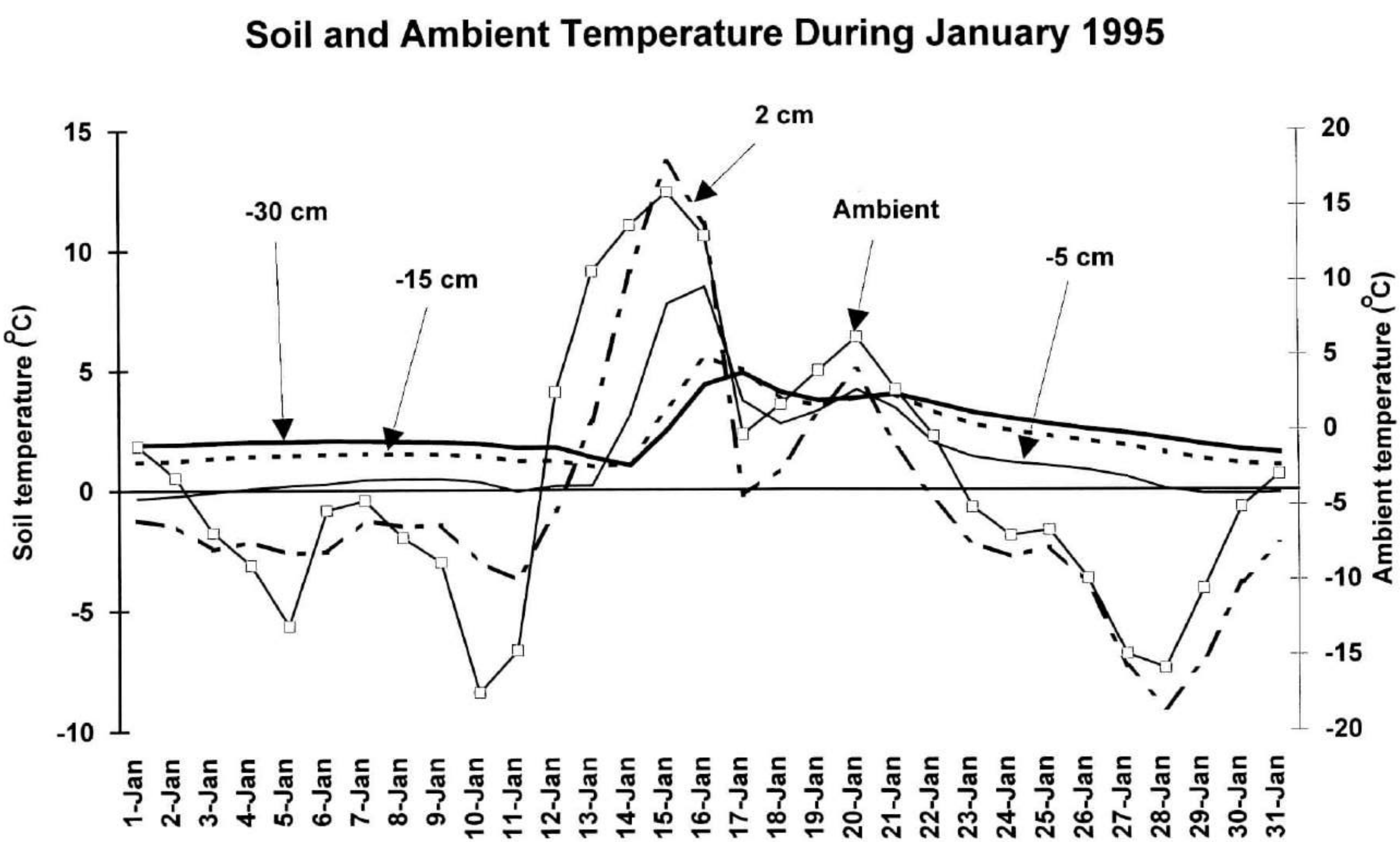
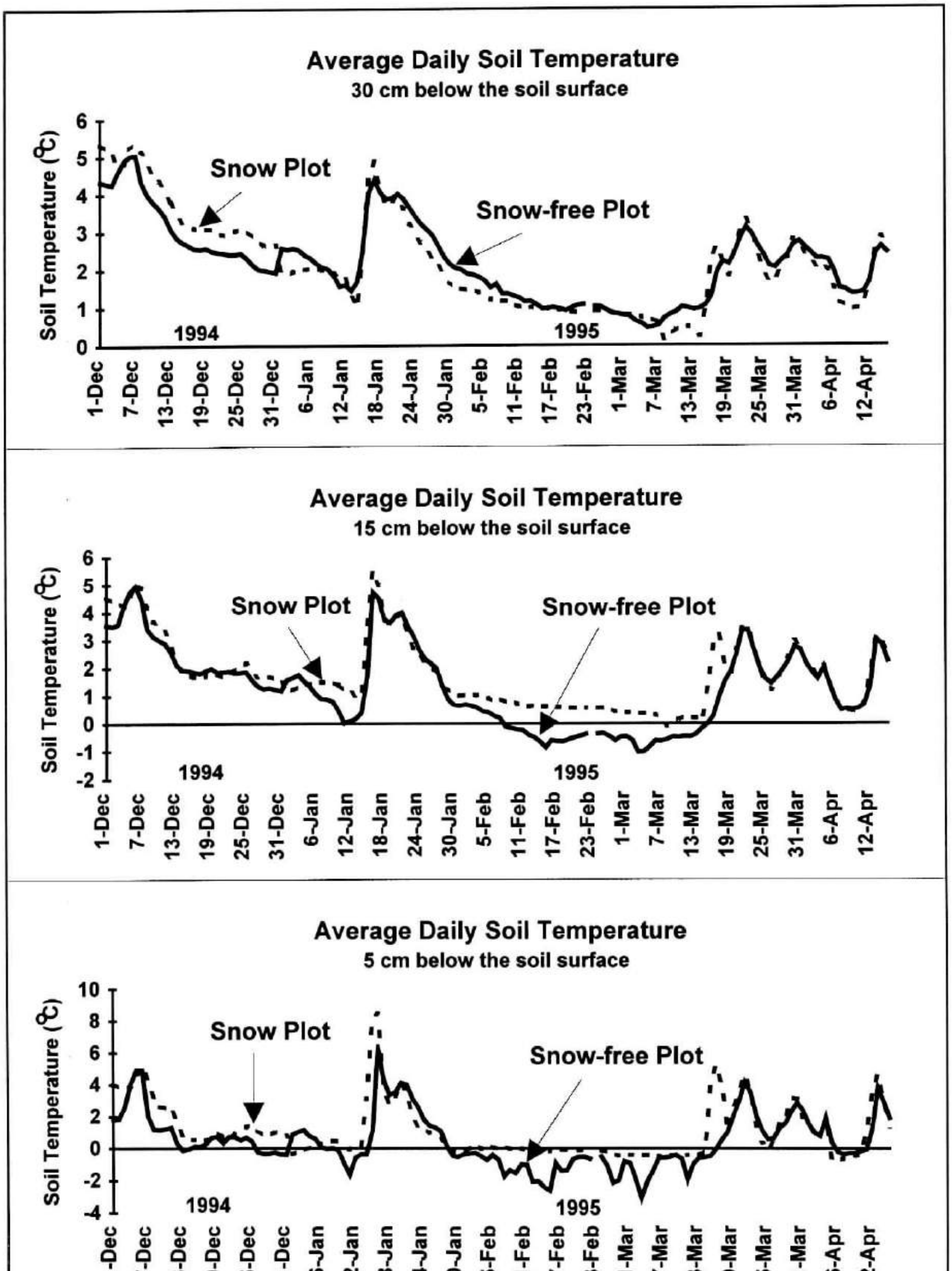


Figure 4. Average daily soil temperature from 1 December 1994 to 15 April 1995 measured at 30, 15, and 5 cm below the soil surface in snow-covered and snow-free plots within a northern hardwood forest stand at the Proctor Maple Research Center in Underhill, VT.

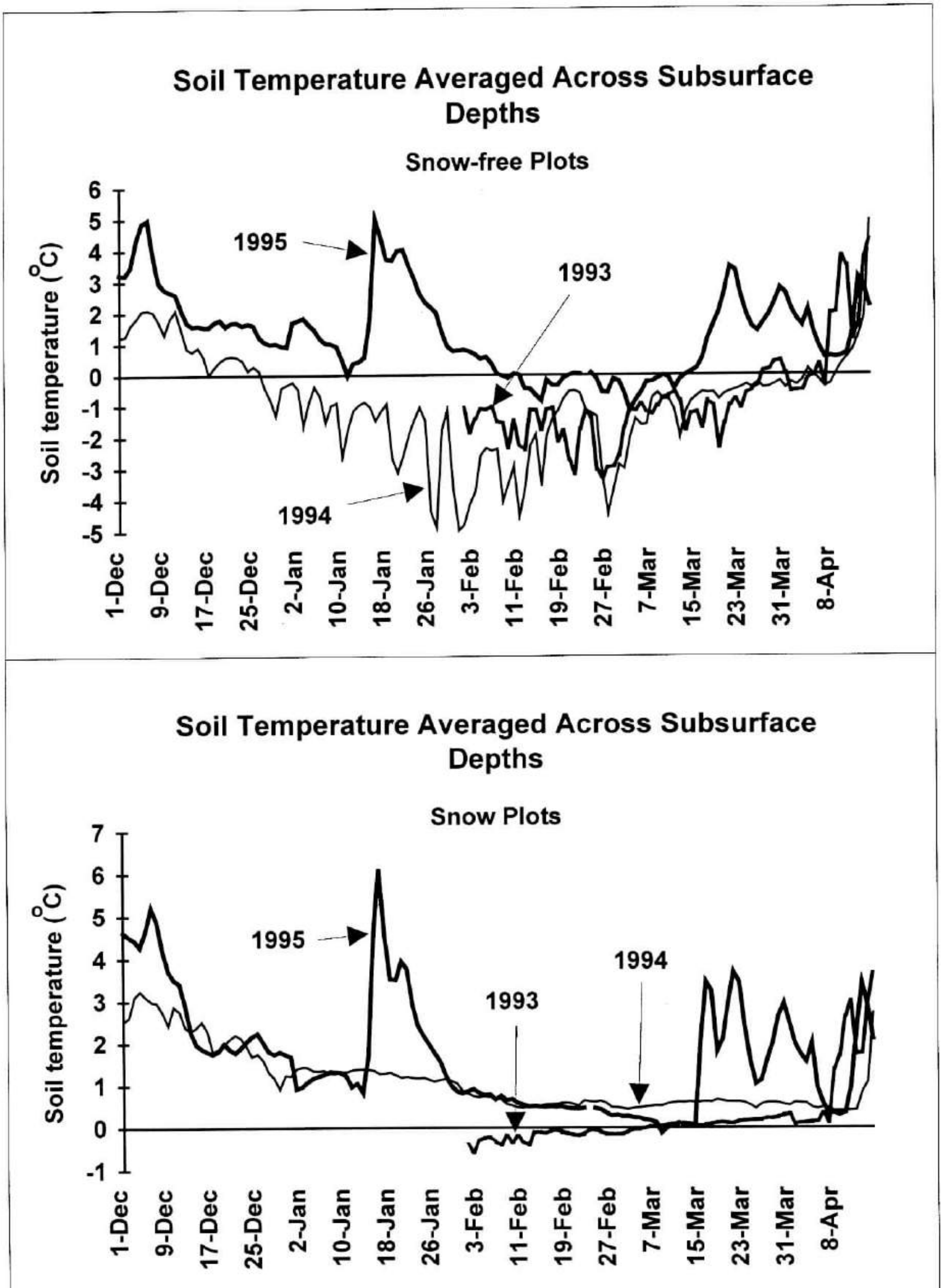


4.7° C during the January thaw, and following the thaw, went below freezing again in early February and remained near or slightly above -1° C until mid March. Soil temperatures at -5 cm in snow-covered plots remained at or near freezing throughout winter and reached a low of -0.5° C in mid March. At -5 cm in snow-free plots, soil temperatures fluxuated with ambient air temperatures, but remained below freezing throughout much of the winter and reached a minimum of -3° C in early March.

Although, trends for snow-free plots were quite similar in 1993 and 1994, soil temperatures in 1995 tended to be on average (1 December to 15 April) warmer at all subsurface depths than those recorded during the two previous winters (Fig. 5). Soil temperatures in snow-free plots averaged 2.2° C warmer across all subsurface depths in 1995 than 1994 (ranging from 2.1 to 2.3° C) and 1993 (ranging from 1.7 to 2.6° C). In snow-covered plots soil temperatures during this same time period averaged 0.6° C warmer in 1995 than 1994 (ranging from 0.4 to 0.7° C) and 0.9° C warmer than in 1993 (ranging from 0.8 to 0.9° C). When 1995 and 1994 soil temperature data for snow-covered plots are compared by soil depth, it is found that 1995 temperatures at -30 and -15 cm are generally warmer in December and during the second half of January (during the January thaw), but are actually colder in early March. At -5 cm in snow-covered plots, 1995 soil temperatures are generally colder than those in 1994 with the exception of early December and mid to late January. The extremely warm temperatures during the second half of January apparently had a large influence on the 1 December to 15 April average temperatures. Ambient air temperature measured at 7.5 m above the ground and averaged from 1 December to 15 April was also 3.3° C warmer in 1995 than 1994 and 1.8° C warmer than 1993 (Fig. 6). The warm temperatures experienced during the extended January thaw in 1995 certainly influenced both average ambient and soil temperatures in 1995, regardless of treatment. Some major differences were noted in the performance of snow-covered plots over the three years. In 1993 soil temperatures at all depths except -30 cm remained below freezing throughout most of the winter. In that year temperatures at -30 cm went above-freezing only after a snow pack of about 30 cm had accumulated. In contrast, 1994 soil temperatures on snow-covered plots remained above freezing at all subsurface depths throughout winter. In 1995 soil temperatures at -30 and -15 cm in snow-covered plots remained above freezing until early March when temperatures at -15 cm dipped below freezing.

The amount of time in 1993-95 that soil temperatures remained below freezing, at the various depths, in snow-covered and snow-free plots, is summarized in Table 1.

Figure 5. Soil temperature averaged across all three subsurface depths (-5, -15, and -30 cm) in snow-free and snow-covered plots for the period of 1 December to 15 April 1993-1995. Data were collected in a northern hardwood forest stand at the Proctor Maple Research Center in Underhill, VT.



Note: In 1993 data collection did not begin until mid January.

Figure 6. Average monthly ambient air temperature measured 7.5 m above the ground for the period of 1 December to 15 April 1993-1995 in a northern hardwood forest stand at the Proctor Maple Research Center in Underhill, VT.

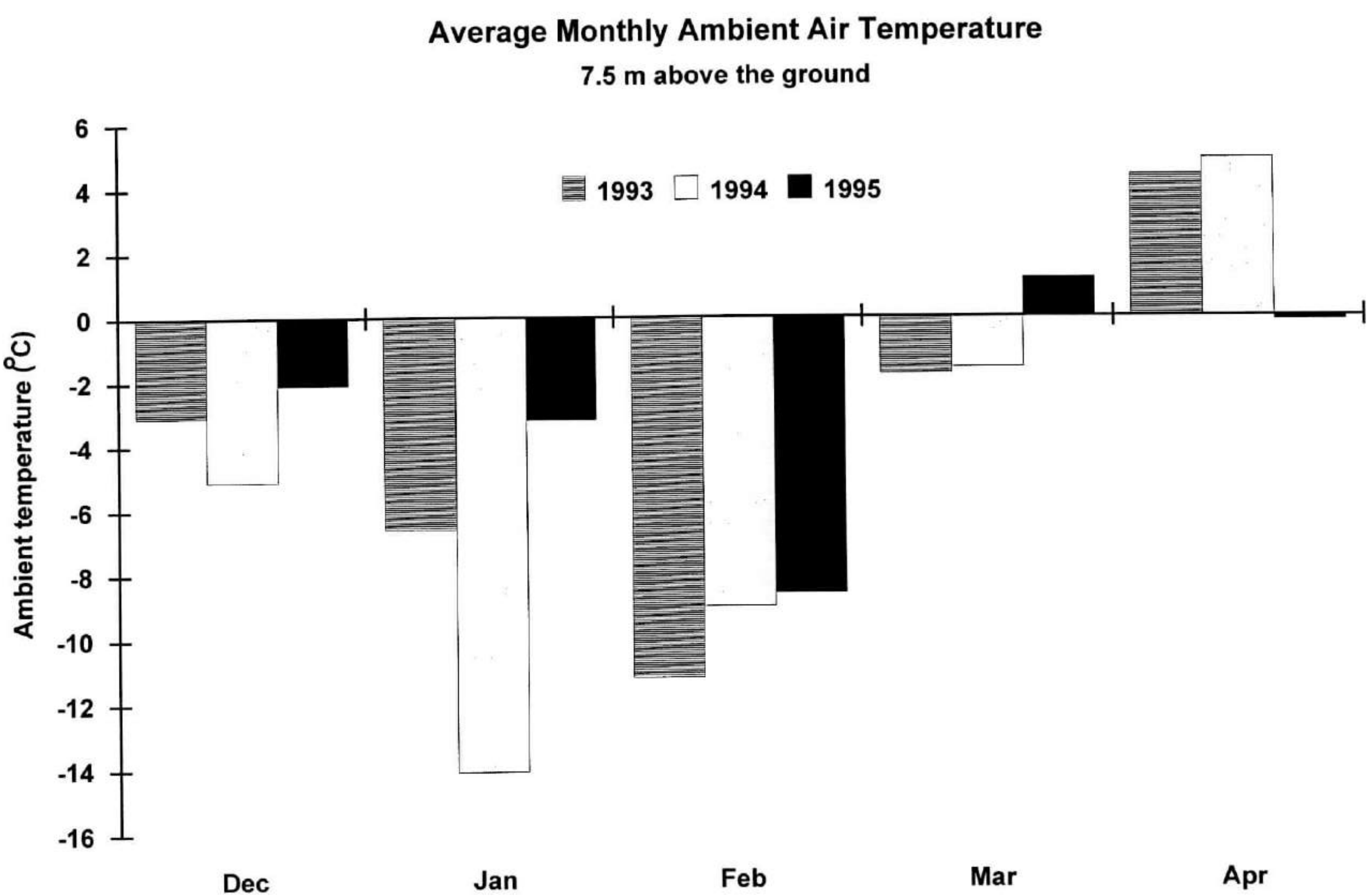


Table 1. Number of hours and % of time that subfreezing soil temperatures occurred, at various depths, between 1 February and 15 April 1993-95, in snow-covered and snow-free plots located at the Proctor Maple Research Center in Underhill, VT.

Soil	Snow-covered						Snow-free					
Depth	1993		1994		1995		1993		1994		1995	
cm	hrs	(%)	hrs	(%)	hrs	(%)	hrs	(%)	hrs	(%)	hrs	(%)
2	1572	(89)	1693	(95)	1236	(71)	1331	(75)	1277	(72)	1106	(64)
-5	1473	(83)	3	(0.2)	1041	(60)	1448	(82)	1496	(84)	1159	(67)
-15	1100	(62)	0	(0)	32	(2)	1579	(89)	1712	(96)	825	(47)
-30	23	(01)	0	(0)	8	(0.5)	1581	(89)	1691	(95)	0	(0)

In all three years the number of hours of subfreezing temperatures decreased with soil depth in snow-covered plots and generally increased with depth in snow-free plots. The exception to this pattern is in 1995 when number of hour of subfreezing temperatures in snow-free plots decreased with depth between -5 and -15 cm, and soil did not freeze at -30 cm. The most striking difference among the three years is the significant reduction in hours of subfreezing temperatures in1994 over 1993 in snow-covered plots at -5,-15, and -30 cm. This reduction in hours of subfreezing temperatures is due to the much earlier snowfall and development of a continuous snow pack in 1994, although maximum snow depths were similar (about 70 cm) in both years. Although, the number of hours of subfreezing temperatures at -15 and -30 cm in 1995 was also reduced from 1993 levels, we believe this was probably the result of generally milder ambient temperatures rather than snow cover, because soil at -30 cm in snow-free plots also did not freeze. The insulating layer of snow (snow plots) increased the number of hours of subfreezing temperatures near the soil surface (2 cm) in all three years, compared to snow-free plots. When averaged over all three years, below freezing temperatures occurred only 0.33% of the time at -30 cm when snow cover was present, but 61% of the time when snow was 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. In mature sugar maple (*Acer saccharum* Marsh.) it has been shown that when roots were exposed to freezing temperatures (-6° C) to a depth of 20 cm, that a significant reduction in sap flow rates, total sap volumes, and total sugar per tree occurred (Robitaille *et al.* 1995). These perturbations persisted for at least two years after treatment and were accompanied by increased canopy transparency (dieback). Although, soil temperatures of -6° C or lower have not been recorded at subsurface depths in snow-covered plots over the past three winters, temperatures of this magnitude were recorded at -5 and -15 cm in 1994 (based on hourly averages) in snow-free plots.

We now have temperature data at different depths for three winters in soils beneath a northern hardwood forest. The three winters were quite different in the timing of snowfall, maximum depth of snow, and duration of a continuous snow pack. In 1994, snowfall and the associated snow pack began in late November and persisted until mid to late April. No significant snowfall occurred until mid January in 1993 and a continuous snow pack did not develop until early February. Despite the difference in timing of snow events, similar maximum depths of snow were recorded in both years (about 70 cm). Result from 1993 indicate that a snow pack of at least 30 cm in depth is necessary to provide a significant moderating effect on soil temperature down to 30 cm. Bertrand *et al.* (1994) also found that a snow pack of 30 cm provided sufficient insulation to prevent roots from freezing and subsequent dieback in mature sugar maple trees. In 1995, despite a snow pack that began in early December, snow depths remained below 30 cm until early February. In fact, the snow pack was completely lost in mid January during a significant thaw event. Maximum snow depths did exceed 30 cm for brief periods in early February and early March, reaching a maximum depth of only 43 cm, but generally were less than 30 cm. Data show that in the absence of snow cover, soil temperatures can be below freezing to a depth of -30 cm for a significant part of the winter. At lesser depths of -5 and -15 cm, soil temperature in the absence of snow cover can be as low as -12 and -6° C, respectively (based on hourly averages). These depths encompass a significant portion of the rooting zone for many tree species, including sugar maple, subjecting roots (and other soil biota) to significant freezing events. These conditions usually occur during winters with extended periods of little or no snow cover. With significant snow (>30 cm) present in December, soil temperatures remained above freezing for the entire winter even at depths as shallow as -5 cm. In 1993 when significant snowfall occurred late, we found that soil temperatures dropped below freezing even to depths of -30 cm. When snow-cover did occur in 1993, soil temperatures began to rise very gradually over the winter, but still remained below freezing at all depths except -30 cm. When milder winter temperatures and significant mid winter thaw events occur, such as in 1995, soil at a depth of -30 cm or greater may not freeze even when snow is absent.

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 of -1 or -2° C. Once winter acclimated, most tree tissues are protected 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.

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.

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LITERATURE CITED:

Bertrand, A., Robitaille, G., Nadeau, P., and Boutin, R. 1994. Effects of soil freezing and drought stress on abscisic acid content of sugar maple sap and leaves. Tree Physiology 14: 413-425.

Robitaille, G., Boutin, R., and Lachance, D. 1995. Effects of soil freezing stress on sap flow and sugar content of mature sugar maples (Acer saccharum). Can. J. For. Res. 25: 577-587.

Human Impact

THE EFFECTS OF SKI AREA DEVELOPMENT ON SUBALPINE SPRUCE-FIR BIRD COMMUNITIES AND THEIR HABITAT ON MOUNT MANSFIELD, VERMONT: AN ANALYSIS OF PRE-TREATMENT DATA.

Progress Report 1995

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Abstract: As part of an Act 250 assessment of the proposed Nose Dive Pod ski area expansion we established a 20 ha study plot (NDPO) and a 20 ha control plot (RABR) on the east slopes of Mt. Mansfield, Vermont to examine the effects of ski area development on Bicknell's Thrush and other birds of subalpine spruce-fir forests. Spot mapping of all breeding birds and analysis of vegetation were conducted on each plot. Twenty-eight species of birds (18 breeding) were recorded on NDPO and 32 (16 breeding) on RABR. Four species are dependent on spruce-fir forest during the breeding season. Eight Bicknell's Thrush (*Catharus bicknelli*) territories (4.5 territories/20 ha) were found in or around the NDPO plot, while 10.75 territories/20 ha were recorded on RABR. Thrushes seemed to be concentrated along current ski trail edges in the NDPO. Differences in densities may have been caused by habitat differences. Examination of the flora showed NDPO to be a lower elevation, mesic site, while RABR was classified as a higher elevation subalpine forest. The conservation status of the Bicknell's Thrush, combined with the paucity of avian population data in subalpine forests and increasing development pressures, argue for careful, long-term impact assessment studies. Contingent upon Act 250 approval for ski expansion, we plan to monitor both sites for at least one more breeding season prior to construction and 6 years thereafter.

Introduction

The Mt. Mansfield Company and the State of Vermont have requested a permit from the District 5 Environmental Commission to develop additional ski trails and a ski lift on state-owned land in the "Nose Dive Pod" area on Mt. Mansfield's east slope. One component of the required Act 250 assessment for this project involves determination of the status of Bicknell's Thrush within the 126 acre project area. This report presents results of avian surveys conducted during June and July of 1995. In addition to documenting the status of Bicknell's Thrush in the Nose Dive Pod area, the work described in this report should provide a foundation for determining the impacts of ski area development on montane breeding bird populations.

Methods

During May and early June of 1995 a 20 ha (49.4 ac) study plot in the proposed project area was marked with blue survey flagging and metal tree tags in a 25 m grid using a fiberglass meter tape, meter hip-chain and compass. The study plot ranged in elevation from approximately 1,067 m (3,500 ft) to 884 m (2,900 ft), covering the highest elevations of the proposed Nose Dive Pod expansion. The approximate location of the study plot is illustrated on the attached project map (Fig 1). Because our detailed field reconnaissance indicated that the project map seemed to be incorrectly scaled, the corners of the study plot were graphically positioned on this map based on their location with known reference to existing ski trails.

We selected this plot configuration to maximize the potential to assess effects of proposed ski trail and lift development on breeding birds in the sub-alpine spruce-fir zone within the project area. Because the precise location of the proposed ski slopes has not been finalized, we attempted to place the four corner markers outside of the proposed development area. This should enable relocation of the interior points, some of which may be lost due to construction activities. The project area's rugged topography and dense vegetation, coupled with a short avian breeding season and constraints of budget and field personnel, precluded the establishment of a larger study plot that would have included both proposed and current gladed ski trails.

A 20 ha control plot was also established in the Ranch Brook watershed south of the Nose Dive Pod area. This plot was situated at similar elevations with a comparable slope aspect as the Nose Dive Pod (NDPO) plot. The Ranch Brook (RABR) plot is located on protected, state-owned land and is undeveloped except for a narrow cross-country ski trail and two hiking trails. This plot will be used to reference any future changes in bird populations and vegetation which may occur in the Nose Dive Pod following activities from the proposed ski area expansion.

Our primary census method involved spot mapping, a standardized technique based on the territorial behavior of breeding birds. This technique enables accurate calculations of the numbers and densities of birds in a given unit of area, as well as determinations of the location and distribution of individual territories. Our spot mapping censuses included all breeding species on each study plot. Using our established 25m gridded reference points, the locations of all observed birds were recorded on a detailed map of each study plot. Special efforts were made to map counter-singing and counter-calling birds of each species, as these enable the most precise delineation of individual territories (Robbins 1970).

Three experienced observers made repeated visits to both plots, recording the location of each bird seen or heard on field maps while slowly walking plot transects. Locations of nests found while spot mapping were also noted. Each plot was completely spot mapped at least five times during the breeding season. Spot mapping was conducted from 13 June to 5 July on the NDPO plot and from 9 June to 6 July on the RABR plot. Censusing was conducted from sunrise to 10:00 while birds vocalized most actively. Several evening censuses were conducted specifically to map Bicknell's Thrushes. In addition, we attempted to note the locations and numbers of all Bicknell's Thrushes observed outside of the NDPO plot but within the 126 acre project area. All observations of Bicknell's Thrushes and other species were transferred from daily field maps to base study plot maps. Simultaneous registrations of two or more vocalizing individuals were used as the primary means of discriminating between adjacent territories, as were repeated registrations in a given area over several census dates.

We examined the vegetation characteristics of each study area. A total of sixty $100m^2$ plots were established on the two gridded plots. Measurements were taken in 10m x 10m quadrats cornered at the intersections of a 100 m grid and square within the grid. NDPO was completed on 6, 11, 12, 19, and 25 September, while RABR was sampled on 29 and 31 August and 5, 7, 18, 19, and 20 September. The general location and topographic setting were described, the slope and aspect measured with clinometer and compass, and the drainage conditions, forest floor, soil, and surface rockiness noted. Within each plot all trees over 5cm dbh were tallied by diameter to the nearest cm. Canopy height was estimated using eye and tape, and canopy cover was estimated visually as a percent of the plot covered. Dead trees were also tallied by diameter, and dead downed wood was treated in the same manner if originally rooted within the plot. In addition the mortality mode (standing, snapped, snag, tip-up) and the decay class (8 step) was recorded for dead trees. A complete species list of all vascular plants was compiled for a nested series of quadrats (1 x 1m; 3.1 x 3.1m; 10 x 10m; and entire 100 x 100m plot). In addition the cover of all plants in the 1 x 1m plot cornered on the grid intersection was visually estimated. In several locations a small soil pit was dug, the soil was characterized, and soil temperature was recorded at depth. One upper mineral soil sample was recovered and used for chemical determinations. A few trees were cored for age and growth determinations. The botanical data collection and analysis were designed and supervised by Dr. Charles Cogbill. We will resample these sites immediately after ski slope development has occurred on the NDPO and every 2-3 years thereafter.

Results and Discussion

Twenty-eight species of birds were recorded on NDPO and 32 on RABR (Table 1). Twelve of these are considered neotropical migrants. Four species (Bicknell's Thrush, Blackpoll Warbler, Pine Siskin, and White-winged Crossbill) are dependent upon spruce-fir forests for breeding habitat.

We detected 18 breeding species during our censusing on NDPO and 16 on RABR (Table 1). The two plots shared 15 species in common. NDPO contained 3 breeding species (American Robin, Brown Creeper, Golden-crowned Kinglet) and RABR 1 breeding species (Ruby-crowned Kinglet) that did not breed on the other plot. Each of these species was found in very low densities. RABR supported 44 more pairs of breeding birds than were found on NDPO. Eleven species were recorded at higher densities on RABR, four species were found in equal numbers, and 5 bird species were recorded at slightly higher densities on NDPO.

Eight Bicknell's Thrush territories (4.5 territories/20 ha) were found within or near the Nose Dive Pod area (Fig. 1). All territories were found to be above approximately 945 m (3,100') elevation. Four territories were located within areas designated for ski trail construction.

Table 1. Species detected, number of territories and breeding status on Nose Dive Pod and Ranch Brook plots, Mt. Mansfield, Vermont, 1995.

Species Detected	No. of NDPO Territories.	Status	No. of RABR Territories	Status
Blackpoll Warbler	23.5	Breeding	40.25	Breeding
Swainson's Thrush	5.5	Breeding	16.5	Breeding
White-throated Sparrow	16	Breeding	16	Breeding
Winter Wren	9	Breeding	12	Breeding
Dark-eyed Junco	4	Breeding	11	Breeding
Bicknell's Thrush	4.5	Breeding	10.75	Breeding
Myrtle Warbler	8	Breeding	10	Breeding
Yellow-bellied Flycatcher	5	Breeding	9	Breeding
Magnolia Warbler	7	Breeding	6	Breeding
Purple Finch	3	Breeding	5	Breeding
Red-breasted Nuthatch	8	Breeding	5	Breeding
Nashville Warbler	3	Breeding	2	Breeding
Black-capped Chickadee	1	Breeding	2	Breeding
Blue Jay	1	Breeding	1	Breeding
Solitary Vireo	1	Breeding	1	Breeding
American Robin	3	Breeding	0	Transient
Brown Creeper	1	Breeding	0	Transient
Golden-crowned Kinglet	2	Breeding	0	Transient
Ruby-crowned Kinglet	0	Not Detected	2	Breeding
Ruffed Grouse	1	Early Breeder	1	Early Breeder
Pine Siskin	0	Early Breeder/ Transient	0	Early Breeder/ Transient
White-winged Crossbill	0	Early Breeder/ Transient	0	Early Breeder/ Transient
Northern Saw-whet Owl	0	Not Detected	0	Early Breeder/ Transient
Northern Flicker	0	Not Detected	0	Transient
Black-and-white Warbler	0	Not Detected	0	Transient
Mourning Dove	0	Not Detected	0	Transient
Cedar Waxwing	0	Not Detected	0	Transient
Hermit Thrush	0	Transient	0	Not Detected
White-breasted Nuthatch	0	Transient	0	Not Detected
Hairy Woodpecker	0	Transient	0	Transient
American Redstart	0	Transient	0	Transient
Black-throated Green Warbler	0	Transient	0	Transient
Black-throated Blue Warbler	0	Transient	0	Transient
Red Crossbill	0	Transient	0	Transient
Total Breeding Territories	106.5		150.5	
Red Squirrel Territories	5 (7 Records)		10 (17 Records)	

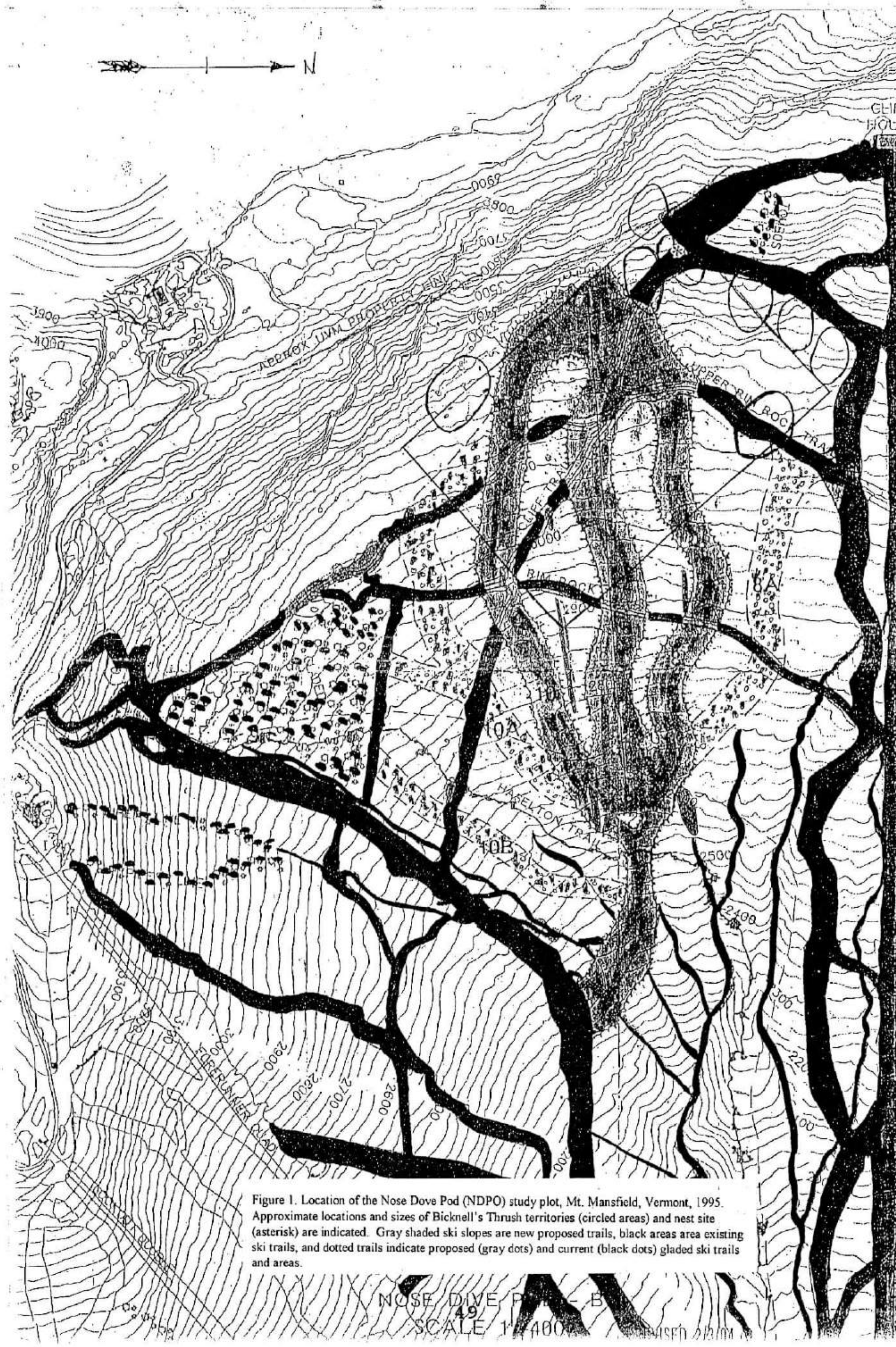

Figure 1. Location of the Nose Dove Pod (NDPO) study plot, Mt. Mansfield, Vermont, 1995. Approximate locations and sizes of Bicknell's Thrush territories (circled areas) and nest site (asterisk) are indicated. Gray shaded ski slopes are new proposed trails, black areas area existing ski trails, and dotted trails indicate proposed (gray dots) and current (black dots) gladed ski trails and areas.

Seven thrush territories were located near existing ski trails. On NDPO, areas of high stem densities are most common immediately along existing ski trail corridors. It appears that Bicknell's Thrush are attracted to these areas, as they provide the species' preferred habitat structure. Similarly, in New Brunswick, Canada, presence/absence surveys for Bicknell's Thrush found the species to be disproportionately located along logging roads where regenerating dense, young balsam fir growth occurred (D. Busby, pers. comm.).

Recent studies have determined that artificial (i.e., human-induced) edge habitats may not be beneficial to birds (e.g., Gates and Gysel 1979; Whitcomb et al. 1981; Wilcove et al. 1986). While many bird species are attracted to the vegetation diversity and structure at artificial edges, they tend to experience higher rates of nest depredation and brood parasitism near these edges. If nesting success is reduced below that occurring in habitats less subject to edge effects, such areas may act as population sinks. We are not currently able to assess this either for the already-fragmented Nose Dive Pod area or for subalpine forests in general, as there are extremely few productivity data available for natural or artificial edge habitats in subalpine spruce-fir forests.

We confirmed breeding by Bicknell's Thrush in the Nose Dive Pod area with the discovery of 3 nests (one recently depredated/abandoned, two from previous years) and the capture of a female in full breeding condition. All three nests were located within an area designated for ski trail construction (Fig. 1). We mist-netted and color-banded 4 adults (3 males, 1 female) on and immediately adjacent to the plot's northwest corner, which supports the highest density of thrushes in the project area (Fig. 1). We plan to monitor these and additional banded birds on the plot in future years.

Bicknell's Thrush densities were higher on the RABR and summit ridgeline plots than on the NDPO plot (Table 2). Vegetation analysis placed the RABR forest in the class of higher elevation subalpine forests and NDPO at lower elevations in the subalpine zone. These habitat differences may account for the lower densities of thrushes on NDPO. The summit ridgeline supports one of the highest breeding densities of Bicknell's Thrush recorded anywhere in the species' range, probably due to the dense, contiguous krummholz forest found at that high elevation. Although at its upper elevations the Nose Dive Pod area is characterized in part by the stunted forests favored by Bicknell's Thrush, the overall structure of the spruce-fir forest in this basin does not provide optimal habitat for the species.

Collection of vegetation and physiographic data before ski area development enabled us to compare the two study sites. Mean slope and aspect of NDPO was 20.9°±7.9 and 106.8 mag°±22.0 (due E), and RABR was 21.3°±7.1 and 162 mag°±32.9 (SSE). The NDPO plot covered an elevational gradient from approximately 915 to 1,070m, while RABR ranged from 975 to 1,150m elevation. Mid-September soil temperatures were 10.5°C on NDPO and 9.4°C on RABR. A soil sample from plot K7 at approximately 1095m elevation on RABR was a well drained histosol with 3cm A/O and Regolith. Organic material content was 8.8%, pH 3.42, 26.7cmol/Kg exchange acidity, Ca 69 mg/Kg, K 75 mg/Kg, Mg 20.9 mg/Kg, Mn 3.8 mg/Kg, and Fe 29 mg/Kg. On the NDPO a soil sample was obtained on plot 6C at approximately 990m elevation. It was identified as a well drained spodsol with weak E and B's. Organic material content was 6.5%, pH 4.37, 27.5 cmol/Kg exchange acidity, Ca 168 mg/Kg, K 29 mg/Kg, Mg 20.9 mg/Kg, Mn 3.7 mg/Kg, and Fe 239 mg/Kg.

Table 2. Bicknell's Thrush territory densities on Mount Mansfield, Vermont.

Study Plot Location	Number of Territories	Breeding Densities[a]
Nose Dive Pod 1995	4.5 / 20 ha	9.0 / 40 ha
Ranch Brook 1995	10.75 / 20 ha	21.5 / 40 ha
Ridgeline 1992-1995	8-12 / 8.8 ha	36.0 - 65.0 / 40 ha

[a] Presumed breeding pairs

Table 3. Understory (below 1.5m tall) from $1m^2$ plots on the NDPO (n=27 plots) and RABR (n=30) study plots, Mt. Mansfield, Vermont, 1995.

Species	% Frequency		% Coverage	
	NDPO	RABR	NDPO	RABR
Abies balsamea	48	50	8.22	8.87
Acer saccharum	0	3	0	0.07
Acer spicatum	4	0	0.07	0
Aster acuminatus	11	17	0.74	0.43
Athyrium felix-femina	7	3	1.19	0.07
Betula cordifolia	7	13	0.30	0.43
Carex arctata	7	0	0.11	0
Carex disperma	0	3	0	0.03
Cinna latifolia (?)	4	0	0.15	0
Clintonia borealis	37	67	5.37	4.57
Coptis groenlandica	0	23	0	0.93
Cornus canadensis	7	7	0.11	0.33
Dennstaedtia punctiloba	4	0	0.37	0
Dryopteris Campyloptera	63	60	16.74	5.47
Dryopteris phegopteris	15	3	0.30	0.27
Fragaria virginiana	4	0	0.15	0
Gaultheria hispidula	4	0	0.15	0
Lycopdium lucidulum	37	37	3.67	2.10
Maianthemum canadense	0	10	0	0.47
Monotropa uniflora	11	0	0.19	0
Oxalis montana	70	73	14.89	9.57
Picea rubens	33	10	8.70	1.67
Pyrus americana	11	0	1.37	0
Solidago macrophylla	19	13	0.59	0.27
Thelypteris novaborensis	4	3	0.15	0.27
Trientalis borealis	0	10	0	0.13
Trillium undulatum	4	3	0.19	0.03

Both sites are relatively heterogeneous with ragged canopies averaging 10.7m (±2.9) in height with 62% canopy cover at NDPO and 9.5m (±3.6) in height with 52% canopy cover on RABR. There were many openings covered with low, herbaceous growth (more at NDPO). NDPO was crossed by three narrow ski trails, while RABR contained one narrow ski trail and a hiking trail. Neither site was considered enriched. The understory was richer at the NDPO, but RABR contained more moss, probably because of its more open canopy (Table 3). Both areas are dominated by balsam fir but NDPO has a higher density with a sizable mix of heart-leafed paper birch (Table 4). Red spruce were scattered and generally small on both sites. NDPO had more spruce, while RABR had larger, although not especially old, trees. The total basal area of 29 m^2/ha on NDPO was about 2/3 that expected of a well developed subalpine forest in the region, while the 24 m^2/ha at RABR reflected that site's more open, distinctly glade-like vegetation over shallow soil on rock ledges (Table 5). Dynamics seen in dead trees were prominent at both sites. RABR had the expected 1:1 ratio of dead to live trees, but NDPO was closer to a 1:2 ratio, indicating its relatively younger and aggrading forest. Both sites were significantly disturbed (distinctly second-growth), most probably by cutting 90 to 110 years ago, and RABR supported a cohort of 60-70 year old trees.

An ordination of the understory vascular flora from 59 subalpine sites that have been sampled in Vermont, New Hampshire, and New York place the two sites within the middle, with the NDPO being toward the wet-mesic end and RABR being toward a slightly higher elevation affinity. A classification (TWINSPAN) of these sites placed both together with many other sampled sites in the Green Mountains, particularly nearby Bolton Mountain. RABR was joined with the Mt. Abraham site at 1,040m elevation while the NDPO site stood alone but close to lower elevation sites such as those on Bolton Mountain at 975m and 1,040m, on Camel's Hump at 914m and on Jay Peak at 975m. Thus, the understory flora seems routine for the Green Mountains and at the expected position (mid-subalpine) based on an elevation gradient. RABR seems to be a higher, lee slope, snow bank system while the NDPO seems to be a lower slope, mesic system. A list of all vascular plants found on each plot and areas of similar elevation on the western side of Mt. Mansfield are found in Table 6.

We believe that the tenuous conservation status of Bicknell's Thrush, combined with the paucity of avian population data in subalpine spruce-fir habitats and increasing development pressures in these habitats throughout Vermont and the Northeast, argue strongly for careful, long-term impact assessment studies. Our current plans, while contingent on Act 250 approval and actual implementation of the Nose Dive Pod expansion plan, involve a minimum six-year follow-up study to evaluate potential impacts of the proposed development on breeding bird populations and the subalpine habitat. While we hope that data collection on both plots will extend well beyond the six years following proposed construction activities, we believe that this time frame is a minimum for performing a meaningful evaluation of the ecological effects of ski area development.

Table 4. Overstory tree (>5cm dbh) density and basal area (m2/ha) from 10 x 10m plots on the NDPO study area (n=27 plots) and RABR (n=30) Mt. Mansfield, Vermont, 1995.

Species	Live				Dead			
	stems/ha		m2/ha		stems/ha		m2/ha	
	NDPO	RABR	NDPO	RABR	NDPO	RABR	NDPO	RABR
Abies balsamea	904	1350	15.31	16.80	270	801	8.09	17.80
Betula cordifolia	367	340	10.15	4.75	130	111	3.55	1.76
Picea rubens	215	150	2.93	1.72	82	73	3.59	4.17
Pyrus americana/decora	63	66	0.74	0.39	0	0	0	0
Prunus pensylvanica	7	10	0.02	0.06	0	0	0	0
Betula alleghaniensis	0	0	0	0	11	3	0.27	0.01
Total	2915	29.15	493	15.5	1920	23.72	986	23.71

Table 5. Basal area (in m²/ha of trees, >5 cm dbh) in 100m² sample plots on NDPO and RABR, Mt. Mansfield, Vermont, 1995.

Plot Location	Balsam Fir		Mt. Birch		Spruce		Mt. Ash		Pin Cherry		m^2/ha	
	NDPO	RABR	NDPO	RABR	NDPO	RABR	NDPO	RABR	NDPO	RABR	NDPO	RABR
1A	0	24.7	0	3.4	0	0	0	0	0	0	0	27.9
1C	0.87	29.1	4.59	10.1	3.68	0	0.67	0	0	0	9.81	39.2
1E	13.7	26.4	0	3.1	0	0	0	0	0	0	13.7	29.5
1G	9.04	11.1	24.28	.3	1.74	.3	0	0	0	0	35.06	11.7
1I	1.15	11.2	7.69	1.6	15.43	2.0	0	0	0	0	24.27	14.7
1K	2.45	34.2	8.15	2.0	0.28	1.8	0	0	0	0	10.88	37.9
3A	24.78	41.5	17.14	3.5	0	1.8	0	0	0	0	41.92	46.7
3C	7.74	26.2	0	0	25.38	0	0	0	0	0	33.12	26.2
3E	12.13	8.1	8.33	1.0	4.59	0	0	0	0	0	25.05	9.1
3G	28.67	33.8	5.73	3.2	0.95	.8	0	0	0	0	35.35	37.8
3I	13.38	36.7	0	5.0	2.54	0	0	0	0	0	15.92	41.7
3K	31.6	16.1	24.63	3.6	1.02	0	0	0	0	0	57.25	19.7
5A	10.21	9.0	8.55	3.3	0.7	.3	1.13	0	0	0	20.59	12.7
5C	5.32	1.7	7.38	.6	0	0	0	0	0	0	12.7	2.4
5E	0	13.9	.20	4.9	0	0	0	0	0	0	.20	18.8
5G	21.18	11.9	13.2	0	6.19	15.6	0.2	0	0	0	40.77	27.6
5I	28.55	6.3	11.34	2.3	0	3.0	0	0	0	0	39.89	11.6
5K	28.14	4.4	5.26	4.5	0.95	0	0	0	0	0	34.35	8.9
7A	9.26	15.0	17.55	8.1	0.5	0	0	.9	0	0	27.31	24.0
7C	0	12.6	.90	10.6	0	0	2.5	.3	3.7	0	7.1	23.5
7E	14.29	29.2	18.21	7.8	0.38	0	0	.4	0	0	32.88	37.4
7G	28.41	9.3	0	4.7	0.48	2.0	0	.4	0	0	28.89	16.3
7I	14.76	17.9	10.75	.5	9.08	.4	0.38	.2	0	1.3	34.97	20.3
7K	0	12.4	0	6.9	0	5.6	0	0	.9	0	0.9	24.9
9A	21.61	8.2	9.7	7.4	0.38	3.1	1.15	5.4	0.57	0	33.41	24.2
9C	8.44	9.4	3.55	29.9	0.28	3.9	3.46	0	0	0	15.73	43.2
9E	10.19	18.1	16.48	2.9	2.75	1.2	8.91	0	0	0	38.33	22.1
9G	12.24	7.2	12.27	5.3	0.67	1.5	3.46	3.5	0	.5	28.64	18.0
9I	27.9	13.7	7.8	6.3	0.92	2.8	0.2	.8	0	0	36.82	23.6
9K	12.11	4.7	18.33	0	0	5.5	0.39	0	0	0	30.83	10.3
All Plots	15.3	16.8	10.2	4.7	2.9	1.7	0.7	.4	0.02	.1	29.15	23.7

Table 4. Species list from the NDPO and RABR 20 ha study areas and the Vermont Monitoring Cooperative studies from the west side of Mt. Mansfield, Vermont at comparable elevations.

Species	NDPO	RABR	West Slope
Abies balsamea	p	p	p
Acer saccharum	p	p	
Acer pensylvanicum	p	p	p
Acer rubrum	p	p	
Acer spicatum	p	p	p
Aralia nudacaulis	p	p	p
Aster acuminatus	p	p	p
Aster punicius	p		
Athyrium felix-femina	p	p	
Amelanchier bartramiana	p		
Betula alleghaniensis	p		
Betula cordifolia	p	p	p
Rumex acetocella	p		
Carex arctata	p	p	
Carex debilis		p	
Carex disperma	p	p	
Carex brunnescens	p	p	
Carex trisperma	p	p	p
Carex intumescens	p	p	p
Chysoplenium sp.	p		
Chelone glabra	p		
Cinna latifolia?	p		
Clintonia borealis	p	p	p
Coptis groenlandica	p	p	p
Cornus canadensis	p	p	p
Deschampsia flexulosa		p	
Diervilla lonicera	p		
Dennstaedtia punctiloba	p	p	p
Drosera rotundifolia	p		
Dryopteris campyloptera	p	p	p
Dryopteris disjuncta	p		
Dryopteris phegopteris	p	p	p
Fagus grandifolia	p		
Habenaria dilatata		p	
Gaultheria hispidula	p	p	p
Glyceria melicaria	p	p	
Lycopodium annotinum			p
Lycopodium lucidulum	p	p	p
Lycopodium clavatum		p	
Lycopodium obscurum		p	
Maianthemum canadense	p	p	p
Medeola virginiana	p		
Monotropa uniflora	p	p	p
Nemopanthus mucronata		p	p
Oxalis montana	p	p	p
Osmumda cinnamonea	p		
Osmunda claytoniana	p	p	
Picea rubens	p	p	p

Table 4. Continued.

Species	NDPO	RABR	West Slope
Picea mariana			p
Prunus pensylvanica	p	p	p
Polypodium virginianum	p	p	
Prunus serotina			p
Pyrus americana	p	p	p
Pyrus decora	p	p	p
Ribes glandulosum	p	p	p
Rubus idaeus	p	p	
Rubus allegheniensis			p
Rubus pubescens	p		
Sambucus pubens	p		
Salix bebbiana	p		p
Solidago macrophylla	p	p	p
Streptopus amplexifolius	p	p	
Streptopus roseus		p	
Thalactrium polygamum	p		
Trientalis borealis	p	p	p
Thelypteris novaborensis	p	p	
Tsuga canadensis	p		
Trillium erectum	p		p
Trillium undulatum	p	p	p
Vaccinium angustifolium	p	p	p
Veratrum viride	p	p	p
Viburnum alnifolium	p		
Viburnum cassinoides		p	
Viola incognita	p	p	
Total Number of Species	62	50	36

Future Plans

In 1996 we will collect a second year of pre-treatment data. We will spot map all breeding bird species on each plot during the month of June. Contingent upon funding availability, we wish to expand studies of possible ski area impacts on the breeding bird communities by establishing 10-20 ha plots on Stratton, Killington, and Burke mountains. Field protocols would be the same as those on Mt. Mansfield plots.

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Literature Cited

Gates, J.E. and L.W. Gysel. 1978. Avian nest dispersion and fledging success in field-forest ecotones. Ecology 59(5): 871-883.

Robbins, C.S. 1970. An international standard for a mapping method in bird census work recommended by the International Bird Census Committee. Audubon Field Notes 24: 722-726.

Whitcomb, R.F., C.S. Robbins, J.F. Lynch, B.L. Whitcomb, K. Klimkiewicz, and D. Bystrak. 1981. Effects of forest fragmentation on avifauna of the eastern deciduous forest. *In* R.L. Burgess and D.M. Sharpe, eds. Forest Island Dynamics in Man-dominated Landscapes. Springer-Verlag, New York. Pp. 125-205.

Wilcove, D.S., C.H. McLellan and A.P. Dobson. 1986. Habitat fragmentation in the temperate zone. *In* M. Soule, ed. Conservation Biology: The Science of Scarcity and Diversity. Sinauer Assoc., Inc., Sunderland, MA.

Historical Ecology of the Upper Stevensville Brook Watershed, Underhill, Vermont

A report for the
Vermont Department of Forests, Parks and Recreation
and
Vermont Monitoring Cooperative

Charles V. Cogbill
June 1996

Introduction

This report is a preliminary land use history of the upper Stevensville Brook in Underhill, Vermont. Most of the tract is mountain timberland and the cultural history concerns logging and associated activities. The information in this report is based on diverse sources, including:

- published articles (especially local history and town reports);
- archival records (especially deeds, censuses, and contracts);
- maps (especially cadastral, land survey, topographic, geologic, and historic);
- state files;
- interviews with land managers,
- and knowledge of local natural history, historical ecology , and regional land-use history.

Significantly there was only a cursory on-site reconnaissance and detailed archeological, forestry, and ecological research must still be done on the ground, before the full history of this site is revealed. Despite being necessarily incomplete, the collation of existing information done here forms a clear basis for evaluating changes over the past 150 years and interpreting the current conditions of the site. Fortunately the dominant land uses at this site are straight forward. Mansfield was a mountain town with little land appropriate for farming. Economically it depended on its forests and processing of the timber at sawmills in nearby towns. Thus it was culturally (later politically) linked to adjacent towns of Underhill and Jericho. This history is an investigation of the activities of timberland owners (sometimes timber barons), and their effects on their ownership.

Location

Upper Stevensville Brook drains the middle and upper slopes southwest of the Forehead on the Mount Mansfield massif. The watershed covers approximately 1000 acres, with roughly one-third above 2500 feet elevation. Its center is located near 44°31' N Latitude 72°50'W Longitude and is underlain by schists of the Underhill Formation. It is a well-eroded but steep west-facing bowl, rimmed with rough cliffs on Maple Ridge to the northeast and gentler slopes on Mount Dewey on the southeast. It extends from 1400 feet elevation just below the junction of the two branches of Stevensville Brook up to the main ridgeline of Mount Mansfield. The highest elevations range from 3950 feet on the

Forehead in the north through a col (Needles Eye) at about 2700 feet to Dewey Mountain at 3370 feet on the south.

Administration and Current Use

The entire area lies within the defunct town of Mansfield, Vermont. Most of the area was annexed in 1839 by Underhill in Chittenden County, while a small piece of the northeast corner near the Forehead later became part of Stowe in Lamoille County. Since 1929 virtually all the area has been owned by the State of Vermont and administered by the Department of Forest Parks and Recreation as part of the Mount Mansfield State Forest. The area north of Stevensville Brook is Compartment #3 and to the south of the brook is Compartment 2 of the Underhill Block of the Forest. Two small (roughly 40 acre) parcels border the western edge of the area along Stevensville Brook; the southern one was bought by the state from J. Marsh in 1992 and the northern one is still privately owned (by R. Smith in 1990).

Direct access to the area is by Stevensville Road which runs 2.8 miles due east from Underhill Center ending at a trailhead parking lot on the south bank of Stevensville Brook in the western (lowest) corner of the area. The three-season public road ends, but a private spur extends north across a bridge to access the Smith property. A main "[logging] truck road" also continues from the parking lot along the south bank of the Stevensville Brook, then crosses the South Branch and continues about one-half mile southwest to a log landing on the unnamed (Nettle Brook?) tributary of the South Branch. Remnants of the old road to Stowe through Nebraska Notch crosses the south west corner of the property and is now connected with the parking lot by the Nebraska Notch hiking trail. Two other trails leave from the same trailhead: the Frost Trail which follows Maple Ridge to the Forehead and the Butler Lodge Trail. The latter goes to a Long Trail hiking cabin at 3020 feet high in the watershed below the Needles Eye. A designated camping area (Twin Brooks Tenting Area) is off the Long Trail at 2200 feet in the upper reaches of the South Branch. Entering the watershed at 2100 feet on the south is the Long Trail, which climbs to Needles Eye and then follows the spine of the Mount Mansfield over the Forehead. Several other foot trails (Wallace Cutoff, Rock Garden, and the Wampahoofus Trails) also traverse the watershed at high elevations and connect the main routes. Finally in the 1930s there was a project to build a road from Halfway House in the Browns River drainage to the north to Nebraska Notch in the Clay Brook drainage to the south. This "CCC road" was never completed in the Stevensville drainage, but the cleared right-of-way crosses the watershed between 2000 to 2200 feet. The area is also laced with old skid trails and is used much for both summer and winter dispersed recreation. The area is also used for ecological research as a designated research site of the Vermont Monitoring Cooperative.

Land Use History

Prehistory

There is little evidence that the land in the Stevensville drainage was affected to any extent by native populations. It is probable that there was some fall hunting in the region. The mountain must have been a special place to the Abenaki, and stories of ascents could easily have included routes along Maple Ridge. Additionally it is very likely that

Abenaki used the trail through Nebraska Notch to travel. In fact, the stories of the burial of "Indian Joe's " father in the Notch indicate use and reverence for this place.

Presettlement Forest

The Town of Mansfield was granted by Benning Wentworth, the royal governor of New Hampshire, as one of his "New Hampshire Grants" in 1763. The first evaluation of the forests on Mount Mansfield came in 1772 when Ira Allen and Capt. Baker surveyed the town of Mansfield. Allen, who by then owned one-third of the 64 proprietory rights in the town, reported in his autobiography that:

> A great proportion of the corners of said lots were made on spruce or fir timber, and if I described them as such, it would show the poorness of the town, and raise many questions that I wished to avoid. I made use of a stratagem that answered my purpose. In my survey bills, I called spruce and fir gum-wood, a name not known by the people of Sharon (the place where the proprietors lived). They asked what kind of timber gumwood was. I told them tall Straight trees that had a gum, much like the gum on cherry trees &c.

Allen sold his property, but subsequent owners were unsuccessful in settling Mansfield, so the town lay unused. (Hagerman 1975). In August, 1786, "Mr. Coit" , a surveyor for the State (republic) of Vermont, surveyed the west boundary of Mansfield. Along the 6 mile length of this outline, which passes through Stevensville village, he marked 2 spruce and 3 beech mile trees (Vt. State Archives). This presettlement composition in the Stevensville Brook drainage was confirmed by a more extensive survey of witness trees at corners of lots made above 1500 feet during the 1804 lotting of Mansfield into 100 acre lots (Table 1). A more general estimate combining witness trees on the west slope of the Green Mountains in Bolton, Underhill and Mansfield around 1800 shows a mixed hardwood-spruce forest (Table 1). The original composition of the Stevensville region forest clearly shows a strong dominance (50% to 60%) of beech, with 33% spruce. Remarkably few trees of other species were found with birch (presumably yellow) following beech, but little maple, hemlock, or ash. There was an elevational trend from hardwood dominated (but mixed spruce) forests below 2500 feet to conifer (spruce and fir) domination at higher elevations (Siccama 1963).

Settlement Period (1789-1836)

Underhill was settled in 1789, but there was little activity in Mansfield. The town of Mansfield was not organized until 1815 and following first settlement in 1799 grew on the Stowe side of the mountain. According to a Stowe history: "...no mention has been made of residents on the western slope[of the town of Mansfield]" (Bigelow 1934). In fact, the Underhill side of the mountain was lotted and treated exactly the same as the Stowe side. The lots on the west were owned and sold by Underhill residents and there were several lots that were cleared for settlement across the Mansfield line. Thus activities on the west slope were connected to towns on the west and in 1839 the area roughly west of the main ridge was annexed to Underhill.

In 1804 all of Mansfield was divided into lots drawn to the rights of the original proprietors. The Stevensville Brook drainage consisted of parts several of these generally 100 acre lots (mostly within #139/2division; #58/2div; #125/2div; #126/2 div; #127/2div.;

#20/3div; #138/2div; #61/4d; and #2 through 10/4d) (see Fig. 3) Still associated with an owner (mostly an absentee proprietor with no real interest), the lots were not used and effectively unowned (Table 2). During the next 20 to 30 years the lots near the Underhill line were obtained, usually at vendue sales (for back taxes) by nearby residents. Thus people such as Jonathan Lee, Josiah Brown, Azarius Williams, and Almus Ward owned the lower stretches of Stevensville Brook. In fact, in 1830 Ward had made "a small improvement or clearing" (MLR 3:288) on lots #125 and 126, the area at the end of the current Stevensville Road. Thus there were preliminary agricultural attempts on the western side of Mansfield, but the dominant ownership was the accumulation of the rights to over 3000 acres on the mountain by Asa Williams (MLR 3:170).

First Cutting Period (1836-1865)

As the market for lumber spread with the increase in Vermont population in the early 1800s, the spruce timber on the easily accessible west slope of Mount Mansfield together with the availability of water power drew the interest of businessmen. In 1836, A. Williams sold his forest land including the Stevensville drainage to David Read of St. Albans who accumulated acres and took on partner J. Wheeler of Burlington for his self-estimated 15,000 in the region. To solidify their claim Wheeler and Read had a survey done of their land and the return of the survey confirmed ownership of 8376 acres in Mansfield(MLR 3:254/5). Then in 1838 these entrepreneurs bought some fields belonging to J. Lee and J. Brown on lot #58 (near Maple Leaf Farm) in Underhill. By 1840, they built a sawmill on the Underhill property. Read and Wheeler sold interest in the mill together with 3500 ac of land to H.P. Hickok (2/3 share), a lumber businessman from Burlington. He took on L.M. Stevens (1/3 share) as a junior partner, and Stevens moved to Underhill Center in 1843 to found the logging village of Stevensville and manage the Underhill mills (Anon. 1992).

Apparently the Hickok and Stevens partnership built a second sawmill just over the Mansfield line on lot #126. In 1849, their water powered mills cut 300 thousand board feet (Mbf) of lumber , obviously from spruce cut off their land in the Stevensville Brook drainage in Mansfield (1850 U.S. Manuf. Census). In 1856 Hickok and Stevens rented the upper mill to C.H. Woodsworth for 8 years and they agreed to "provide spruce for 4 years to stock the sawmill with logs to amount of 400 logs [roughly 100 Mbf] per year if required to do so" (ULR 16:250). Hickok and Stevens also leased their land to be harvested by local farmers, but "such as timber not to be cut faster than the land is fitted for cultivation" (ULR 16:252). By the end of the 1850s Stevensville had two saw mills, a shingle mill, a measure factory, and 30 families working in the sawmill, woodworking industries (peck measurers, cheese and butter boxes) or in the woods. In 1859 the Hickok and Stevens sawmill, with one circular and one upright saw, cut 60M feet of boards and box materials from "600 [~150 Mbf] spruce logs" (U.S. Manuf. Census 1860). This seems to have been the high point of activity at the upper mill, as in 1864 Hickok and Stevens sold much of the mill lot and adjacent land to Hiram Hicks. In 1865 Stevens moved to Jericho apparently signaling the end of the Stevensville community. Hicks moved to the farmhouse on the property and apparently farmed the area which would become the Marsh property. Ownership of the mountain property became unclear at this time and Hickok and Stevens perhaps abandoned claim to the now cut over (for merchantable spruce that is) land.

Quiet Period (1865-1889)

From 1865 to 1879 was relatively uneventful in Stevensville Brook, several farmers (e.g. H.Hicks, Peter Laflache, J. Papineau, and D. Wells) lived on small farms at the end of the Stevensville road, but several worked in woodworking industries (e.g. Papineau was a cooper). The Tillison steam mill in Underhill Center was running in 1869 producing 20 Mbf of lumber and 320M shingles (1870 U.S. Manuf Census). The mill industry did not expand until after the railroad reached Underhill in 1877. At this same time large steam mills were built in town, one each in Underhill Flats, North Underhill, Pleasant Valley, with a combined capacity of 4500 Mbf (Child 1882, Dwyer 1976). L.O. Horton took over the mill at Underhill Center and produced clapboards, hardwood and spruce lumber, and flooring from 1000M/yr of logs(Child 1882). There was obvious diversification, use of external markets and a great increase in demand for timber, including some for hardwoods. Some wood must have come from Stevensville Brook, but ownership of this area was not cleared until 1879 when Hickok and Stevens finally disposed of their mill property in Stevensville. Soon after in 1880 Anson Field bought the remaining rights to "Mansfield Mountain Land" of 2000 acres from the heirs of J. Wheeler.(ULR 21:574; 21:390). Nine years later Field sold the 2000 acres to L.F. and G.E. Terrill who were merchants and lumber manufactures from Underhill Center.

Second Cutting Period (1889-1898)

After the sale to the Terrill brothers, the 2000 acres of Stevensville Brook drainage was subject to heavy cutting as D.L. Terrill had leased Bicknell's sawmill with its 500M/year capacity on the Browns River (Child 1882). From 1892 to 1897 the stumpage rights in the Browns' River drainage on Mount Mansfield passed through various loggers. In 1897 the Terrills bought the stumpage of "all timber both hard and soft standing, lying of growing forever on land" (ULR 25:355) in the Browns River drainage, just north of Stevensville Brook. Together with logger G.M. Knight, who operated the steam mill in Underhill Flats, Terrill cut up to 50M/day in 1897 feeding 1000M of softwood and 600 Mbf of hardwood to this and thousands of board feet to mills as far as Burlington (Dwyer 1976). This was a short intense cut as the next year Terrill sold his operation to W.H. Martin of Royalton, Vt. the 2100 acres and "all the timber and right of stumpage" in the Stevensville Brook (25:451).

In the meantime the residents at the end of the Stevensville Road continued small scale farming. Apparently crops were produced until at least 1901 (26:129) and the area was in open hay fields from 1912 (26:199). A 1915 map shows a small area of "tillage" between the branches of Stevensville Brook and pasture and fence line around the Lebarge, erstwhile Hicks, farm.

Third Cutting Period (1904-1929)

W. H. Martin moved to Underhill, but within six years he sold out to C.H. Green who in turn passed the 2100 acres of "wild land" and stumpage to Champlain Realty Company (a subsidiary of International Paper Company) (26:112, 26:422). In general logging in the old town of Mansfield continued to feed the mills of Underhill as in 1905, the "surrounding hills are rich in both hard and soft wood and the leading industry of [Underhill] is the sawmill and lumber business of which D.W. Knight gets out 2 million feet of lumber each season, besides handling large quantities of wood and small lumber for shipment to other mills (Expansion 3(1):1).It is unclear how much timber Champlain had cut, but its long ownership, other regional operations, and indications of growth releases in tree rings dating from the 1920s (P. Hannah, pers. comm.), all indicate extensive cutting. A 1915 map showed second growth hardwood, presumably resulting from early farm clearance, in the vicinity of the Marsh property and up to 1800 feet between the tributaries of the South Branch. Above this zone was a broad area of culled hardwoods (hardwoods with the former spruce removed) and above about 2800 feet spruce reproduction and balsam from cutting of coniferous forest. Only at the highest elevation above about 3200 feet was there no cutting a forest described as "old growth spruce and balsam" (1915 type map). Significantly most of the area to the north of Stevensville Brook (Compartment 3) was labeled as "burn" in 1915 and "old clear cut (burn)" in 1966. These areas probably resulted from the extensive fires in 1903 or 1908, which raged, especially in previously cut stands. Here the burn occurs down to 1600 feet and is bordered by unburned culled hardwoods.

<u>State Ownership</u> (1929-present)

In February 1929 Vermont acquired approximately 1238 acres from Champlain Realty Co. (29:493). Since that time there have been several harvests in the watershed, but records before 1971 are skimpy. There are indications of a thinning release in the 1930s in several areas (P. Hannah, pers. comm.). The lower elevation and unburned area north of Stevensville Brook and much of the area south of the brook in compartment #3 were improved by the girdling of culls and the removal of "old residuals". The volume in this stand in 1971 was 4.4 Mbf/acre (83% sugar maple) with 0.14 Mbf/acre•year growth. In 1983 55 acres of this area south of Stevensville Brook was thin-harvested, removing 66 Mbf and 285 cords (FPR records, Essex).

Compartment #2 was more extensively managed than #3. In the winter of 1956 a "Lavanway" conducted a harvest, logging between the North Branch and the tributary (Nettle Brook?) of the South Branch (northern third of compartment #2) of Stevensville Brook (FPR records, Essex). From 200 acres, including this area, the Stevens Brook South Sale removed 141.8 Mbf and 496 cords in 1983 to 1985. In addition from 1977 to 1979, 300 cords were cut ; in 1981 152 Mbf and 100 cords of tops were removed as salvage from 140 acres from the area around the two branches of the South Branch(FPR records, Essex). In total, virtually the entire area below (west of) the Long Trail, and a section of shelterwood logging up to 2700 feet around the Needles Eye, have been harvested during the past 20 years. The only area not to receive any management activity is the high elevation on Dewey Mountain and the burned, old cutover, and stunted growth above about 2200 feet in the "natural area" on the upper slopes of the Forehead.

<u>Summary of Land Use</u>

The upper Stevensville Brook drainage has been intensively used for forest production for about 150 years. The lowest reaches of the valley near the confluence of the two branches was an early sawmill privilege and the site of several small farmsteads in the 1800s. Activities associated with these properties extended up to about 1700 feet elevation and included clearance for cultivation and pastures and the cutting of woodlots beyond for farm consumption. The vast majority of the watershed, however, was used exclusively for timber production, initially feeding the local water-powered mill and then larger steam mills in Underhill and Jericho. Through time, separate ownerships of this timberland, which was always held as a large block following the drainage, corresponds to four periods of logging interest (see sections above, Table 3). Hickok and Stevens did an initial cut for spruce; Terrill Bros. did a short and intensive cut of the remaining softwood; Champlain Realty began the removal of hardwoods; and the Vermont Department of Forests has actively managed the site for continued production through site improvement and periodic harvests of both hardwoods and softwoods. Although all operations were substantial, evidently only in the Terrill operation did the removal rate exceed the growth replacement of these forests (Table 3).

Overall an estimated 10 million board feet (roughly an average of 10 M/ac) was removed from the valley over 150 years. The majority of this timber was spruce, although hardwood harvests became more prevalent in the 1900s and are predominant today. Thus most of the merchantable spruce has been removed although there are residual spruce trees almost 300 years old in the watershed (P. Hannah, pers. comm., B. Engstrom pers. comm.). Interestingly most of these old trees at lower elevations show releases or initiation 130 years ago, indicating that the prime spruce sites were harvested in the first cuts. Although most of the spruce and fir is now found above 2500 feet , there are environmental limitations (i.e. Act 250) on harvest. The only area unaffected by logging (old growth?) is the stunted and windswept fir and occasional spruce at the highest elevations on Dewey Mountain . Culled hardwoods at middle elevations had spruce removed, but still have scattered large hardwood trees, especially yellow birch, holdovers from the original mixed woods on the slopes. Except for the area burned in the turn of the century fires (regenerating to birch?), most of the area is productive and currently sustains an estimated 5M/ac, albeit the result of 150 years of selective harvests.

Table 1. Presettlement surveys (1786-1804) with % witness trees on corners of lots on the west slope of Mount Mansfield in parts of Underhill, Bolton and Mansfield (data from Vermont Surveyor General's records in State Archives; Proprietors Books; and Siccama 1963).

	Mansfield >1500'	3 towns west slope
trees n=	59	151
Beech	61	34
Spruce	32	32
Birch	3	12
Maple		7
Hemlock	3	4
Fir		4
Ash		3
Str. Maple		2
Cherry		1
Ironwood		1

Table 2. Chronology and ownership (transfer arrows from grantor to grantee indicate documentation from Underhill or Mansfield Town Land Records) of the mountain land within Stevensville Brook drainage, Underhill, Vermont. Brackets indicate owners without information on clear transfers.

1789	Underhill settled
1792	
1796	
1799	first settler in Mansfield
1804	Lotting survey of Mansfield
1808	
1812	
1816	
1820	
1824	
1826	
1830	{Lee and Brown} ↓
1836	Wheeler and Read ↓ (survey return of 8376 ac)
1840	Hickok and Stevens (3500 ac and mill)
1844	
1849	west part of Mansfield annexed to Underhill
1853	{Cook and Ballard}
1856	
1858	
1862	
1865	Stevens sells out and moves to Jericho
1870	
1874	
1876	
1880	A. Field [mortgage foreclosure by Wheeler]
1884	↓
1889	D.L. Terrill (2000ac)
1892	↓
1898	W.N. Martin ↓ (2100 ac)
1900	C.H. Green ↓ (2100 ac)
1904	Champlain Realty (2100 ac)
1908	
1912	
1916	
1920	
1924	
1929	State of Vermont (1238 ac)
1932	
1936	
1940	
1944	
1948	
1952	
1956	
1960	
1964	
1968	
1972	
1976	
1980	
1984	
1988	
1992	
1996	

Table 3. Logging intensity associated with Stevensville Brook , west slope of Mount Mansfield, Underhill, Vermont (data from various archival sources including Underhill Land Records, U.S. Manufactures Census, Childs' Gazetteer, Vermont Forest and Park files). Volumes estimated in M board feet with conversion of 2 cords per M.

Operation	dates	years	area	total cut	cut/year	cut/area	cut/ac•yr
			acres	M	M/yr	M/ac	M/ac•yr
Hickok & Stevens	1841-1865	25	3500	~5000	200	1.4	0.06
Terrill	1889-1898	10	2000	~1500	~750	3.3	0.33
Champlain Realty	1904-1929	26	2100	??	??	??	??
Vermont F&P	1970-1990	20	2000	733.5	36.7	0.37	0.02
Underhill #2	1977-1979	3	140	202	67.3	1.44	0.5
Stevensville N&S	1983-1985	3	255	531.5	177.2	2.08	0.67
						growth	
1971 reference (#3)			155			4.4	0.14

BIBLIOGRAPHY

Anon. 1905 Underhill. Expansion {Vermont Industrial Magazine} 3(1):1

Anon. 1991. They left their mark. Bicentennial committee of Jericho and Underhill.

Beers, F.W. 1869. Atlas of Chittenden County, Vt.. Beers, F.W Co. New York.

Bigelow, W.J. 1934. History of Stowe, Vermont (1763-1934).

Child, H.H. 1882. Gazetteer and business directory of Chittenden County, Vermont.

Dwyer, L. 1976. History of Underhill, Vermont. by the Town of Underhill.

Forest, Parks, and Recreation, Department forestry files, Essex Junction and Acquisition files, Waterbury

Hagerman, R.L. 1975. Mansfield, the story of Vermont's loftiest mountain. Essex Publ. Co. Essex, VT.

Howard, L.D. 1979. Phytosociology and plant succession in the foothills of the Green Mountains, Vermont. Ph.D. thesis Univ. of Vermont, Burlington, VT.

Mackenzie, M.A. 1979. The nature of the presettlement vegetation in the Township of Mansfield, Vermont. A.B. paper in Northern Studies at Middlebury College, Middlebury, VT

Mount Mansfield U.S.G.S. 7.5' quad (1948, revised 1980)

Siccama, T.G. 1974. Vegetation, Soil, and Climate on the Green Mountains of Vermont. Ecological Monographs 44: 325-349.

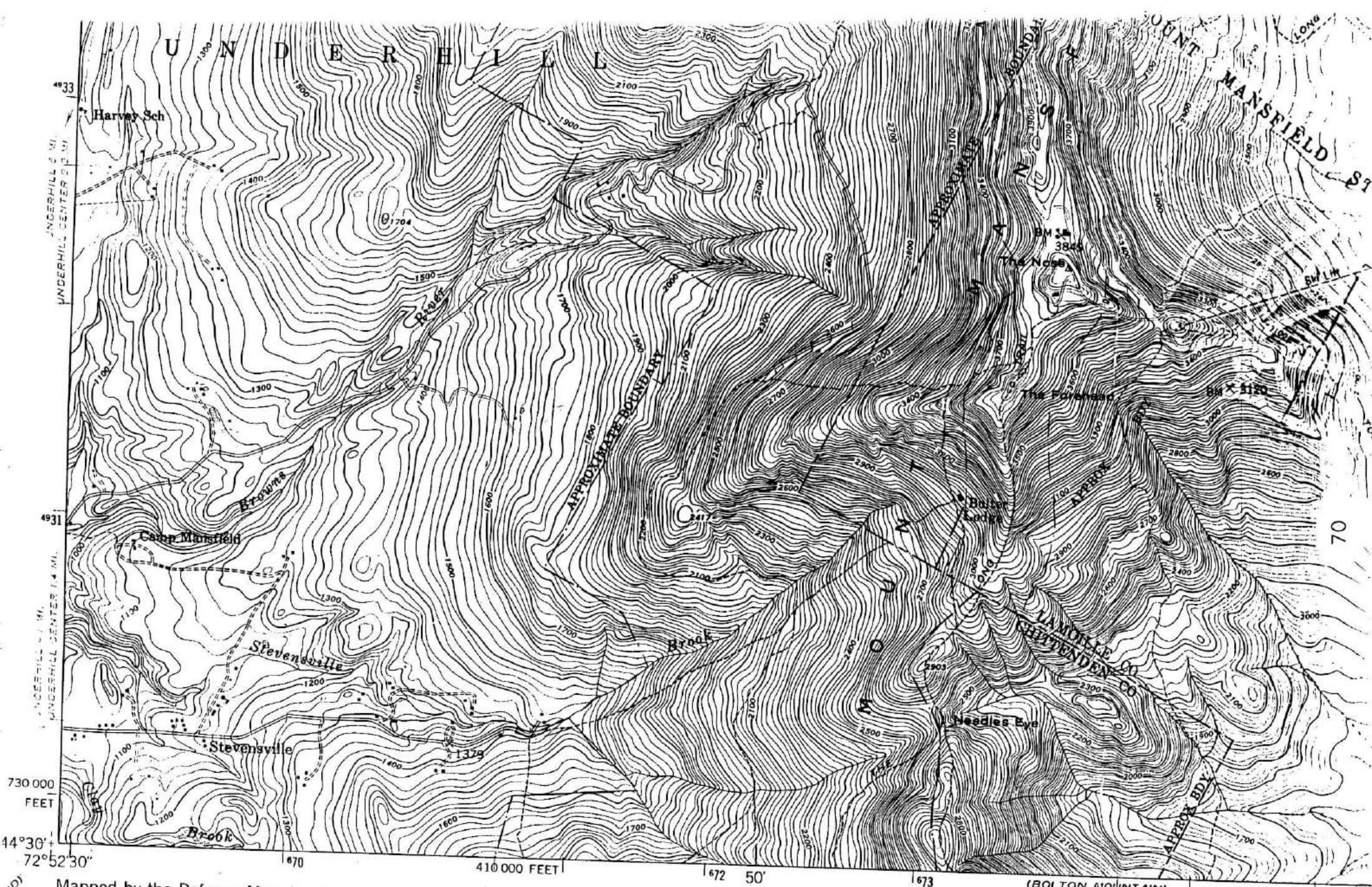
Surveyor General's Papers Vol. 10. in Vermont State Archives, Montpelier, VT

Tax Maps, n.d. Town of Underhill

Thompson, Zaddock. 1853. Natural History of Vermont. Charles Tuttle Co., Rutland, VT. (1982 2nd printing).

Walling's Wall Map of Chittenden Co. 1850

Appendix 1. Maps of Topography, Land Division, and Management in the Stevensville region of Underhill, Vermont.



Mapped by the Defense Mapping Agency
Published for civil use by the Geological Survey

Control by USGS, NOS/NOAA, and USCE

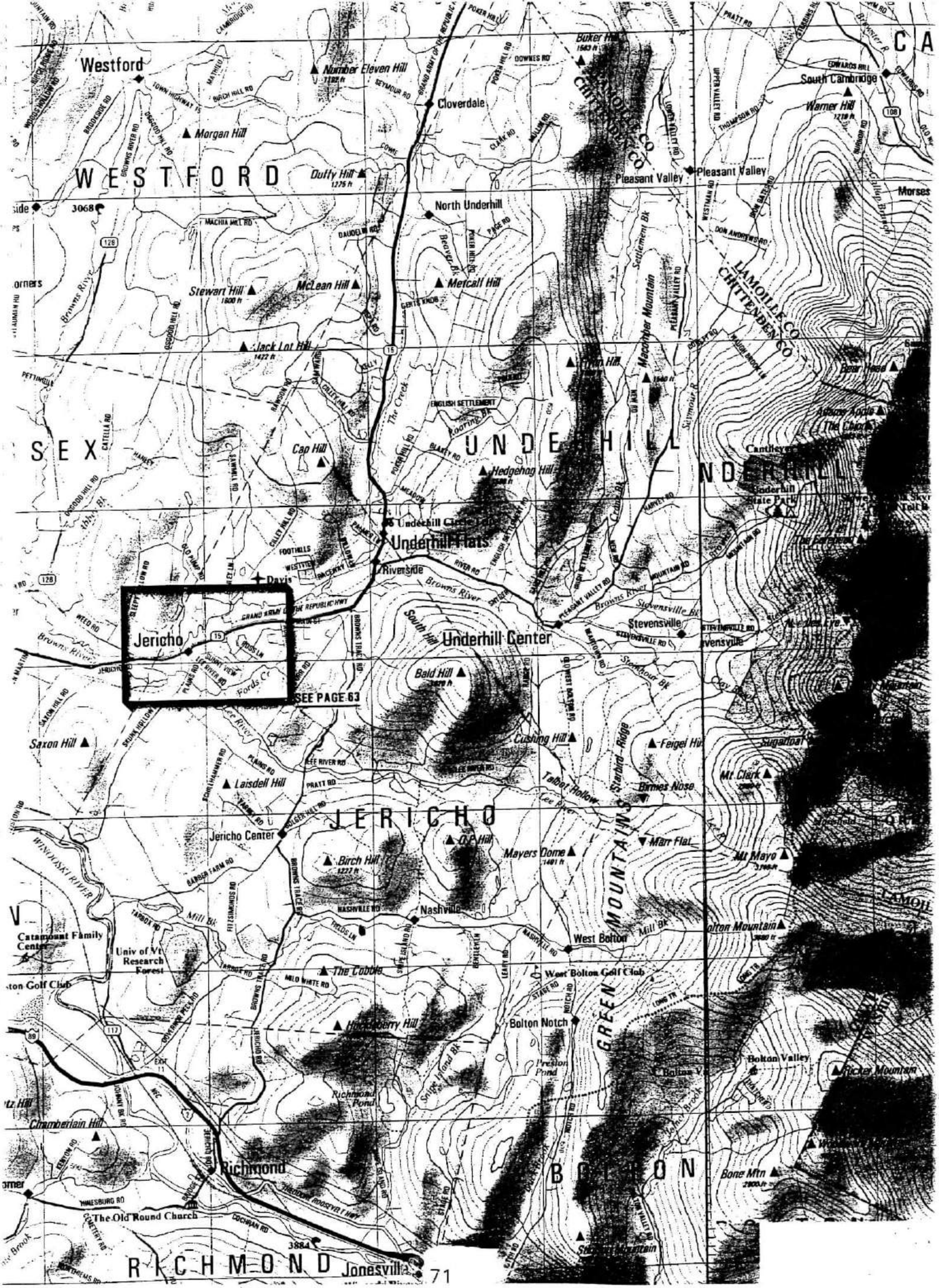
Topography by photogrammetric methods from aerial photographs taken 1947. Field checked 1948

Polyconic projection. 10,000-foot grid ticks based on Vermont coordinate system. 1000-meter Universal Transverse Mercator grid ticks, zone 18, shown in blue. 1927 North American Datum. To place on the predicted North American Datum 1983 move the projection lines

MN GN 15½° 276 MILS 1°32' 27 MILS

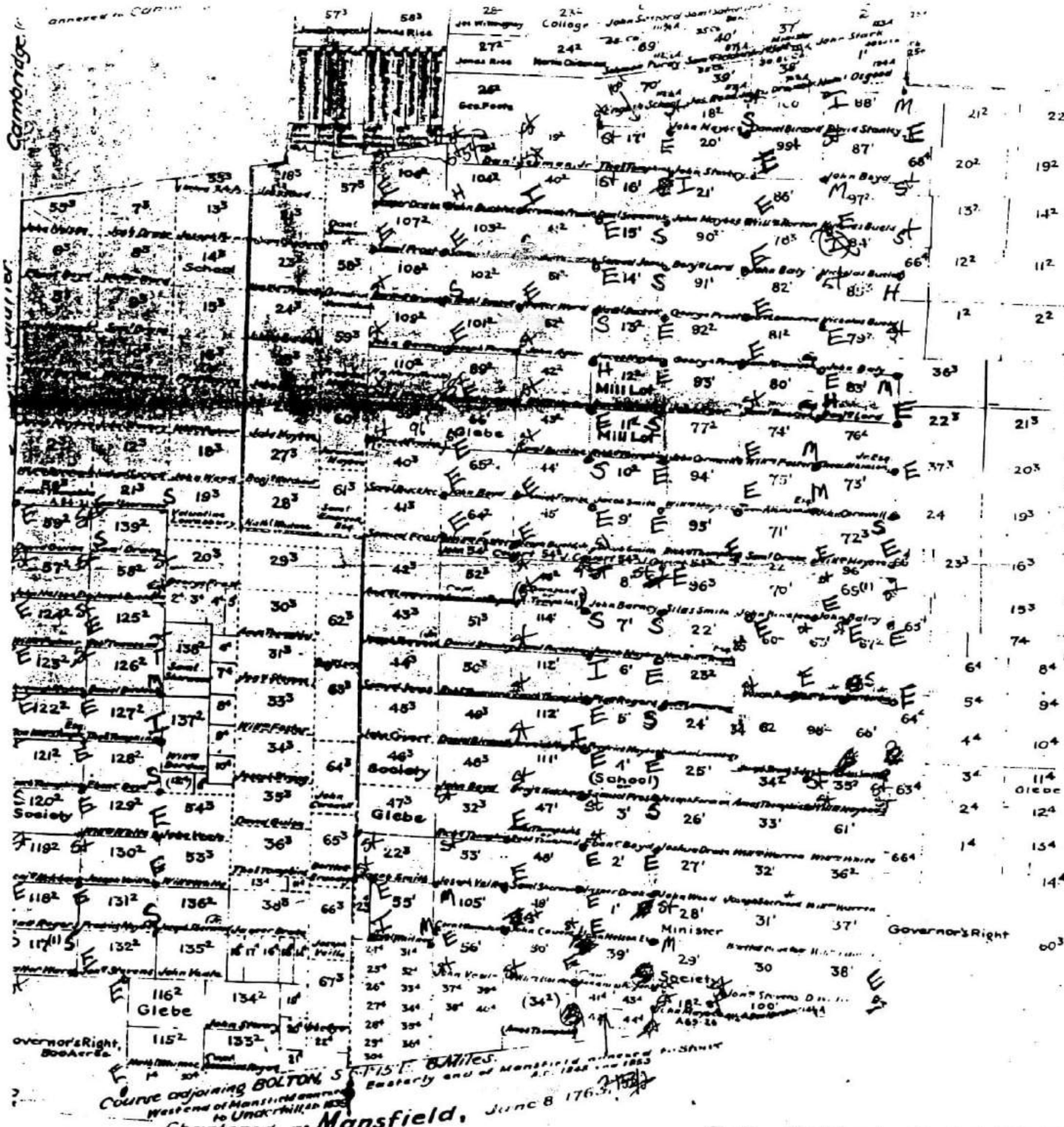
SCALE 1:24 000

CONTOUR INTERVAL 20 FEET

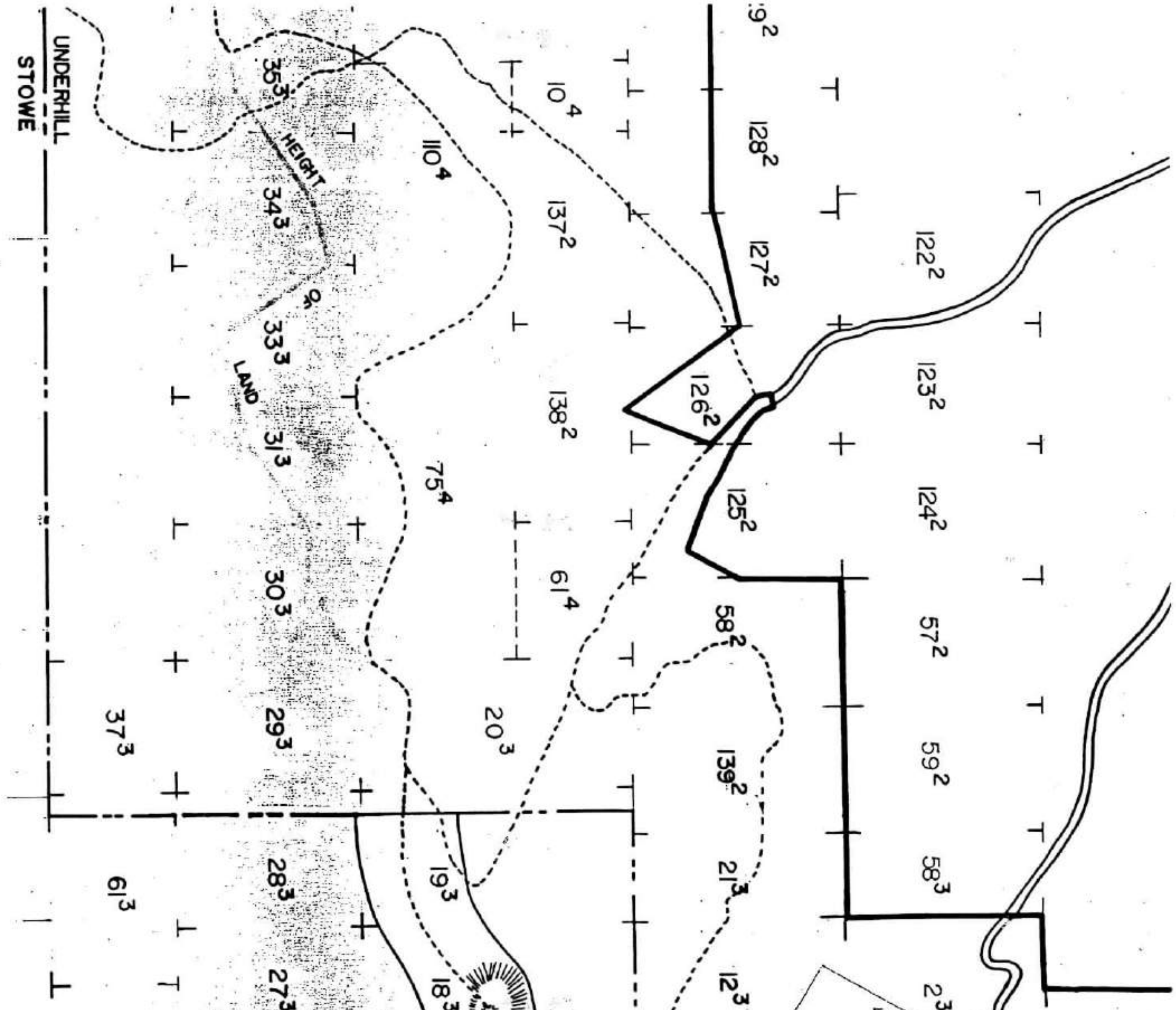


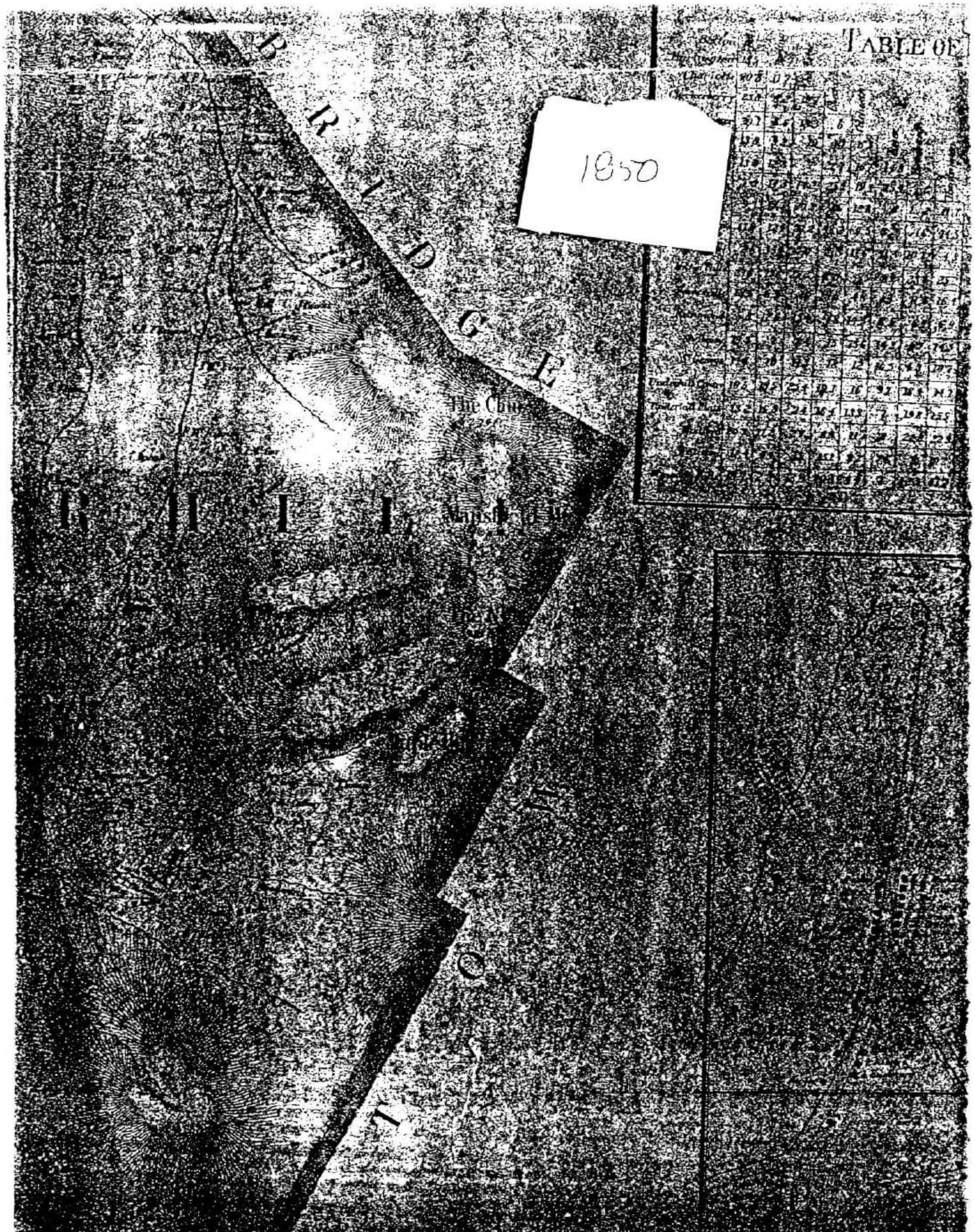
Westford
WESTFORD
Number Eleven Hill
Cloverdale
Morgan Hill
Duffy Hill
North Underhill
Pleasant Valley
South Cambridge
Warner Hill
Stewart Hill
McLean Hill
Metcalf Hill
Jack Lot Hill
Macomber Mountain
LAMOILLE CO
CHITTENDEN CO
Cap Hill
UNDERHILL
Hedgehog Hill
Underhill Flats
Riverside
Davis
Browns River
Jericho
Underhill Center
Stevensville
Bald Hill
SEE PAGE 63
Saxon Hill
Cushing Hill
Feigel Hill
Laisdell Hill
Mt Clark
JERICHO
Jericho Center
Birch Hill
Mayers Dome
Mt Mayo
Nashville
West Bolton
Bolton Mountain
Catamount Family Center
Univ of Vt Research Forest
The Cobble
West Bolton Golf Club
Bolton Notch
GREEN MOUNTAINS
Bolton Valley
Ricker Mountain
Preston Pond
Richmond Pond
Chamberlain Hill
Richmond
BOLTON
Bone Mtn
The Old Round Church
RICHMOND
Jonesville

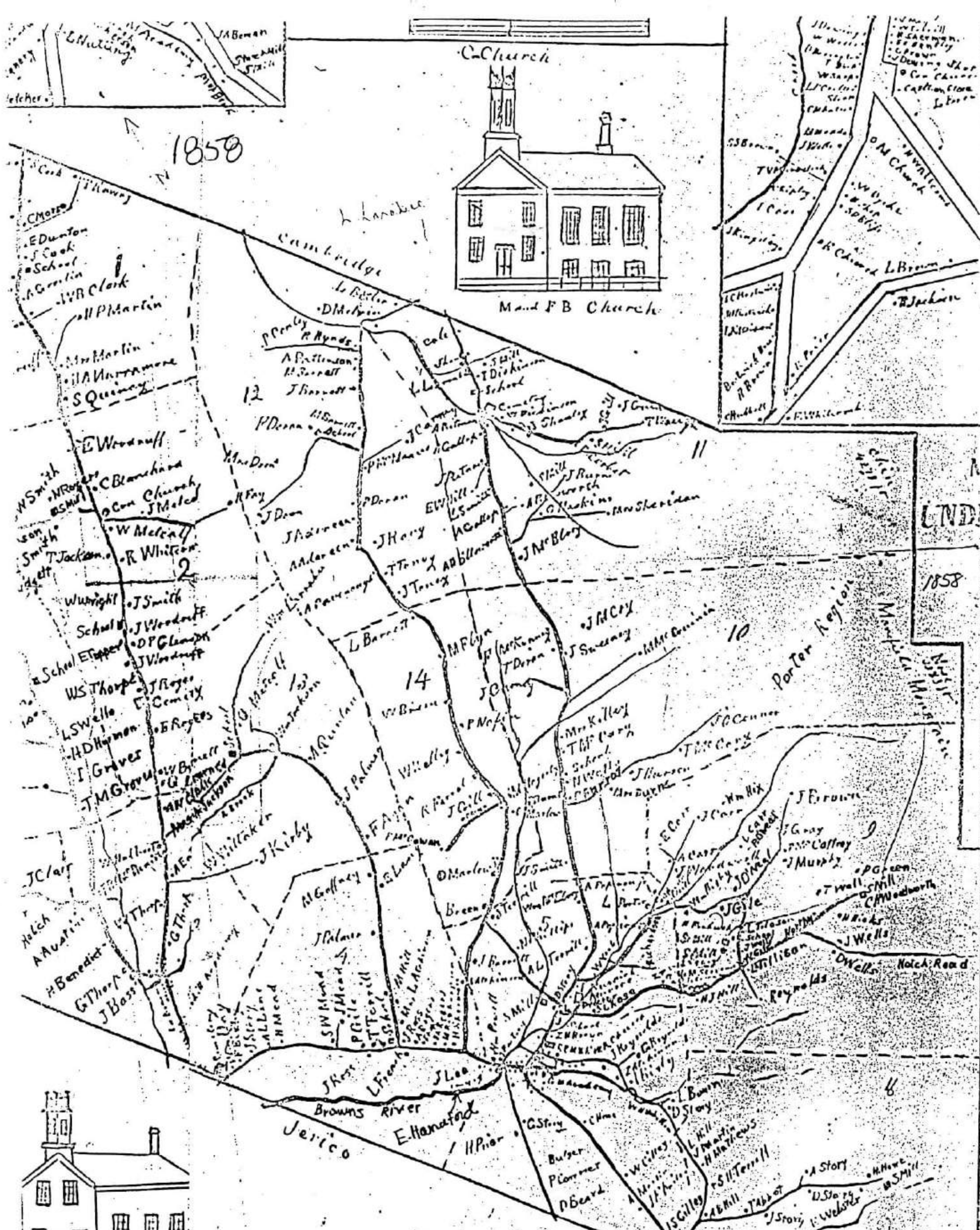
Mansfield Lotting

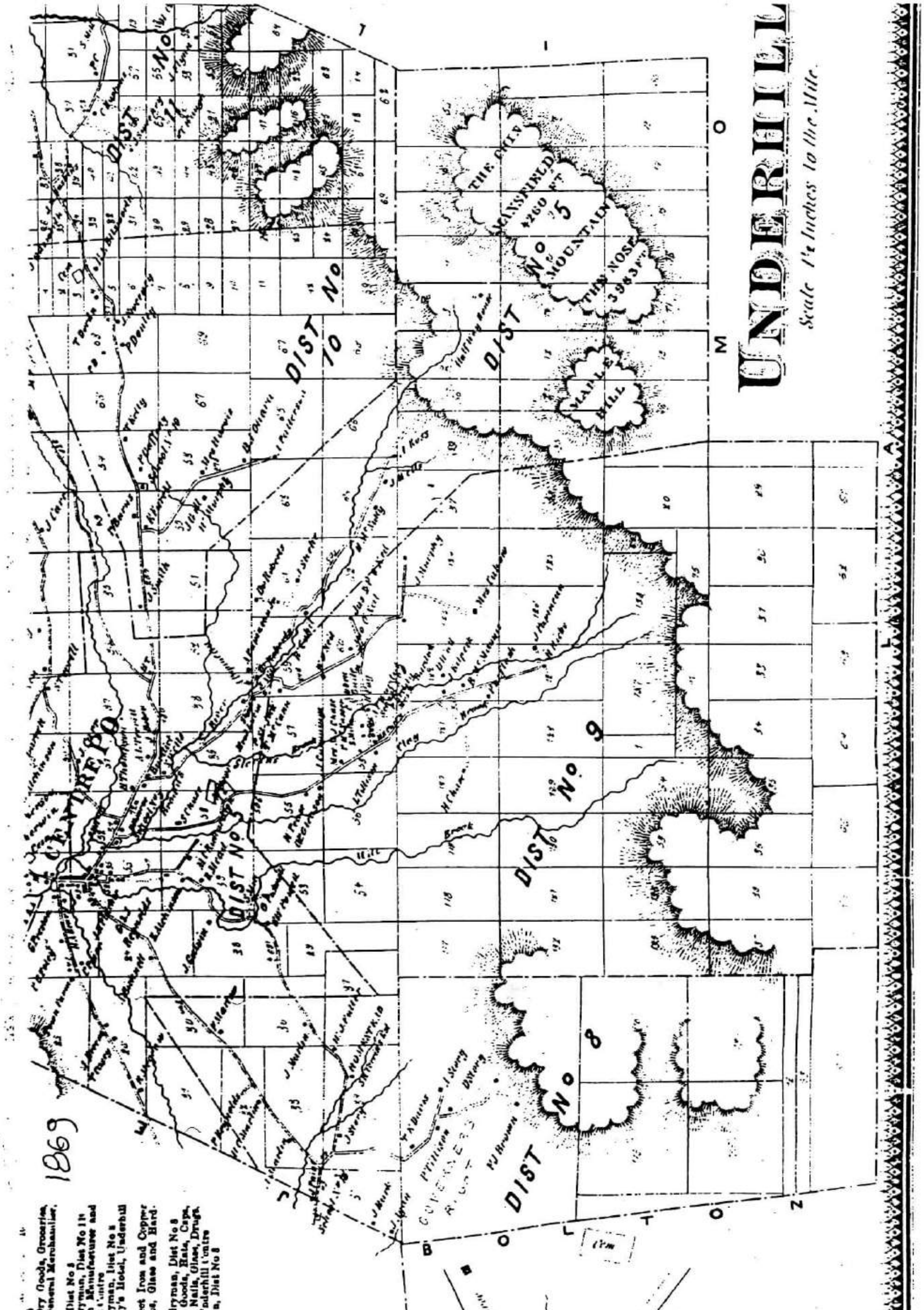


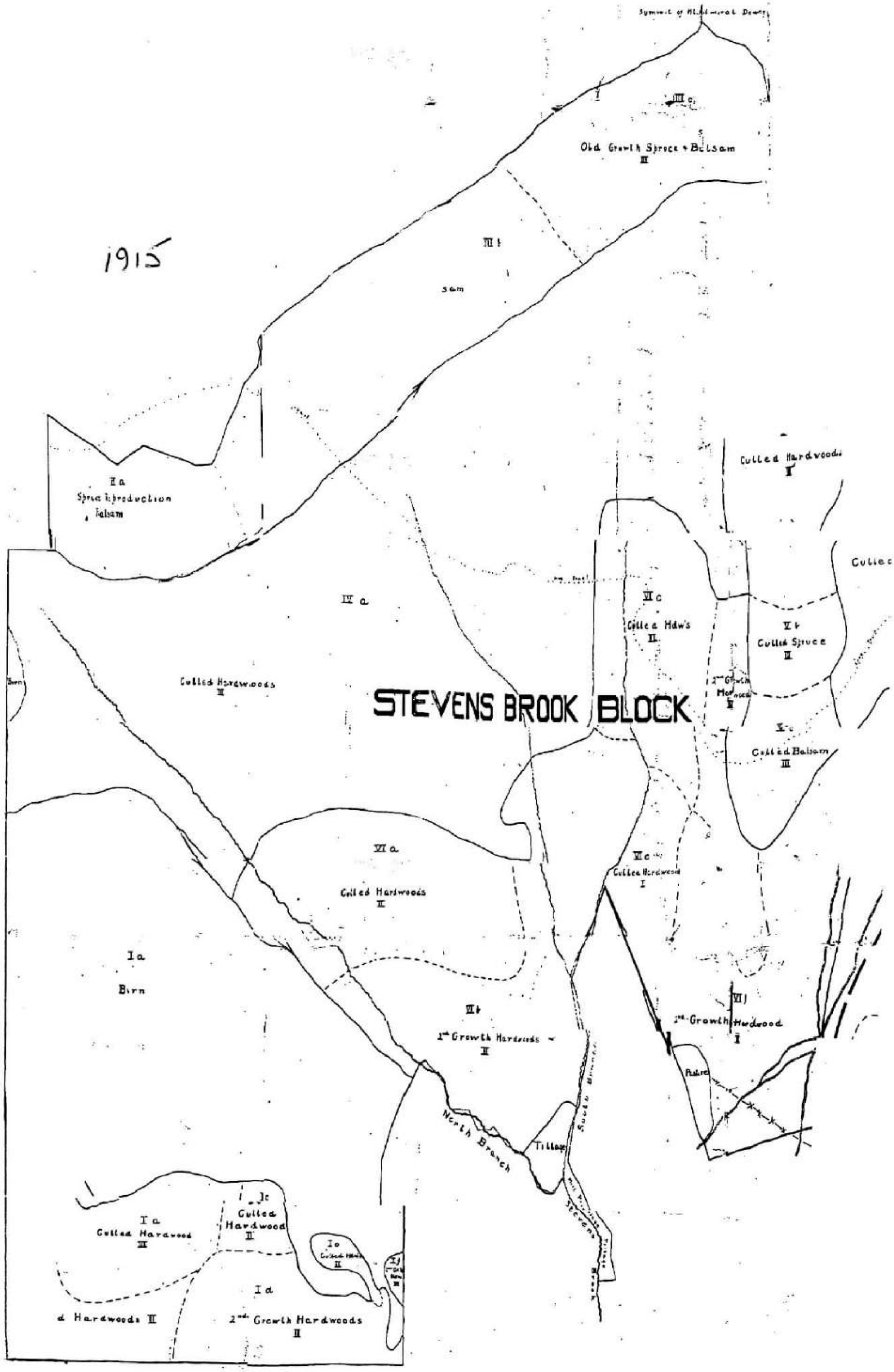
PLAN OF STOWE

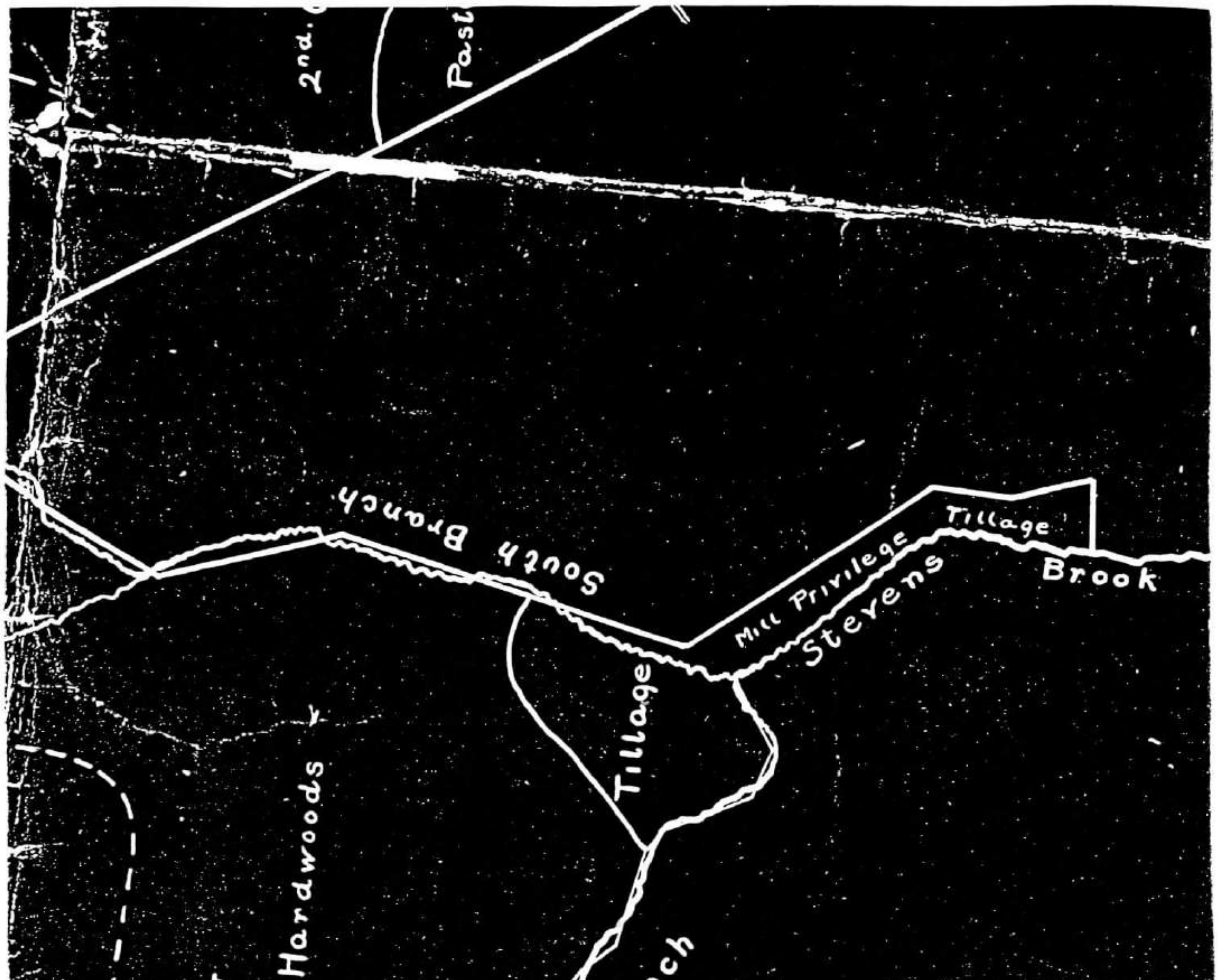

UNDERHILL
STOWE
HEIGHT OF LAND
FOREHEAD
MT. MANSFIELD
LONG TRAIL
UNDERHILL
STOWE
LWCF
PA
PA
PA
M.K.G.

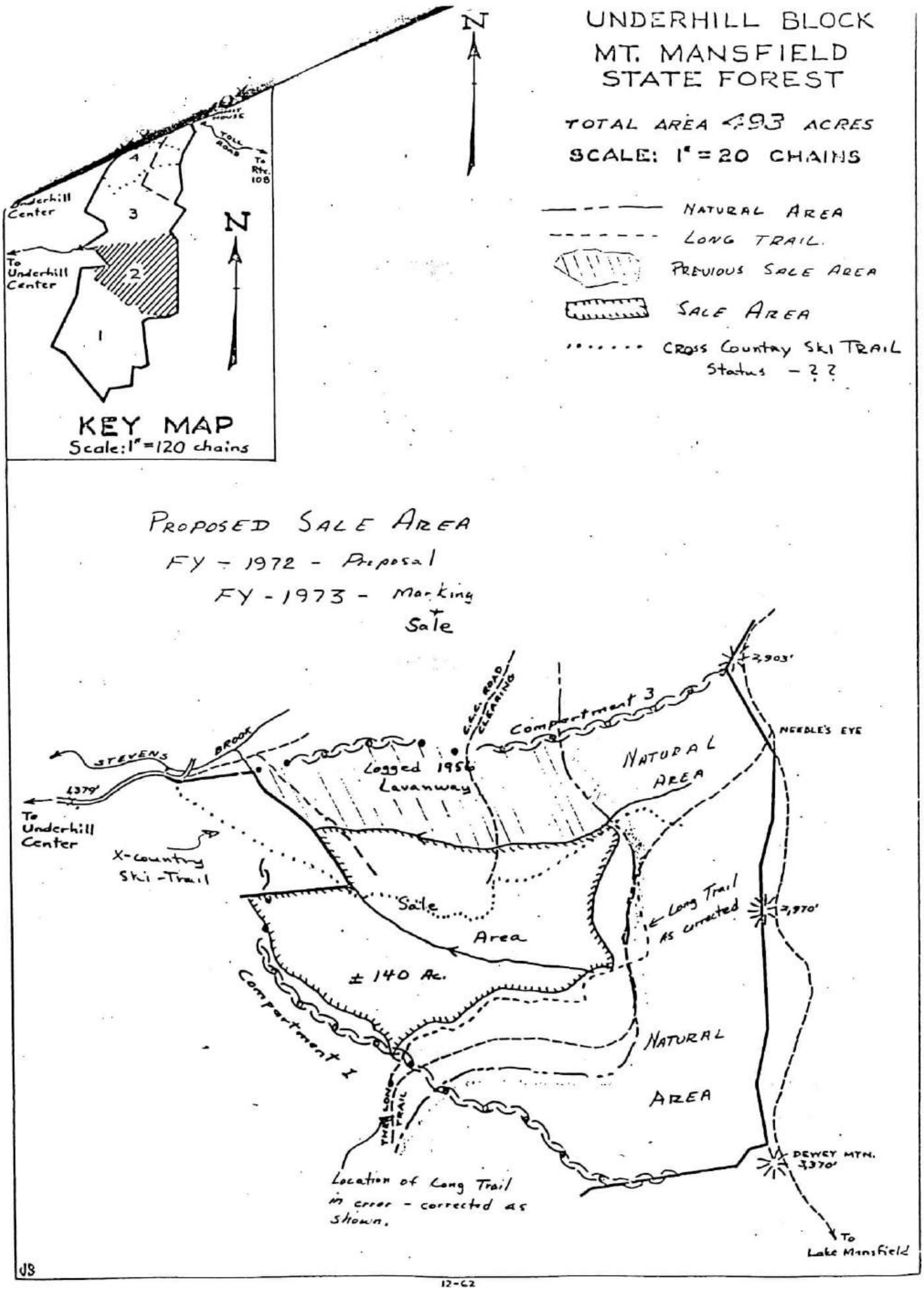

1850
B R I D G E
TABLE OF

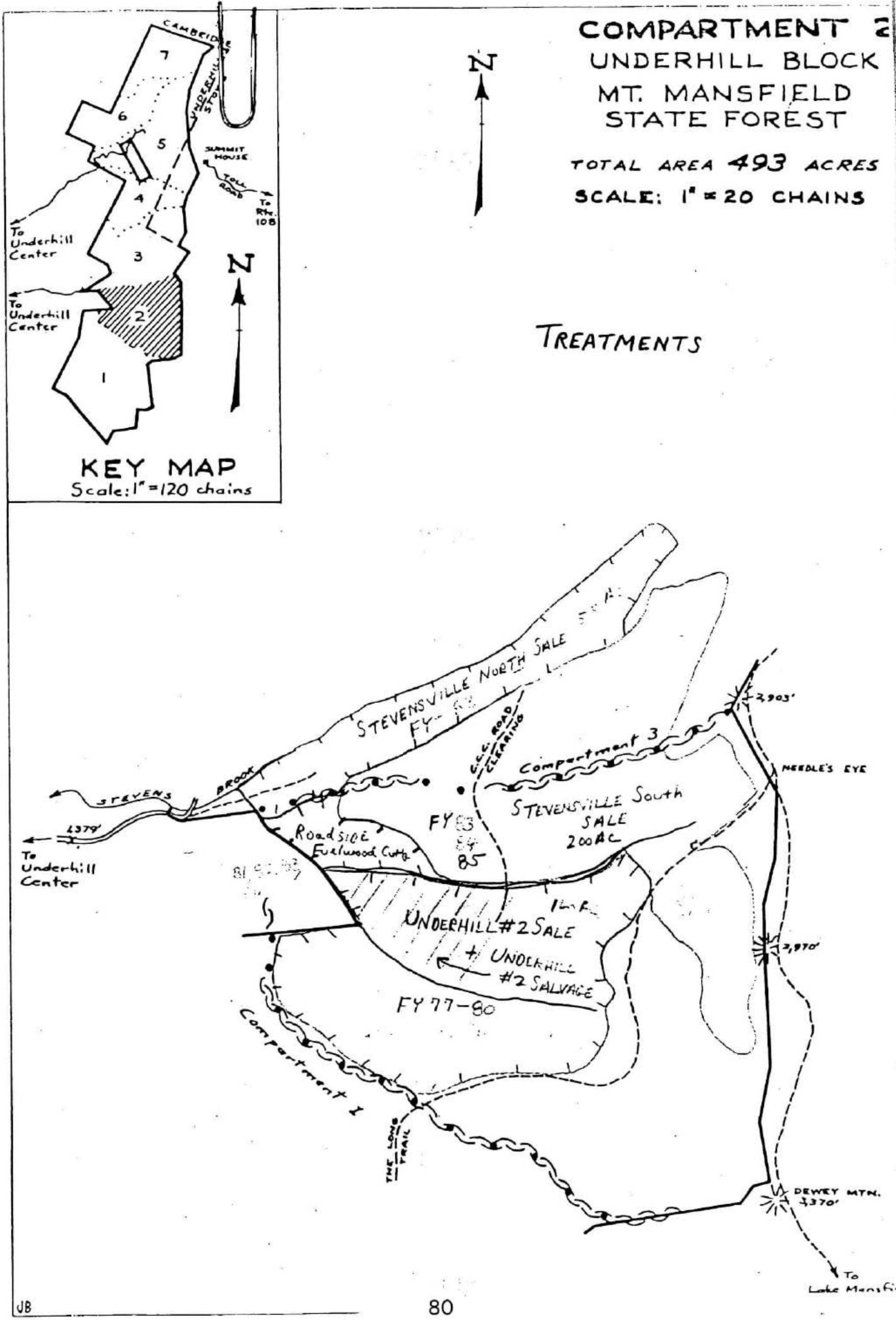

1858
C Church
M and F B Church
Cambridge
S Quincy
E Woodruff
C Blanchard
J Smith
WS Thorpe
I Graves
J Kirby
14
10
11
12
Porter Region
Browns River
Jerico
E Hanaford
J Lee
J Gile
J Wells
D Wells
Hatch Road
Reynolds
A Story
J Story
J S Gilley
1858

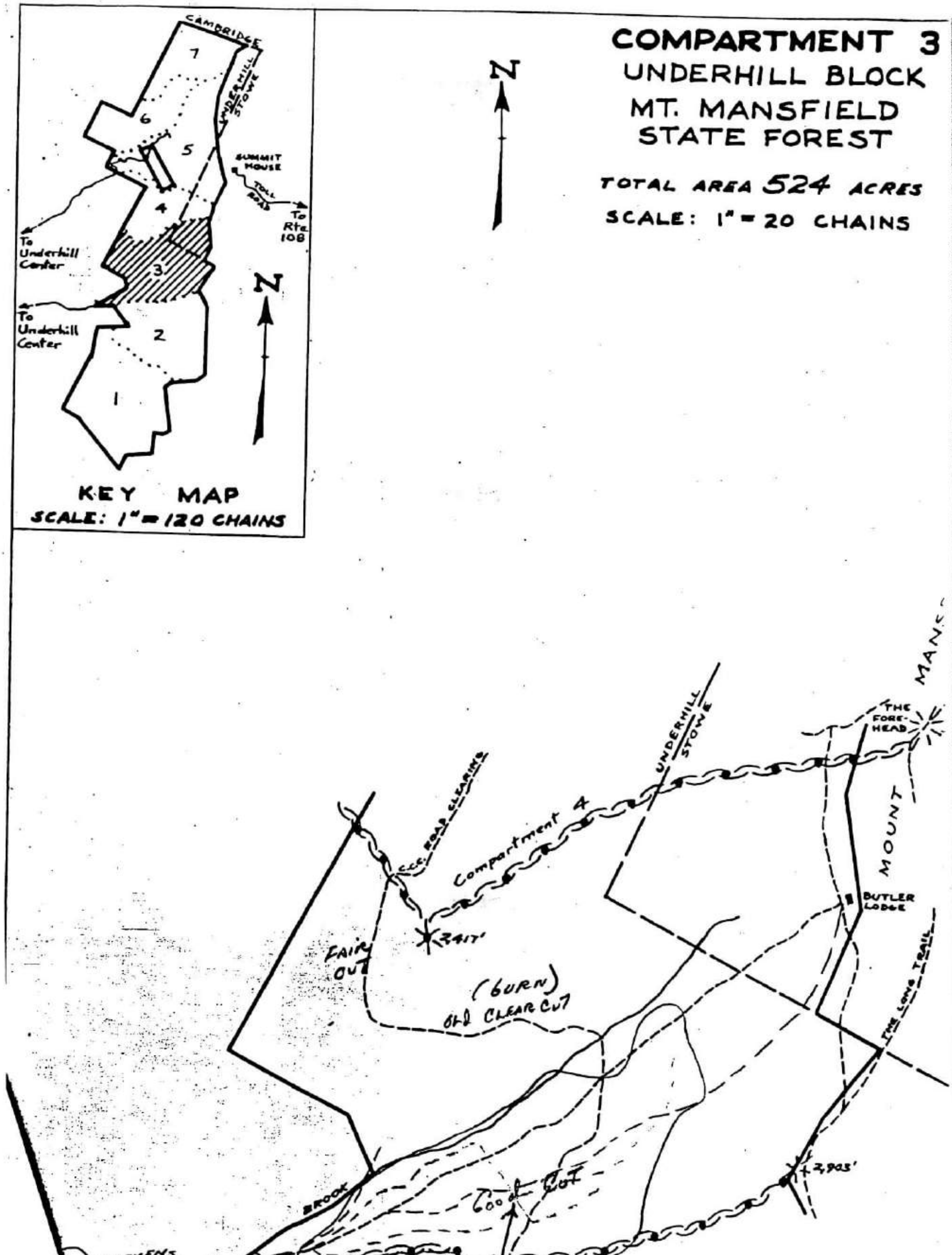

UNDERHILL
Scale 1½ Inches to the Mile
1869
MANSFIELD MOUNTAIN
THE CHIN
4280 FT
THE NOSE
3983 FT
MAPLE HILL
CENTRE P.O.
DIST No 5
DIST No 8
DIST No 9
DIST No 10
DIST No 11
DIST No 3
B O L T O N
M
O
A
L
Z

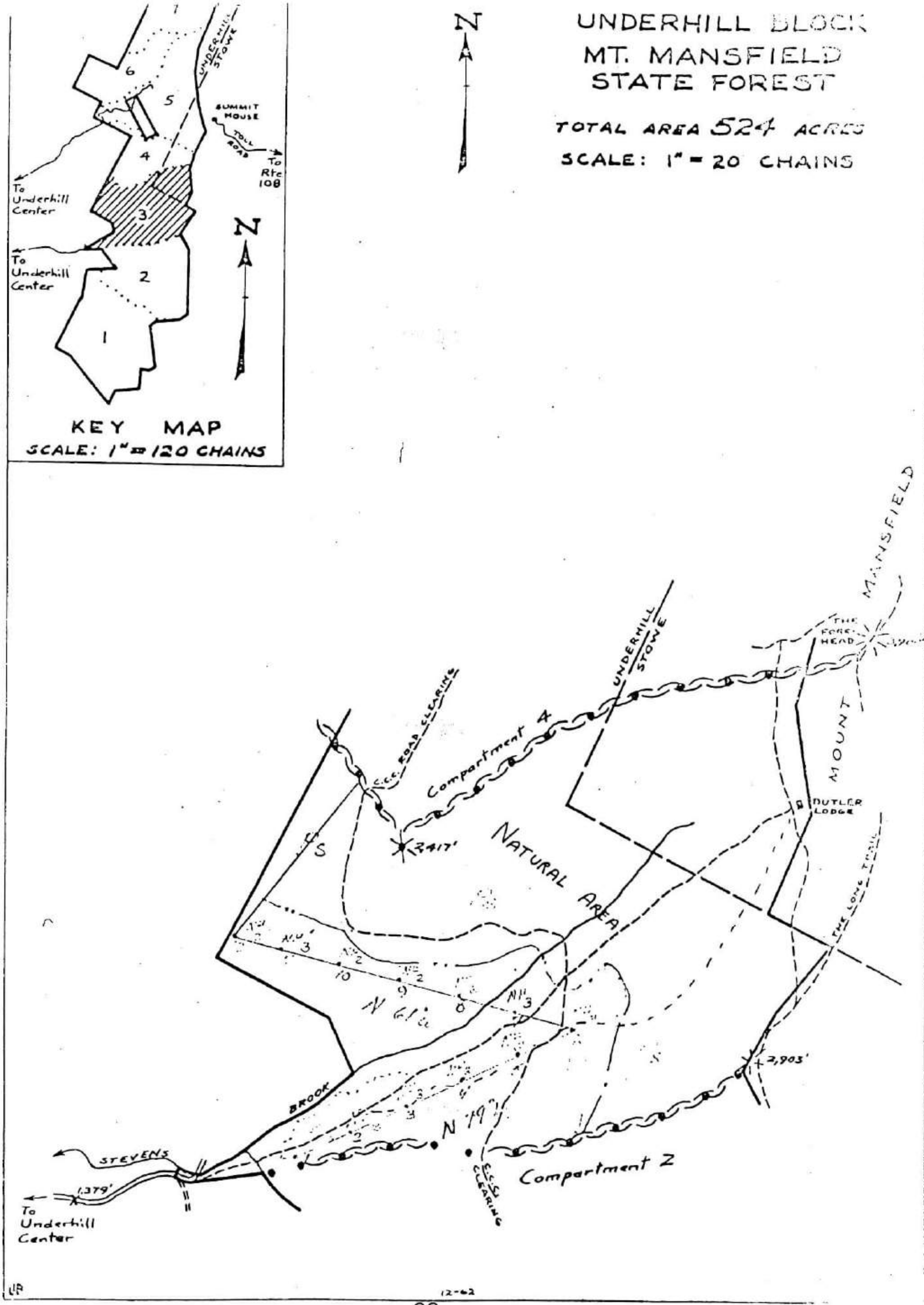

1915
Summit of Mt. Admiral Dewey
Old Growth Spruce + Balsam
III
sam
II a
Spruce Reproduction
Balsam
Culled Hardwoods
II
IV a
Culled Hardwoods
III
STEVENS BROOK BLOCK
VI c
Culled Hdw's
II
V b
Culled Spruce
II
Culled Balsam
III
VI a
Culled Hardwoods
II
VII c
Culled Hardwood
I
I a
Birn
VI b
1st Growth Hardwoods
II
2nd Growth Hardwood
I
Pasture
North Branch
South Branch
Tillage
Stevens Brook
I a
Culled Hardwood
III
I c
Culled Hardwood
II
I d
2nd Growth Hardwoods
II
d Hardwoods II


South Branch
Tillage
Mill Privilege
Stevens
Brook
Tillage
VI b
2nd. Growth Hardwoods
II
North Branch
If
2nd Gth Hdw.
III


UNDERHILL BLOCK
MT. MANSFIELD
STATE FOREST
TOTAL AREA 493 ACRES
SCALE: 1" = 20 CHAINS
NATURAL AREA
LONG TRAIL
PREVIOUS SALE AREA
SALE AREA
CROSS COUNTRY SKI TRAIL
Status - ??
KEY MAP
Scale: 1" = 120 chains
Underhill Center
To Underhill Center
To Rte. 108
TOLL ROAD
1
2
3
4
N
PROPOSED SALE AREA
FY - 1972 - Proposal
FY - 1973 - Marking + Sale
STEVENS BROOK
1379'
To Underhill Center
X-country Ski-Trail
Logged 1956 Lavanway
C.C.C. ROAD CLEARING
Compartment 3
NATURAL AREA
3,903'
NEEDLE'S EYE
Sale Area
± 140 Ac.
Long Trail as corrected
3,970'
Compartment 1
NATURAL AREA
THE LONG TRAIL
DEWEY MTN. 3370'
Location of Long Trail in error - corrected as shown.
To Lake Mansfield
JB
12-62


COMPARTMENT 2
UNDERHILL BLOCK
MT. MANSFIELD
STATE FOREST
TOTAL AREA 493 ACRES
SCALE: 1" = 20 CHAINS
N
TREATMENTS
KEY MAP
Scale: 1" = 120 chains
CAMBRIDGE
SUMMIT HOUSE
TOLL ROAD
To Rte. 108
To Underhill Center
To Underhill Center
1
2
3
4
5
6
7
STEVENSVILLE NORTH SALE
STEVENS BROOK
C.C.C. ROAD CLEARING
Compartment 3
Stevensville South SALE 200 Ac
Roadside Fuelwood Cutts
FY 83 84 85
UNDERHILL #2 SALE
+ UNDERHILL #2 SALVAGE
FY 77-80
Compartment 1
THE LONG TRAIL
1379'
To Underhill Center
2,903'
NEEDLE'S EYE
2,970'
DEWEY MTN. 3370'
To Lake Mansfield
JB


COMPARTMENT 3
UNDERHILL BLOCK
MT. MANSFIELD
STATE FOREST
TOTAL AREA 524 ACRES
SCALE: 1" = 20 CHAINS
N
CAMBRIDGE
UNDERHILL STOWE
SUMMIT HOUSE
TOLL ROAD
To Rte 108
To Underhill Center
To Underhill Center
7
6
5
4
3
2
1
N
KEY MAP
SCALE: 1" = 120 CHAINS
MANS
MOUNT
THE FORE-HEAD
UNDERHILL STOWE
C.C.C. ROAD CLEARING
Compartment 4
2417'
FAIR CUT
(burn)
Old CLEAR CUT
BUTLER LODGE
THE LONG TRAIL
2,903'
Good Cut
BROOK
STEVENS
1,379'
C.C.C. CLEARING
Compartment 2
Two
ORANGE
FLAGS
AT FORK
SALE BOUNDARY
TRAILS


UNDERHILL BLOCK
MT. MANSFIELD
STATE FOREST
TOTAL AREA 524 ACRES
SCALE: 1" = 20 CHAINS
KEY MAP
SCALE: 1" = 120 CHAINS
UNDERHILL STOWE
SUMMIT HOUSE
TOLL ROAD
To Rte 108
To Underhill Center
To Underhill Center
Compartment 4
C.C.C. ROAD CLEARING
2417'
NATURAL AREA
MOUNT MANSFIELD
THE FOREHEAD
BUTLER LODGE
THE LONG TRAIL
2,903'
BROOK
STEVENS
1,379'
To Underhill Center
C.C.C. CLEARING
Compartment 2
12-62

Appendix 2. ownership chain

Abstracts of transactions involving mountain timber land and mill properties in the Stevensville region of Underhill, Vermont.

1827 Asa Williams to Jonah Palmer #57 100ac (2:186)

1830 Ward to Wheeler and Read #125 &#126 on "each of which I have heretofore made a small improvement or clearing" (3:288)

1836 Azarias Williams to David Read tract in Mansfield Also all lots I own 3300 ac except #57 sold to Palmer (3:170)

1836 Survey Bill for John Wheeler and David Read a tract in Mansfield by J. Beeman surveyor 8376 ac (MLR 3:254) map (3:255) Wit trees: M,E,S

1836 David Read to J. Wheeler half undivided share in lots in Mansfield~15,000 ac

1837 Wheeler and Read to Abner Fuller #56 (3:268)

1837 Wheeler and Read to Almus Ward and Ward #59 occupied by Aaron Hall on south recently purchased of Hall (3:257; mortg 3:257)

1837 H. Ward Ward to Alnus Ward #57,59 from Aaron Hall 1837 Also J Wheeler and Read 1837 (3:257)

1837 Mortgage Almus Ward to Wheeler and Read #59 and same land which my brother Harvey Ward now lives and which he sold interest see Aaron Hall to A& H Ward. (3:280)

1837 John Wheeler and Read to P. Delano and J. Munn #34 ex 21 ac occupied by Geo. Tower ~80 ac

1838 J. Lee to Wheeler and Read #58 6 ac (9:385)

1838 J. Brown to Wheeler and Read plough field #58 10 ac. (9:388)

1840 J. Wheeler & D. Read to H. Hickok 2/3 undivided land mills and buildings 3500 ac bought of Johathan Lee and J. Brown 22 ac -mill property L.M. Stevens owns 1/3 part mill on #57&58 (10-188)

1840 John Wheeler & David Read to Jesse Lull (#43 & #5) (MLR 4:25)

1841 Jonathan Lee to Hickok and Stevens 5 ac part #55 up stream (10:363)

1841 Jesse Pike to Hickok and Stevens 14 ac in #57 (10:365)

1841 Josiah Brown to Hickok and Stevens all lot #55 not including Read, Wheeler and Stevens Also 88 ac 2/3 to Hickok and 1/3 Stevens (10:366)

1841 Hickok and Stevens to Day part #57 (10:368)

1841 Benj Day to Hickok and Stevens part #60 SW corner of land 6 ac to old Mansfield line (10:236)

1842 Hickok and Stevens to L. Sawyer #93 27 ac with all privileges, except and reserving all the sawing timber and trees suitable for sawing on part of land south of the Mead road (11:20)

1849 Hickok and Stevens water mill 300M of lumber 3 employees (U.S. Manuf. Census 1850)

1850 map with sawmill at end of road with house of C.W. Woodworth to west and H. Hicks further east

1853 Read and Wheeler to D. Hogan 100 ac on old town line (14:482)

1853 Read and Wheeler to Lewis Carr #68 same 1837 Bostwick (14:486)

1854 Hickok and Stevens to Stephen Tillison 10 ac (15:274)

1855 L. Carr to Read and Wheeler #68 from Boswick and Burg 1837 and Read and Wheeler 1853 (15:320)

1856 Hickok and Stevens to C.H. Woodsworth rent for 8 years 2ac plus mill H&S agrees provided spruce for 4 years to stock the sawmill with logs to amount of 400 logs per year if required to do Woodsworth to saw at $2.50/M and store them in the mill yard without charge (16:250)

1856 Indenture between Hickok and Stevens and J.C. Wells near sawmill and #123 lease of 78 ac--timber not to be cut faster than the land is fitted for cultivation (16:252)

1858 Sawmill of C.H. Woodsworth at end of road with P. Green, T. Wall and H. Hicks nearby. Notch Road with houses of J and D Wells. (MS map UTH)

1850s at Stevensville two saw mills a shingle mill a peck measure factory 1860 census: 30 families

1859 Hickok and Stevens mill sawmill (1 circular and one upright saw) cut to 60M feet of boards and some box material 600 spruce logs Also Forbush steam mill with 10 employees wood working 200M in making cheese boxes measurers and butter boxes (U.S. Manuf. Census 1860)

1860 Hickok and Stevens to H. Hicks 50 ac adjacent to mill (17:296)

1864 H. Hickok and Stevens to Hiram Hicks south side of Stevensville Brook to the upper saw mill at NE corner of Danl Wells 40 ac also much of mill lot on south side of road with house (18:152)

1869 Tillison steam mill 20M lumber and 320M of shingles (U.S. Manuf. Census 1870)

1869 H Hicks at end of road with J Papineau to north P Laflache further west (Beer's Atlas)

1870 Lysander Brown to J. Carr same as Story to Barron 1828 20 ac reserving the sawmill and mill priv. and all mill fixtures and use of the mill yard from here (18:495)

1871 S. Chase to Terrills now occupied by Chase 11 ac (18:543)

1873 Saml Chase to D. Hicks all from H&S 1867 19:325 except to Terrill 1871 11 ac (18:607)

1877 Railroad to Underhill

1877 B. Day and E.S Whicomb built and cut lumber mostly cut off mountain (Dwyer 1976)

1877 D.G. French to Ed Hurlburt half undivided share from French 1871 20-147 (18:705)

1879 H. Hickok to L.M. Stevens part of lot North of line #126 to old town line plus #29 in Stowe (21:351)

1879 Hickok to Stevens 2.75 ac know as the mill lot in Stevensville (21:390)

1880 Mary Wheeler to Anson Field the "Mansfield Mountain Land" same Reed and Wheeler to Cook and Ballard 1853 clear title John Wheeler lifetime interest with mortgage given by Cook and Ballard for purchase (21:574)

1882 Delevan Terrill general merchant and dealer in lumber and Londus Terrill dealer in dry goods and general merch. agent for Studebaker farm wagons and Franklin Co. (Child 1882)

1885 Darwin French to L.F. Terrill and G.E. Terrill half undivided share French and Hurlburt store 1883 Hurlburt to Waite Hurlburt all from D.G. French 1877 18:705 (22:396)

1889 Anson Field to D. L. Terrill near steam mill together with land contracted also 2000 ac mountain land same from J.B. Wheeler 1879 21:574 (24:88)

1889 Darius Knight took over mill owned by E.J. Booth manufactures lumber and turned handles cut 2MM feet per year

1894 stumpage contract G.L. Johnson (Hardwick) to G.E. Towers land in Cambridge and Underhill 24:553 Johnson reserves stumpage to $7500paid in 1895-97 providing Towers shall in years cut >1500M of stumpage of $1.50/M which is reserved upon the excess >1500M Also to Towers the farm from C.P.Smith 1893 now occd by Towers adjacent to land lots #11, 51, 54, 55, 56 in Underhill and lands bought of Smith (25:90)

1897 G.E. Terrill to L.F. Terrill half undivided share to same from D.G. French 1885 and same from B. Day 1885 (25:288)

1897 George C. Tower to D.L Terrill timber in Underhill all timber both hard and soft standing, lying or growing forever on land I own in Town of Underhill adjacent lands owned by D.L. Terrill and lying SE of E slope or cant of ridge or spur running in a SW direction from the North Peak of Mt. Mansfield.(25:355)

1897 D.L. Terrill to G.C. Towers all timber of every kind north and west of the ridge which runs SW from the town line between Underhill and Stowe meaning all timber on the n & W slope of said ridge and extending to Cambridge line and to Towers land (25:345)

1897 D.L. Terrill to L.F. Terrill all 2000 ac of mountain land (25:355)

1897 Mortgage L.F. Terrill to Nat Life Insur. Co. discharged 1899 (25:289)

1897 D.L. Terrill to L.F. Terrill all the timber both hard and soft standing lying or growing forever on land owned by G.C. Tower in Underhill adjoining Terrill land lies se slope or east of the ridge or space running in a SW direction from the North Peak of Mount Mansfield and being same timber convey from Tower to Terrill 1897 (25:367)

1897 Terrill and Knight 800M feet cut on taking to steam mill yard (50M/day) for season 1MM start to saw in March on Howe farm 600M feet of hardwood to be cut at Terrill and Knight mill (Dwyer 1976)

1898 L. F. Terrill to W.N. Martin all from French 23:97 and bought to Terrill by Day adm Hurlburt 1895 23:140 and is half undivided by G. Towers 1897 25:208 reserving use of the storehouse fro 1 year Also the land by D. L. Terrill 1897 25-355 2100 ac all timber with right of stumpage L.F. to D.L. Terrill 1897 (25:45)

1892 Agreement between C.S. Palmer and L.S. Lamson and G.L. Johnson rents land in Underhill and Cambridge. Johnson has the right to cut all the softwood timber standing on lands also the right to make and suitable roads for removing timber Also right to erect buildings and mills Palmer and Lamson have the right to cut the hardwood on land as fast as the softwood timber has been cut and removed but not to interfere with the piles and manufacturing of softwood timber$400 Johnson agrees to sell land before for 12 yr [1904] (24:430)

1898 lease to Palmer and Lamson 24-430 C. Palmer and Lamson to G.L. Johnson all land and 18 lots in Underhill reserving stumpage at $1.50/M until $2000 (24:553)

1900 W.H. Marten to C.H. Green all the wild land from L.A. Terrill 1898 2100 ac Also the timber and right of stumpage from D.L. Terrill 1897 (26-112)

1904 Charles H. Green to Champlain Realty all land 25:467 2100 ac also all the timber with right of stumpage conveyed from L. Terrill 1897: (26:422)

1905 surrounding hills rich in both hard and soft wood leading industry of the place is the sawmill and lumber business of D.W. Knight gets oyt 2MM feet of lumber each season, besides handling large quantities of wood and small lumber for shipment to other mills (Expansion 3(1):1).

1915 pasture and tillage near jct with 2nd growth hardwoods in nearby woods and burn to north

1929 Feb Champlain Realty Co. (IP) to State of Vermont 1238 ac (29:493)

1956 logging south of Stevensville Brook by Lavanway

Transactions involving the "Marsh property on Stevensville Brook, Underhill, Vermont

1860 Hickok and Stevens to H. Hicks adjacent to mill lot 50 ac (17:296)

1864 H. Hickok and Stevens to Hiram Hicks south side of Stevensville Brook to the upper saw mill at NE corner of Danl Wells 40 ac also much of mill lot on south side of road with house (18:152)

1865 H. Hicks to M.C. Wells east half of land Hickok and Stevens 1860 and house (18:180)

1865 Eliza Hicks to W. Burdick all of M. C. Wells 1865 (18:235)

1865 W Burdick to R. Woodworth all from E. Hicks 1865 25 ac (18:277)

1866 Joel Woodworth to Peter Laflache all from Burdick 1865 (18:339)

1867 Hiram Hicks to D. Wall 10 ac off the east end of land from H&S 1864 (18:386)

1873 Peter to William Laflache25 ac (20:357)

1880 E Hicks to J Hicks all same day as Hiram to Edward Hicks all 1864 from H&S log house (21:480/1)

1887 Hiram Hicks to Oliver King all from Hickok and Stevens 1864 except 10 ac sold to Daniel Hull (23:233)

1888 M. King to Hiram Hicks as 1887 (23:314)

1888 Hiram Hicks to Lewis Lavigne all from King 1888 and house (23:417)

1901 Adm to G. A. Terrill all same Lavigne from Homer and J. Hicks 1888 26 ac (26:156)

1901 Wm Laflache to G. A Terrill all from Thorpe 1879 11 ac and from Joel Woodsworth 1866 and P.Laflache 25 ac (26:196)

1901 G.A. Terrill to Patrick Green all from Lewis Lavigne 26 ac and William Laflache 36ac Terrill reserves contract to crops produce and products until $250 (26:199)

1912 Patrick Green to Edward Green all land from Terrill also household furnature and Ed to have hay wagon (28:129)

1912 Ed. Green to Henry Lebarge 62 ac (28:160)

1925 Henry Lebarge to Mary Stokes 62 ac (30:508)

1987 Mary French to John Marsh 75 ac (62:269)

1992 John Marsh to State of Vermont 43 ac at terminus of Stevensville Rd. (72:75)

PIMS
Photographic Inventory Monitoring System

Excerpts from this Thesis and Procedural Manual

A Monitoring Protocol for Measuring Trail Treadway Impact in the Mount Mansfield Arctic-Alpine Zone

Mark Haberle
March 1996

A Senior Thesis
Submitted in Fulfillment of a Bachelor of Science Degree
Environmental Program - University of Vermont

Committee of Evaluators:
Richard Paradis: Natural Areas Manager, University of Vermont
Lars Botzojorns: Director of Field Programs, The Green Mountain Club
William Howland: Executive Director, The Green Mountain Audubon Nature Center

Abstract

The purpose of this study was to design, create, and evaluate a monitoring protocol for the University of Vermont Mount Mansfield Natural Area. There is a lack of quantifiable data related to the impacts of increasing visitor use on the fragile and rare alpine environment within the Natural Area. The Photographic Inventory Monitoring System (PIMS), is designed to provide that data over the long term in the form of quantifiable trend analysis. PIMS is designed to be easy to execute requiring little to no ecological knowledge, require little field time to collect data, and provide for a wide range of data.

Key Phrases:
Alpine
Ecological Monitoring
Endangered, Threatened, and Rare Species
Photomonitoring
Quadropod
Species of Special Concern
Treadway Impact Monitoring

Table of Contents

"*Ecological Monitoring is not in-depth ecological research; and, while the two are related, they should not be confused with each other.*" (Henry and McCanny, 1994, p. 2)

Chapter One - Introduction

The Photographic Inventory Monitoring System (PIMS) is designed to provide a quantitative database about the trail treadway and the associated ecosystems located along the Long Trail in the University of Vermont (UVM) Natural Area Mount Mansfield. This Natural Area has been in university ownership since the late 1800's; it is a registered National Natural Landmark, a Vermont Fragile Area, and a registered Core Area in the Champlain Adirondack Biosphere Reserve under UNESCO.

The focus area of this study is within the alpine zones encompassing a section of the Long Trail located between the Nose and the Chin on Mount Mansfield. Due to the harsh growing environment and the natural history of the alpine zones, several Species of Special Concern (both state rare and federally endangered) exist in the study area. For example, *Prenanthes boottii* (Boott's Rattlesnake-root) grows on Mount Mansfield and is listed as endangered in Vermont and a candidate for federal protection. The increasing visitor usage along the ridgeline has created a strong concern for the health of the ecosystems and the continued existence of those remaining rare species.

Currently ridgeline use on Mount Mansfield has been the center of much debate among the Natural Area's associated managing parties. Permeating this debate is the need for a database that will reflect the impact of visitor use on the floral communities of the alpine zone. PIMS targets this need with an ecological monitoring design that is easy to repeat, execute, and that provides a viable data set for ecological trend analysis.

Maintenance of this protocol by the UVM Natural Areas will provide an efficient monitoring program to aid in future management decisions. With a quantifiable database, issues such as visitor use impacts will be more discernible. The proposed monitoring protocol will offer the opportunity to explore the management and protection of rare and fragile environments by providing a wide range of data. The database will serve to: provide photographic vouchers of species protected from collection, provide ecological benchmarks for further testing, track changes over time in the specific alpine ecosystem, provide a map for reconstruction if the system is subject to any catastrophic event, aid in predicting future changes, aid in the development of restoration goals, provide a time indicator for key phenological and weather related changes, and serve as an "early warning system" for the ecological integrity of the communities.

Finally, the resulting monitoring protocol may serve as a model program for other fragile natural areas under stress from elevated levels of visitor usage.

1.3 Study Objectives

The objectives designed to guide this research are:

1. To develop and establish a long-term monitoring program for the trail system in the alpine zone within UVM's Mount Mansfield Natural Area.

2. To critique and refine the monitoring protocol with emphasis on ease of repetition, data processing, data management, and data relevance.

Chapter Four - Findings

4.1 Study Area

The area studied is within the alpine zone located between the Nose and the Chin on the UVM Natural Area Mount Mansfield. This area was selected as it sustains a high level of trampling impact. The area has also been selected because of its relative easy access via the Mansfield Company auto-road. Lastly the area is of a reasonable size to monitor in one day.

4.2 Sample locations

Samples will be taken along transects bisecting the trail treadway. These locations were selected according to areas of special concern and available exposed bedrock for anchoring transect locator pins.

Transect 1 - A heavily used visitor staging area. Visitors not well enough equipped or not desiring to go all the way to the summit often arrive at this site as the terminus of their hike. The area offers open views and areas to sit and relax. For that reason it sees a high number of visitors spreading out or straying from the trail treadway. The transect crosses the treadway in a sedge meadow and offers a good example of a community that is fragmented by the denudation of the trail treadway.

Transect 2 - An example of a heavily eroded section of the treadway. Where the transect crosses the treadway erosion has created a gully upwards of 12 inches deep. This evidences the gullying effect of trampling impact. It is also located within a convienient distance from transect 1 making monitoring of both sites quick and easy.

Transect 3 - An example of an area that is under little to no trampling stress. This area is strung off to the visitors due to previous impact. The site is not located on the trail treadway. This site is a representation of an area that is revegetating from past impact.

Transect 4 - An example of a heavily used trail junction. This site receives traffic arriving from the gondola, the Subway Trail, and the Long Trail. It also offers good views and areas to rest therefore visitors are prone to stray from the trail treadway.

Transect 5 and 6 - Examples of wet bog communities. Both of these sites bisect the treadway in a trail junction/staging area where the environment is saturated for most of the hiking season. Existing at this site are puncheons that are used to traverse the wet area. Because of the proliferation of dogs on the summit and their affinity for the cooling effect of getting wet, the bog is showing signs of dog trails paralleling the puncheons. As well the area is showing the increasing denuded area in the bog mat that is used by dogs to lay down in and cool off. Both the dog trails and the cooling area are selected as sites to be monitored.

Transect 7 - An example of an area that is bordered on one side by a restricted use area. Where the transect bisects the trail treadway the northwestern side is strung off as a research site and, therefore, should see a reduction in the amount of impact sustained by the plants. The opposite side of the site represents a standard makeup of community types.

Transect 8 - This site is selected because of its proximity to the inventory sites established by Howland for his Mountain Biogeography project. The site lies just off a large meadow in which Howland has done extensive inventory work.

Transect 9 - This final transect is selected because of its proximity to the summit. The site is a heavily eroded and gullyed section of the treadway located just prior to the summit. The area is representative of the largest staging area of the ridgeline - the summit.

4.3 Samples

The samples gathered with PIMS are in the form of color slides shot on Fugi Provia 200 ASA slide film. Provia film is designed to be scanned and should facilitate any computer assisted analysis of the database. The slides will be vertical shots of the vegetation with a graduated quadrat frame included in the photo frame. Oblique photos will also be taken at each site offering a qualitative element to the database.

The quadrat frame size has been established at 30cm x 100cm with a 5cm grid pattern. This design is used to provide a reference for counting the vegetation and quantifying the change in species density, frequency, and cover. The grid pattern has been established by creating six species curves to determine the optimal sampling size. The quadrat frame was designed in conjunction with the design of the quadropod and the limitations of the camera. The quadrat frame is designed to allow for random sampling of any size area in multiples of 5cm to allow for unbiased sampling within the individual data sets. Species curves and inventories are included in the Appendix.

4.4 Sampling Frequency

PIMS is designed to indicate trends. The recommended sampling frequency is once per year (perpetually) within the summer season to include July or August. To sample outside those months will create a data set that is affected by the morphological characteristics of the plants.

4.4 Quadropod

The quadropod consists of the camera mounting box, the quadrat frame support legs, the oblique orientation platform and post, and the oblique compass arm. When assembled, these pieces are used to orient the camera for an accurate repetition of the photos that were taken when the monitoring was last done. The quadropod is collapsible to facilitate traveling between the transect sites along the trail.

The quadropod is constructed of MDO plywood. This material was chosen because it has a high number of laminates in respect to its thickness. This results in a strong and relatively lightweight material for constructing the quadropod. MDO is also resistant to warping over time which could affect the camera orientation.

Compasses are used as an orientation tool for the quadropod and the oblique orientation platform. An azimuth is indicated for each quadrat site to which the quadropod is oriented. The compass for the oblique photos is affixed to the compass arm which effectively removes the compass from the magnetic effects of the clinometer and camera quick release mounts.

The oblique orientation platform also has a clinometer affixed to the platform. This device is used to vertically orient the platform either up or down the trail treadway. The vertical orientation data is given in the form of (+) up, or (-) down, degrees and is matched to the scale on the side of the clinometer ensuring the camera is oriented vertically the same at each monitoring.

The quadropod is leveled front to back and side to side with a set of levels oriented perpendicular to each other and affixed to the camera mounting box. When both levels are set correctly the quadropod will be level in all directions ensuring that the camera focal point is in the same place as when the monitoring last occurred.

The camera is attached to the quadropod on one of four quick release mounts depending on which photo series is being shot. Three quick release mounts are located on the camera mounting box and one is located on the oblique orientation platform. The quick release mounts are used to allow the shooting of five different (three vertical and two oblique) photographs while only orienting the quadropod once. This effectively reduces any impact that may occur when orienting the quadropod.

The quadrat frame support legs are designed to hold the quadrat frame at a specific distance from the camera lens. The result is the shooting of the grid pattern of the quadrat frame over the vegetation. The distance remains the same for each shoot and so remains consistent for quantifying the photographs. The quadrat frame support legs each have two adjustable legs attached to them. The legs are adjusted so the quadropod is at a specified height at each transect site and properly leveled out.

4.6 Quadrat Frame

The quadrat frame is constructed of 1/2" PVC piping with nylon stringing for the grid pattern. The PVC piping is chosen because it is strong and flexible. The size of the quadrat frame is 100cm x 30cm with a 5cm square grid pattern.

4.7 Transect Locators

The transect sites are permanently identified with locator pins. These pins are 1/2" stainless steel bolts driven into the bedrock with lead expansion bolts and capped with epoxy. The bolts are placed between 1m and 10m off the trail treadway to remain hidden from view. The pins are relocated using site descriptions and site photographs.

4.8 Transect Lines

The transect lines are 1/4" braided nylon rope with loops at either end. The loops are stretched taut over the pins according to an east/west orientation. Along the transect lines are aluminum ferrules crimped to the line. The ferrules each represent a quadrat site for monitoring.

4.9 Camera

The camera is a Cannon EOS Elan EF with a 28-80mm f/3.5-5.6 Ultrasonic Lens. The camera has the quick release mount adapter permanently affixed to the bottom to assure accurate positioning in the release mounts for the photo shoots. The camera functions allow for bracketing of the photos, remote triggering, and manual aperture setting. The bracketing creates a series of photographs that are over, under, and correctly exposed so as to ensure at least one picture with good contrast. The remote trigger eliminates shaking of the quadropod when shooting the pictures. The aperture can be set manually so as to create the greatest depth of field for each photograph.

4.10 Data Processing

The data processing requirements consist of maintaining the photo series schedule outlined on the transect data sheets and making note if there is any alteration to it. The film, when taken, is sent to the developers. When it is returned the slides are arranged into archiving sheets per the instructions in the protocol manual and sent to the VMC for permanent storage. The data is accessed at the VMC according to their archival and retrieval process.

4.11 Data Sheets

There is one data sheet annually for PIMS. One side consists of the site data that must be recorded at each transect site. The other side consists of the photo series schedule and must be used if there is any change to the schedule.

Table of Contents

Chapter Three - Site Data

3.1 Introduction

The following chapter contains the core data for this protocol. In it you will find all the data needed to re-locate the transect sites and orient the quadropod. Once the rest of the protocol has become familiar this is the only chapter you may need to complete the data collection process.

The chapter is broken down into nine different subsections (3.2.1-3.2.9) each corresponding to the nine individual transect sites. Each subsection begins with a paragraph describing the location of the transect site. Following that is a list of orientation data to be used to locate the quadropod and the oblique orientation platform. Each subsection also has two pages of pictures to help in locating the transect site as mentioned in 2.2.1.

This chapter should be referred to for location of the individual transect sites and orientation of the quadropod and oblique platform. Again, once you are familiar with Chapter One and Chapter Two this chapter should provide all the information necessary to proceed from transect to transect.

Measuring Leg:	The quadrat frame support leg that is matched to the indicated ferrule height.
Ferrule Height:	The height along the quadrat frame support leg centimeter tape to which the ferrule is matched.
Azimuth:	The direction the north arrow should indicate when the quadropod is correctly oriented.

3.2 Transect Site Data

Inclination:	The degree of inclination indicated by the inclinometer when the oblique platform is correctly oriented.

3.2.1 Transect 1

Site Description:

A large rock cairn called Frenchman's Pile is located approximately .2 miles North on the Long Trail (LT) from the Summit Station. About 40 feet North along the LT from Frenchman's Pile is the first transect. At this transect the trail is lined on both sides by a scree wall (a low rock wall defining the edge of the trail treadway) and is about 1.5 meters in width.

East Pin Location: On a bedrock spur about 10-15 feet east of the treadway.
West Pin Location: On a bedrock spur approximately 15 feet west of the treadway.

Transect Azimuth: 340°
Transect Length from east to west loop: 1,058cm

Azimuth from Frenchman's Pile to west pin: 110°
Azimuth from Frenchman's Pile to east pin: 150°

Orientation Information:

East Quadrat Frame (T1-QE)

Measuring Leg	R
Ferrule Height	8.5
Azimuth	330°

West Quadrat Frame (T1-QW)

Measuring Leg	R	
Ferrule Height	20	
Azimuth	330°	
Oblique (T1-OBN)	Azimuth: 340°	Inclination: (-10)
Oblique (T1-OBS)	Azimuth: 160°	Inclination: (-15)

3.2.2 Transect 2

Site Description:

Approximately 150-200 feet north on LT from transect 1 the treadway is about 1 meter in width and is characterized by a deep trench in the organic mat. The transect is located approximately 50 feet south of the first puncheon on the LT north of Frenchman's Pile. The transect is perpendicular to the treadway and shorter in length than transect 1.

East Pin Location: On a bedrock spur about 5 feet east of the treadway.
West Pin Location: On an isolated block 5 feet west of the treadway in a Bearberry dominated mat.

Transect Azimuth: 280°
Transect Length from east to west loop: 559cm

Azimuth from first puncheon to west pin: 220°
Azimuth from first puncheon to east pin: 200°

Orientation Information:

East Quadrat Frame (T2-QE)

Measuring Leg	L
Ferrule Height	7.5
Azimuth	345°

West Quadrat Frame (T2-QW)

Measuring Leg	R		
Ferrule Height	14.5		
Azimuth	345°		
Oblique (T2-OBN)	Azimuth: 340°	Inclination:	(-15)
Oblique (T2-OBS)	Azimuth: 170°	Inclination:	15

3.2.3 Transect 3

Site Description:

Transect 3 is located at the northern junction of the Amherst trail and LT. This transect site lies just off the eastern edge of Drift Rock in a strung- off revegetation area. The transect is **not** on the Long Trail treadway.

East Pin Location: On 105° azimuth from the west pin.
West Pin Location: Under the overhang of the eastern side of Drift Rock.

Transect Azimuth: 285°
Transect Length from east to west loop: 464cm

Orientation Information:

East Quadrat Frame (T3-QE)

Measuring Leg	R		
Ferrule Height	0		
Azimuth	340°		

Middle Quadrat Frame (T3-QM)

Measuring Leg	L		
Ferrule Height	(-5)*		
Azimuth	340°		

West Quadrat Frame (T3-QW)

Measuring Leg	R		
Ferrule Height	5.5		
Azimuth	340°		
Oblique (T3-OBN)		Azimuth: 30°	Inclination: (-35)
Oblique (T3-OBS)		Azimuth: 160°	Inclination: (-20)

* The ferrule height for the Middle Quadrat Frame (T3-QM) is 5cm **below** the bottom of the quadrat support leg.

3.2.4 Transect 4

Site Description:

Transect 4 lies at the junction of the LT, Subway, and Cliff trails. More specifically, it lies across the area where the Subway trail intersects the LT. The transect bisects the last few feet of the Subway trail.

East Pin Location: A few feet prior to the Subway/LT junction. It is about two feet up on a rock block to the right of the treadway as you are headed north along the LT. It may be hidden under a fir branch
West Pin Location: To the left of the Subway trail as you approach the LT junction. It is located under a Black spruce next to a patch of screed-in moss and sedge.

The transect is perpendicular to the top of the Subway trail and diagonal to the LT.

Transect Azimuth: 340°
Transect Length from east to west loop: 733cm

Azimuth from the blaze at the top of the Subway trail to the west pin: 325°
Azimuth from the blaze at the top of the Subway trail to the east pin: 175°

Orientation Information:

East Quadrat Frame (T4-QE)

Measuring Leg	R		
Ferrule Height	33		
Azimuth	290°		
Oblique (T4-OBN)		Azimuth: 310°	Inclination: (-5)
Oblique (T4-OBS)		Azimuth: 180°	Inclination: (-10)

East Quadrat Frame (T4-QM)

Measuring Leg	R
Ferrule Height	38.5
Azimuth	290°

West Quadrat Frame (T4-QW)

Measuring Leg	R
Ferrule Height	33.5
Azimuth	290°

3.2.5 Transect 5

Site Description:

Both transect 5 and 6 are located across the marshy area at the Profanity, Sunset Ridge, and LT junction. Both transects cross the puncheon that lie along the LT.

East Pin Location: On a bedrock outcropping between the puncheons of the LT and the puncheons headed down Profanity Trail. It is about 15 feet from the LT treadway and is at the edge of the marshy area to the left of a bearberry mat.
West Pin Location: On the northern side ofthe marshy area along the base of the rock face. It is about 1 foot above the tops of the sedges and 15 feet from the treadway.

Transect Azimuth: 355°
Transect Length from east to west loop: 822cm

Azimuth from the Profanity/LT junction to the west pin: 200°
Azimuth from the Profanity/LT junction to the east pin: 335°

Orientation Information:

East Quadrat Frame (T5-QE)

Measuring Leg	R
Ferrule Height	8.5
Azimuth	305°

Middle Quadrat Frame (T5-QM)

Measuring Leg	R
Ferrule Height	8.5
Azimuth	300°

West Quadrat Frame (T5-QW)

Measuring Leg	R	
Ferrule Height	20	
Azimuth	300°	
Oblique (T5-OBN)	Azimuth: 300°	Inclination: (-15)
Oblique (T5-OBS)	Azimuth: 120°	Inclination: (-25)

3.2.6 Transect 6

Site Description:

Both transect 5 and 6 are located across the marshy area at Profanity Trail, Sunset Ridge, and LT junction. Both transects cross the puncheon that lie along the LT.

East Pin Location: On a bedrock outcropping between the LT north and Profanity Trail. It is located about 10 feet from the treadway to the left of a bearberry mat on a steep sloping rock spur.
West Pin Location: On the northern side of the marshy area along the base of the rock face. It is about 1 foot above the tops of the sedges and 15 feet from the treadway.

Transect Azimuth: 280°
Transect Length from east to west loop: 660cm

Azimuth from the Profanity/LT junction to the west pin: 60°
Azimuth from the Profanity/LT junction to the east pin: 335°

Orientation Information:

East Quadrat Frame (T6-QE)

Measuring Leg	L
Ferrule Height	12
Azimuth	330°

West Quadrat Frame (T6-QW)

Measuring Leg	R
Ferrule Height	14
Azimuth	325°

3.2.7 Transect 7

Site Description:

Transect 7 lies 15 feet north on the LT from the "West Chin Natural Area" sign. It is south on the LT from the Diapensia site by approximately 50 feet.

East Pin Location: On an isolated block in the middle of an extensive Bearberry/Rush mat about 20 feet off the treadway. It is located on the terminus of a rock tumble that leads up a small rise to the Diapensia site.
West Pin Location: On a patch of isolated bedrock approximately 20 feet off the treadway. It is located on a patch of bedroack of about two square feet on the West Chin Natural Area in the middle of a Bearberry/Rush mat.

Transect Azimuth: 320°
Transect Length from east to west loop: 1,068cm

Azimuth from the summit to the west pin: 70° (or 250° from the pin to the summit)
Azimuth from the summit to the east pin: 60° (or 240° from the pin to the summit)

Orientation Information:

East Quadrat Frame (T7-QE)

Measuring Leg	R
Ferrule Height	6
Azimuth	300°

West Quadrat Frame (T7-QW)

Measuring Leg	R	
Ferrule Height	10	
Azimuth	290°	
Oblique (T7-OBN)	Azimuth: 290°	Inclination: (-10)
Oblique (T7-OBS)	Azimuth: 120°	Inclination: (-25)

3.2.8 Transect 8

Site Description:

Transect 8 bisects the LT treadway approximately one tenth of a mile south of the summit. It is located on the south side of the summit in a saddle between the Chin and the West Chin. The transect lies about 20 feet south along the LT from a drainage that runs out of the large sedge meadow to the east of the LT.

East Pin Location: On an bedrock point about 30 feet off the treadway up a series of rock steps. Follow a series of rock steps toward the center of the sedge meadow between the summit and the Diapensia site.
West Pin Location: On an isolated block about 5 feet from the treadway and 20 feet from the drainage that runs out of the sedge meadow in the saddle.

Transect Azimuth: 345°
Transect Length from east to west loop: 1,031cm

Azimuth from the summit to the west pin: 50° (or 230° from the pin to the summit)
Azimuth from the summit to the east pin: 60° (or 250° from the pin to the summit)

Orientation Information:

East Quadrat Frame (T8-QE)

Measuring Leg	R
Ferrule Height	18.5
Azimuth	280°

West Quadrat Frame (T8-QW)

Measuring Leg	R	
Ferrule Height	14.5	
Azimuth	280°	
Oblique (T8-OBN)	Azimuth: 305°	Inclination: (-5)
Oblique (T8-OBS)	Azimuth: 105°	Inclination: (-15)

3.2.9 Transect 9

Site Description:

Transect 9 lies about 100 feet south along the LT from the USGS survey marker located at the summit. The site is characterized by deep chanelling on the treadway's east side. The transect is located 5-10 feet north along the LT from the last cairn and the transect is perpendicular to the treadway.

East Pin Location: On a rock shelf about 10 feet off the treadway.
West Pin Location: On a bedrock depression approximately 10 feet off the treadway.

Transect Azimuth: 320°
Transect Length from east to west loop: 816cm

Azimuth from the summit to the west pin: 40° (or 220° from the pin to the summit)
Azimuth from the summit to the east pin: 65° (or 245° from the pin to the summit)

Orientation Information:

East Quadrat Frame (T9-QE)

Measuring Leg	L
Ferrule Height	20
Azimuth	305°

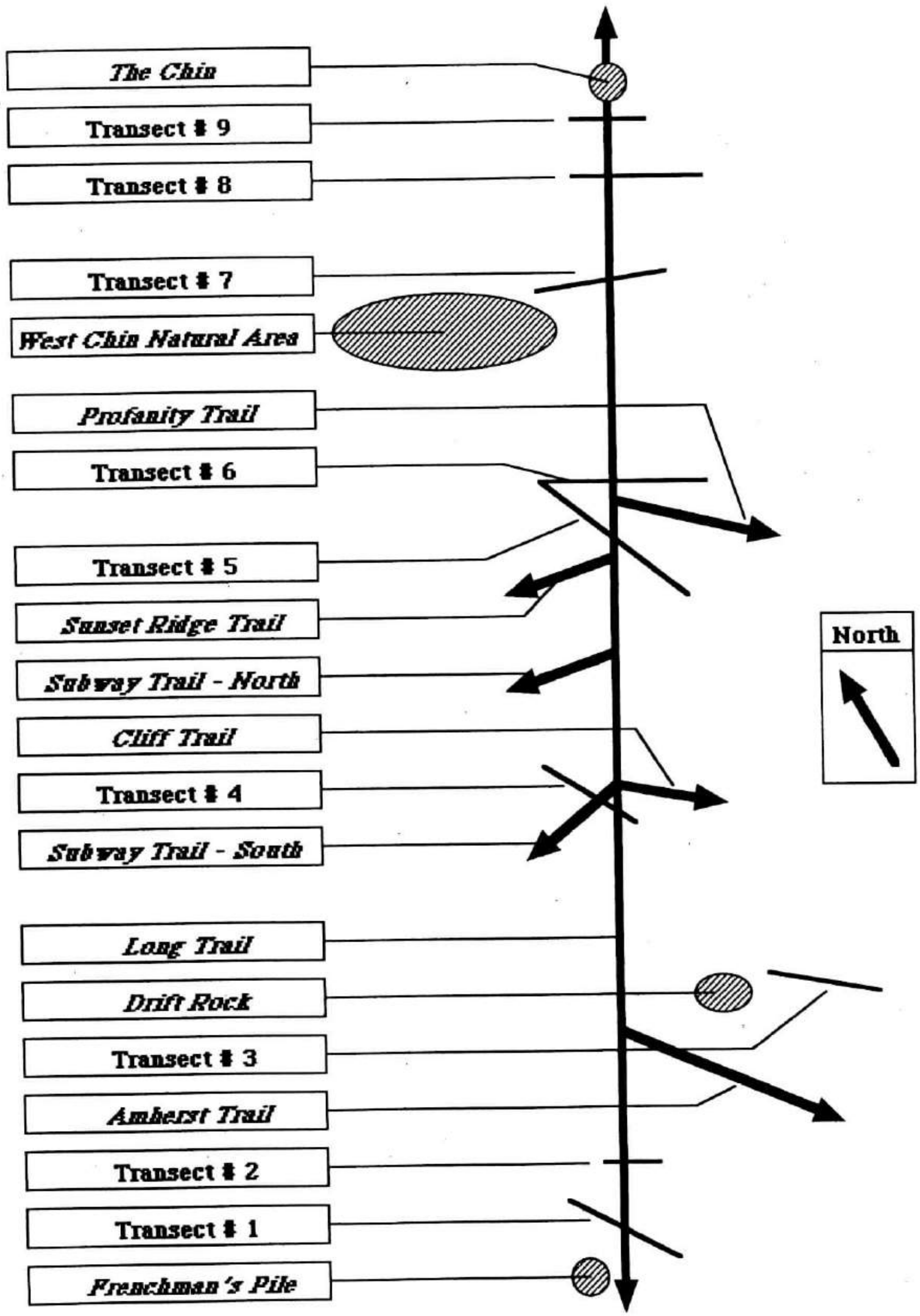
West Quadrat Frame (T9-QW)

Measuring Leg	R	
Ferrule Height	7	
Azimuth	305°	
Oblique 1 (T9-OBN)	Azimuth: 290°	Inclination: (-20)
Oblique 1 (T9-OBS)	Azimuth: 300°	Inclination: (-20)

Transect Line Specifications

Transect #1		
From East Loop To:	Ferrule #1	315 cm
	Ferrule #2	549 cm
	West Loop	1,058 cm
Transect #2		
From East Loop To:	Ferrule #1	237 cm
	Ferrule #2	234 cm
	West Loop	559 cm
Transect #3		
From East Loop To:	Ferrule #1	50 cm
	Ferrule #2	262 cm
	Ferrule #3	300 cm
	West Loop	464 cm
Transect #4		
From East Loop To:	Ferrule #1	302 cm
	Ferrule #2	393 cm
	Ferrule #3	582 cm
	West Loop	733 cm
Transect #5		
From East Loop To:	Ferrule #1	136 cm
	Ferrule #2	239 cm
	Ferrule #3	373 cm
	West Loop	822 cm
Transect #6		
From East Loop To:	Ferrule #1	262 cm
	Ferrule #2	282 cm
	West Loop	660 cm
Transect #7		
From East Loop To:	Ferrule #1	368 cm
	Ferrule #2	522 cm
	West Loop	1,068 cm
Transect #8		
From East Loop To:	Ferrule #1	629 cm
	Ferrule #2	773 cm
	West Loop	1,031 cm
Transect #9		
From East Loop To:	Ferrule #1	350 cm
	Ferrule #2	411 cm
	West Loop	816 cm

Transect Site Location Map
Linear Rendition of Transect Site Locations



Surface Waters

A Biological and Chemical Survey of Selected Surface Waters in the Lye Brook Wilderness Area, Vermont

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Lye Brook Wilderness Study of Surface Waters Executive Summary

Introduction

The Vermont Department of Environmental Conservation (VTDEC) has monitored water quality in and around the Lye Brook Wilderness Area (LBW) since 1980 in an effort to document the effects of acid deposition on sensitive lakes. In 1993, the Vermont Monitoring Cooperative (VMC), working with the Green Mountain National Forest (GMNF) and the VTDEC, established a southern Vermont monitoring site in the LBW. VTDEC and GMNF subsequently entered into three consecutive cooperative agreements to jointly conduct expanded surface water monitoring activities in response to mandates under the Clean Air Act to protect Air Quality Related Values (AQRV) in Class I Wilderness Areas such as the LBW. The following monitoring activities were conducted by the Vermont Department of Environmental Conservation under the conditions of these agreements from 1993 through 1995:

- Fish and aquatic macroinvertebrate communities were sampled at seven stream sites in and around the LBW.
- Quantitative and qualitative benthic macroinvertebrate samples were collected at four lakes and ponds in and around the LBW.
- Sediments were collected from two lakes and analyzed for selected organic and inorganic contaminants.
- Water chemistry was monitored at all stream and lake sites where biological sampling was conducted.
- Fish were collected from four lakes; edible portions of tissue were analyzed for selected organic and inorganic contaminants.

The study area is highly susceptible to surface water acidification primarily due to the fact that the waterbodies are situated in geologic areas resistant to chemical weathering. Much of the surface water in the study area is affected by organic acids and is tannic/brown in color. This region of Vermont has in addition, some of the highest levels of sulfate deposition and ozone in the state (R. Poirot - Personal Communication). Long distance transport of atmospheric pollutant is the suspected cause of these air quality related issues.

Results

Lake Water Chemistry: Water chemistry was sampled three times a year in all years at Branch and Bourn Pond. Both ponds are considered to be acidified, with average Calcite Saturation Indices (CSI) greater than 6. The pH of Branch Pond is consistently less than 5.00 standard units while Bourn Pond is in the 5.00-5.50 range on a consistent basis. Both lakes are relatively high in organic carbon and aluminum. It is likely that the organic carbon ameliorates the potential toxic effects of aluminum to aquatic biota in these lakes. Little Mud Pond was sampled twice in 1993, and Lye Brook Meadows was sampled once in 1995. Both waterbodies are acidic and highly colored and support significant sphagnum mats. Ionic concentrations were lower in Little Mud Pond than in the other lakes and ponds sampled in the study area. Both waterbodies are considered to be acidified. Branch and Bourn Ponds both exhibit thermal stratification. Although no dissolved oxygen samples were collected, biological analyses indicate severe oxygen depletion in the hypolimnion of these lakes. Long-term monitoring data collected from acid sensitive lakes and ponds by VTDEC since 1981 suggest a trend of decreasing calcium, magnesium, and sulfate in ponded surface waters statewide, with a lake-specific trend of decreasing sulfate described for Bourn Pond (Stoddard and Kellogg, 1993).

Lake Sediments: Sediments from Bourn and Branch Ponds were collected from deep areas of the lakes. No chlorinated pesticides or poly-chlorinated biphenyls (PCB's) were detected. Three polycyclic aromatic hydrocarbons (PAH) were detected. Flouranthene and pyrene were detected at very low levels in sediments from both lakes; phenanthrene was detected in sediment from Branch Pond. All PAH concentrations were well below concentrations known to threaten the well-being of aquatic life. Lead and mercury were detected at levels indicating potential low-level risk to aquatic biota. It is likely that the source of these contaminants is atmospheric deposition.

Lake Benthos: Benthic macroinvertebrates were sampled from different habitats in Branch, Bourn, and Little Mud Ponds in May, 1993, and Lye Brook Meadows in July, 1995. Ekman dredge samples were collected from both profundal and sub-littoral areas of Branch and Bourn Ponds and from sub-littoral only at Little Mud Pond. Qualitative littoral sampling was conducted at all four ponds. Total taxa richness from the Ekman dredge sampling ranged from six in the profundal zones of Branch and Bourn Ponds to 18 in Little Mud Pond. Sub-littoral samples were generally more diverse than profundal samples. Dipterans, primarily of the Chaoboridae and Chironomidae families, dominated the profundus of both lakes, with the profundal community of Bourn Pond made up of 96 percent Chaoboridae. Communities in both profundal zones were indicative of severe oxygen stress. No taxa of the acid-sensitive groups Mollusca/Crustacea/Ephemeroptera were observed in any of the profundal and sublittoral Ekman dredge samples. Qualitative shoreline sampling produced more taxa. Taxa richness in Little Mud, Bourn, and Branch Ponds averaged about 60 taxa, while Lye Brook Meadow produced 40 taxa. No Crustacea (eg. crayfish) were observed in any of the four waterbodies. No acid-sensitive mayflies or mollusca were observed in Lye Brook Meadows. Little Mud Pond contained one mayfly species but no mollusca. Branch and Bourn Ponds both contained three mayfly and two molluscan taxa.

Fish Tissue Contaminants: During 1994 and 1995, fish for contaminant analysis of edible tissue were collected from Branch, Bourn, Stratton, and Grout Pond by angling and gill nets. Only brook trout were collected from Branch, Bourn, and Stratton Ponds. Brown bullhead, chain pickerel, and smallmouth bass were collected from Grout Pond. Concentrations of PCBs and chlorinated pesticides were below detection limits in all brook trout samples. Metabolites of DDT, up to 0.12 ppm DDE in smallmouth bass, were detected in all samples from Grout Pond. Mercury was detected in all samples. Concentrations ranged from 0.08

ppm in brook trout from Stratton Pond to 1.45 ppm in one smallmouth bass from Grout Pond. Of five smallmouth bass tested from Grout Pond, four had concentrations of mercury in excess of 1.00 ppm, the FDA action level for mercury in fish. Additional metal fish tissue analysis was conducted at Grout Pond during the summer of 1996.

Stream Chemistry: Stream chemistry was sampled at two sites each on Bourn and Lye Brook, and one site each on Branch Pond Brook and Winhall River. Considerable spatial and temporal variability was observed in stream chemistry parameters. All streams sampled underwent a reduction in pH, alkalinity, and calcium in response to snowmelt and spring run-off. Lack of significant spring run-off followed by drought conditions in 1995 resulted in higher pHs throughout most of the 1995 sampling period than in the previous two years. Differences in stream chemistry were observed between upstream and downstream sites on Bourn and Lye Brooks. All stream sites are considered to be acidified, with the exception of the downstream site on Lye Brook. Stream chemistry at this site is influenced by dolomitic outcroppings which increase pH and alkalinity. A maximum alkalinity of 10.5 mg/l was observed at this site in the fall of 1995, compared with an alkalinity of less than one mg/l at the upstream site at the same time. Concentrations of aluminum were highest during periods of run-off. Aluminum was observed at concentrations that, depending on the duration of exposure, would be potentially toxic to aquatic biota.

Stream Fish Populations: Stream fish populations were sampled by electroshocking at six sites on four streams; two sites each on Lye and Bourn Brooks and one site each on Branch Pond Brook and the Winhall River. All four streams are characterized as small cold-water streams. No fish were observed at the most upstream site on Lye Brook. Only brook trout at relatively low densities were found at the upstream Bourn Brook site and the Branch Pond Brook site. Three and four species were found at the lower Lye and Bourn Brook sites respectively. A total of eight species, including three salmonids, were found at the Winhall River site. Salmonid species observed were brook and brown trout, and Atlantic salmon; non-salmonids included slimy sculpin, longnose and blacknose dace, white sucker, and creek chub.

Stream Macroinvertebrate Populations: Stream macroinvertebrates were sampled at seven sites on four streams. Substrate composition at all sites was dominated by boulder and cobble. Most sites were sampled annually for the three years of the project. Sampling was conducted in the fall using standardized kick-net sampling techniques consistent with VTDEC field protocols. In addition to an estimate of the abundance per unit sampling effort, a number of community-based metrics were calculated, including total number of taxa present (taxa richness), the total number of stonefly, mayfly, and caddisfly taxa present (EPT richness), a bio-index indicative of overall productivity (Bio-Index or BI), a diversity index, the relative dominance of an individual taxon (% Dom Tax), and the percent composition of various taxonomic and functional components of the macroinvertebrate community. The upstream Lye Brook sites exhibited poor biological integrity and were the most biologically depauperate and least diverse of the sites sampled. The uppermost site was dominated by dipterans and had no mayfly or stonefly taxa, which were abundant at all other sites. The upper Lye Brook site was unique among the sites sampled in that it was characterized as enriched and had a significant periphytic blue-green algal growth at the time of sampling.

The Branch Pond Brook and upper Bourn Brook sites exhibited some biological impairment in 1994, a year when stream pH's were generally lower than in 1993 or 1995. It is likely that the reduced biological integrity at these sites is at least in part a result of episodic exposures to high acidity and to high levels of aluminum. The Winhall River and lower Bourn Brook sites had the most diverse and well-balanced benthic communities of the sites sampled. These two sites, along with the lowest Lye Brook site, were all rated as having good to excellent biological integrity.

Recommendations: Recommendations are made in this report relative to maintaining a continued long-term monitoring presence in the Lye Brook Wilderness Area. It is recommended that stream and lake chemical monitoring should continue at the intensity conducted during these studies; and that biological monitoring should be repeated on a regular basis at five-year intervals.

Characterization of Groundwater Recharge and Flow in a Vermont Upland Watershed Using Stable Isotope Tracing Techniques

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Abstract

Precipitation and groundwater samples, collected weekly over an 18 month period from the uppermost watershed of the Browns River on the slopes of Mt. Mansfield, were analyzed for delta^{18}O, deltaD, and 3H composition. Differences in seasonal temperature and elevation are reflected in the delta^{18}O composition of precipitation, which ranges yearly over ~20 per mil (%). Mean annual delta^{18}O of precipitation decreases by 2.5 % per 1000 m of elevation gain.

The delta^{18}O of groundwater collected from seven residential wells within the basin varies only 2 % yearly, with the exception of a spring 300 m higher in elevation than the other wells, which shows a yearly variation of 4.3 %. In the warmer months (April to November), the delta^{18}O signature remains constant (within 0.2 %) , while in the colder months (December to March), the delta^{18}O composition varies by as much as 2 %, excepting the high spring, in which delta^{18}O varies throughout the year.

Flow in deep bedrock is well mixed, exhibiting a steady isotopic composition. The delta^{18}O variation detected in wells and springs during the colder months is likely caused by a decrease in evapotranspiration near the wells, which allows influx of recharge following precipitation events. During the warmer months, recharge to bedrock in the valley, where most of the wells are located, appears to be greatly reduced.

Measurements of 3H indicate that the age of groundwater at most of the sampling locations is less than 5 years. Two of the deep bedrock wells contain groundwater that may be between 21 and 34 years, based on comparison with historical tritium deposition. These ages suggest travel rates of 0.2 m/day to 6.6 m/day for groundwater flow in the fractured bedrock.

Hydrologic Monitoring at Nettle Brook, Mount Mansfield

James Shanley

U.S. Geological Survey
Water Resources Division

Hydrologic monitoring at Nettle Brook

Highlights from Water Year 1995

Extremes in weather and climate make for extremes in hydrology. At Nettle Brook, our small stream station on the west flank of Mt. Mansfield, 1995 had one extreme followed by another. Highlights in streamflow for the water year (October 1, 1994 through September 30, 1995) included low fall flow, a major January thaw, a very early snowmelt hardly worthy of the name, a bone-dry June, followed on July 1 by the highest instantaneous flow of record, and a 3-day period of very heavy rain and flooding in August (fig. 1).

Sustained streamflow is dependent on sustained stores of water in the soil and groundwater. In our northern climate, two separate major seasonal events limit recharge to these subsurface storage reservoirs. In summer, recharge is limited by evaporation and transpiration by the forest canopy. These processes, collectively known as evapotranspiration, or ET, return one-third to one-half of annual precipitation to the atmosphere. In winter, recharge is limited by lack of supply to the subsurface; precipitation does not infiltrate, but rather is stored in the snowpack. The counterparts to these low-flow periods are the high-flow periods in later autumn, when ET is greatly reduced, and in spring, when water locked up in the snowpack is released rather quickly and subsequent rains fall on saturated soils while ET is still minimal. Typically, one-half of total annual streamflow occurs in a six-week period during snowmelt.

On Mt. Mansfield, autumn flow usually reaches a peak in November or December. In the fall of 1994, however, rainfall was somewhat below average, thus flow was below average coming into the winter months. Dry conditions continued in the early winter; snowpack development was minimal. An unusually strong January thaw took out much of this snowpack. The temperature in Burlington reached 66 F, an all-time January record. Streamflow at Nettle Brook increased significantly during the thaw, but was kept in check by the meager snowpack and lack of accompanying rainfall.

Warm temperatures arrived in early March, and the snowpack, which had never developed to its usual depth, rapidly succumbed and produced a snowmelt notable for its earliness and low peak discharges; flow was an order of magnitude lower than that in the 1994 snowmelt (fig. 2).

In June, flow is typically still running high from sustained discharge of groundwater recharged during snowmelt, while ET demand has just begun. In 1995, however, continued below average precipitation after snowmelt, coupled with the low groundwater tables due to limited recharge during snowmelt, brought on drought conditions by late spring. At the end of June, flow in Nettle Brook was reminiscent of late September.

The drought showed signs of breaking in July, as the thunderstorm season got rolling. Although summer in Vermont is as wet as any other season, precipitation tends to be concentrated in shorter periods of higher rainfall intensity. When summer precipitation falls on dry soils, most of the water is captured in the unsaturated zone, where it is subsequently lost to ET before it infiltrates far enough to recharge groundwater. However, at high rain intensities, water that does run off -- because it falls directly on stream channels or saturated riparian zones, or is rapidly transmitted through soil cracks or other macropores -- may cause high peak flows of limited duration. In these storms, flow returns to baseflow conditions in a matter of hours. One such thunderstorm took place on July 1. Forty mm of rain -- nearly triple the rainfall for the entire month of June -- fell within 2 hours, causing the highest flow peak of the year.

The real drought-busting storms occurred in early August (fig. 3), when a major flood struck parts of northern Vermont. While most of the areas affected received the heaviest rain on the night of Saturday, August 5, the heaviest rains at Mt. Mansfield fell during the day on Friday and Saturday. In all, 175 mm (7 inches) of rain fell. The cumulative effects of the heavy rainfall caused the highest peak on Saturday afternoon, though less rain fell that day, and caused sustained high flows by Sunday, August 6 (fig. 3).

The low snowpack and subsequent drought were the dominant factors in the overall low annual runoff. Runoff was 43.51 cm in water year 1995 compared to 58.48 cm in water year 1994.

Water-quality sampling

Water quality sampling in 1995 centered around snowmelt and storm events. In conjunction with other projects, stream samples have been collected for analysis of Hg (mercury), NO_3 (nitrate), DOC (dissolved organic carbon), silica (Si), and other major ions. These data are in a preliminary stage of analysis. The major ion data will be used to compute input-output budgets, using the NADP site at Proctor for the input data. Input-output budgets establish boundary conditions helpful to understanding what processes control biogeochemical cycling in the ecosystem.

Figure captions

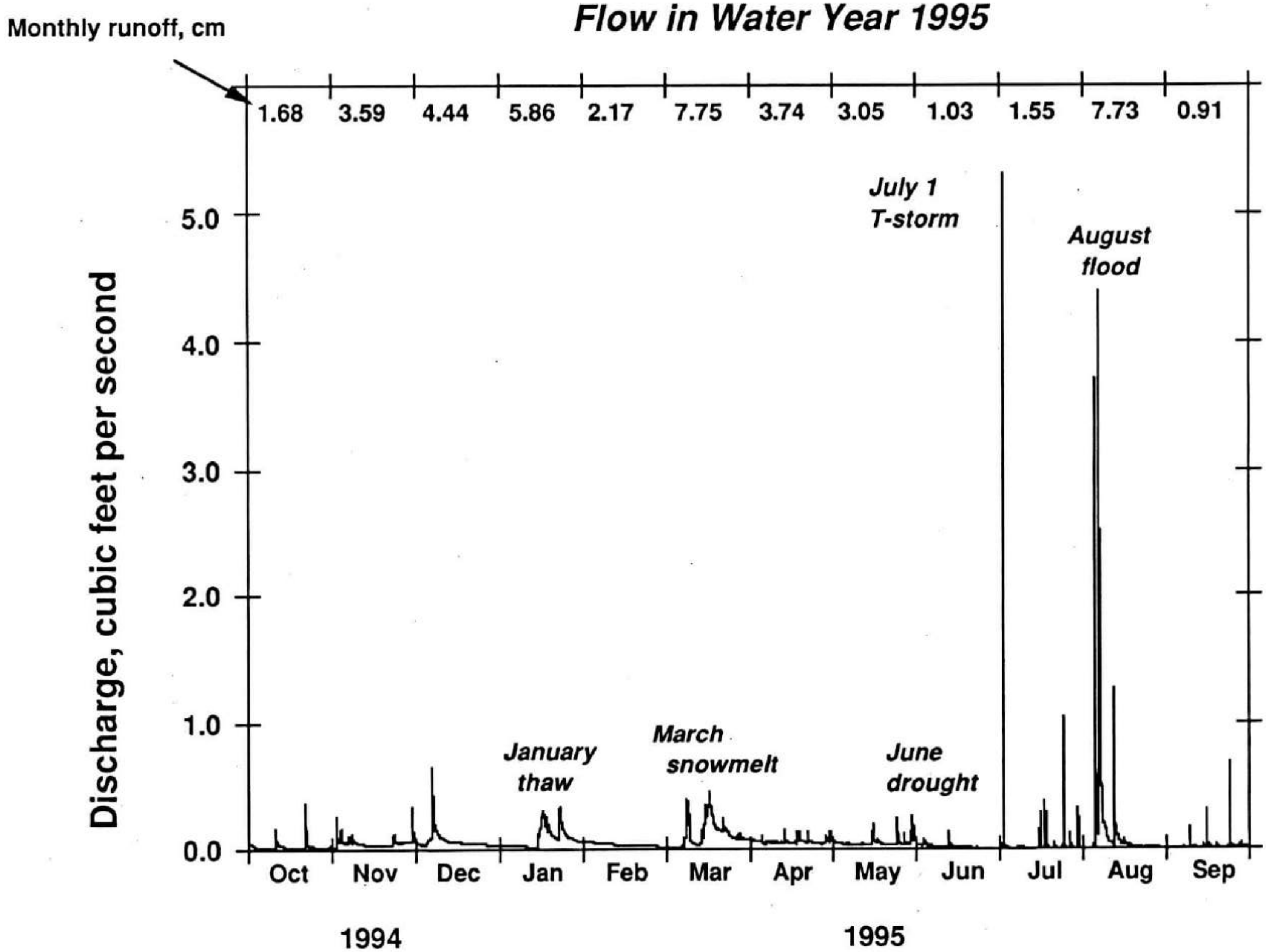
1. Nettle Brook hydrograph for water year 1995. Monthly runoff given across top of plot. Runoff is total flow (L^3) divided by basin area (L^2), giving units of L, which can be directly compared to precipitation amount.

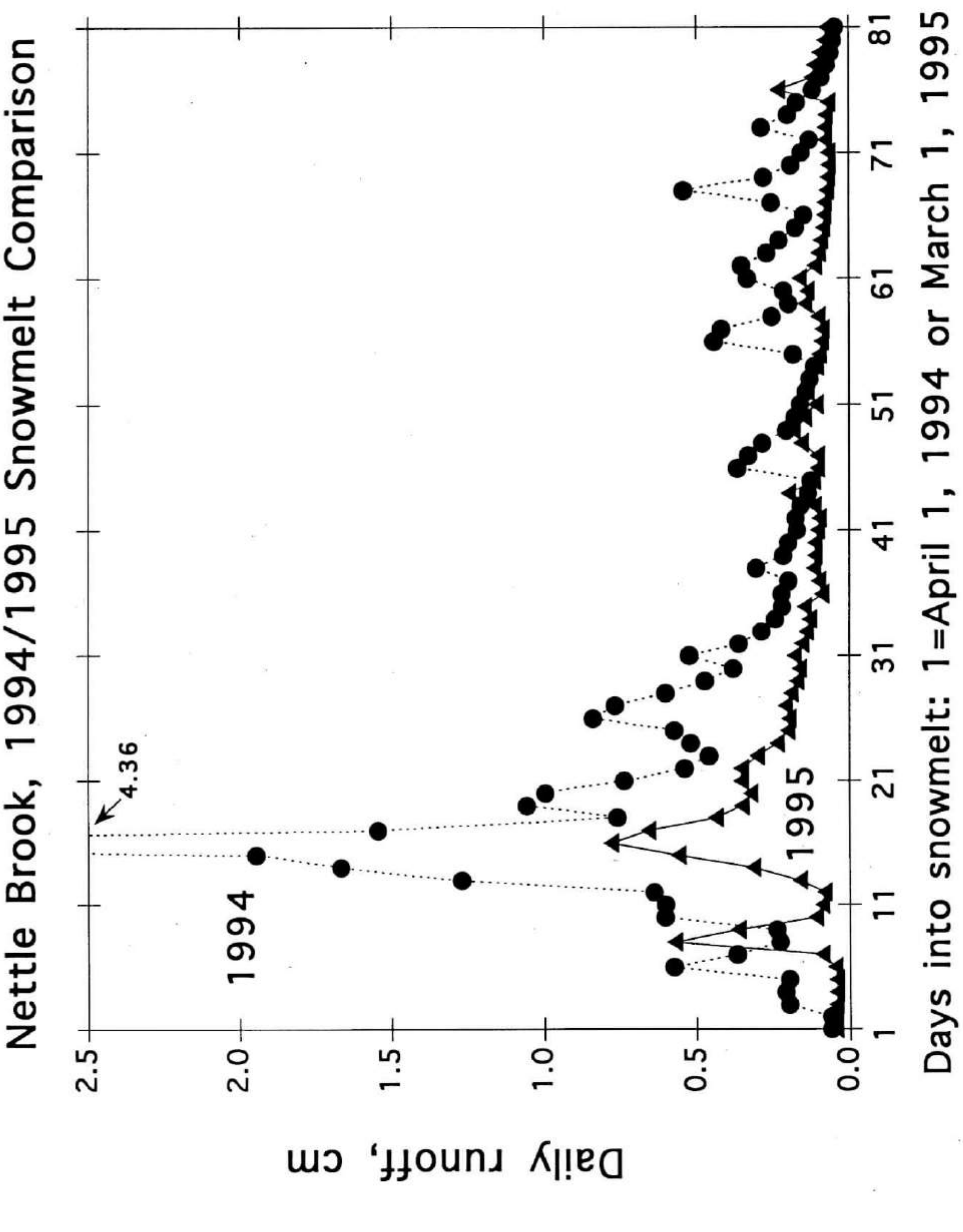
2. Comparison of daily runoff during and after snowmelt in 1994 and 1995. Note 1995 snowmelt began one month earlier, had much smaller peak flows, and was followed by a drought.

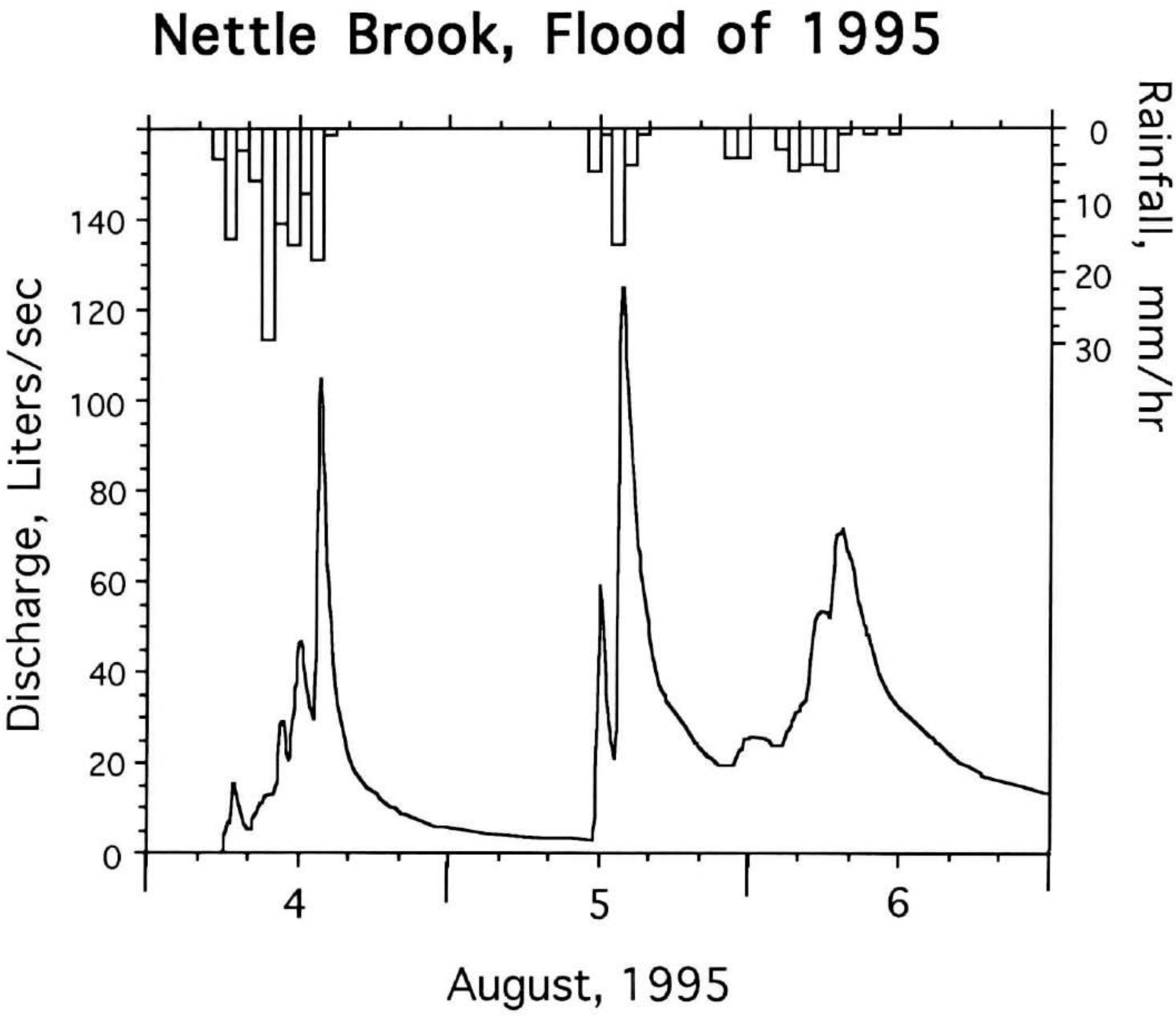
3. Rainfall and discharge for the August, 1995 flood.

Nettle Brook:

Flow in Water Year 1995




Nettle Brook, 1994/1995 Snowmelt Comparison
Daily runoff, cm
2.5
2.0
1.5
1.0
0.5
0.0
1
11
21
31
41
51
61
71
81
4.36
1994
1995
Days into snowmelt: 1=April 1, 1994 or March 1, 1995



Nettle Brook, Flood of 1995
Discharge, Liters/sec
0
20
40
60
80
100
120
140
Rainfall, mm/hr
0
10
20
30
4
5
6
August, 1995

Terrestrial Fauna

Amphibian Monitoring on Mt. Mansfield, Vermont

Stephen C. Trombulak
James Andrews
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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, make them especially well suited as an indicator taxa of changes in environmental conditions in forest environments.

Highlights of our activities and results for 1995 include (1) no young redback salamanders were found in the drift fences at 1,200 and 2,200 feet, (2) few young spotted salamanders were found, (3) many young frogs and toads were found, and (4) patterns of abundance of all amphibians since 1993 appear to be stable or increasing, with the exceptions of redback salamanders and wood frogs, which appear to oscillate.

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 1995 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

Since 1991, three techniques have been 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 from April to June 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. The number of egg masses provide an index of the abundance of adult females of each species. In 1995, 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, and the Lake of the Clouds.

Results and Discussion

Inventory: We have so far identified 13 species of amphibians from this area, from a total possible of 24 species reported from Vermont, 21 of which show evidence of breeding in recent years. The list of species inventoried has not changed since 1992, and we are therefore confident that all species present have been identified from across the elevational range of the study area (Figure 3). Six of these 13 are generally common, being observed or heard on almost all visits when suitable habitat is visited under appropriate conditions:

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.
Northern spring peeper: heard calling regularly from ponds throughout the area, primarily below 2000 feet, but in small numbers as high as 3900 feet.
Spotted salamander: adults found in drift fences at all elevations, on night-time road searches, and egg masses found in the spring in many of the ponds in the area.
Northern two-lined salamander: drift fences and streams up to 3900 feet.
Wood frog: located up to tree line where breeding ponds occur, including Lake of the Clouds at 3,900 feet.

Six species are locally common, being seen regularly in their appropriate habitat:

Gray treefrog: heard calling from ponds, primarily below 2000 feet.
Eastern American toad: concentrated below 2200 feet, but also occasionally found at elevations near 4000 feet.
Northern dusky salamander: found in streams and drift fences at all elevations up to 3,900 feet.
Northern spring salamander: scattered in streams up to 2200 feet.
Green frog: caught regularly at drift fences, mainly below 2000 feet.
Pickerel frog: observed on roads and in drift fences up to about 2,200 feet.

The bullfrog is heard or seen only rarely at sites along Pleasant Valley Road near 1,200 feet.

Population trends: We have only five years of data on these species (1991-95). It is too soon to draw any major conclusions on trends in their demography; however, the following summarizes what we have observed to date for five indicator species.

Spring peepers: commonly caught at drift fences (Tables 1 and 2) and seen or heard during night-time road searches (Tables 3 and 4). They are by far the most common species observed on the roads and had many times the number of choruses (107) of any other species. Data from drift fences and choruses suggest an increase from the previous year (after a decline in 1994), but many fewer young were observed in 1995 than of other anurans (Tables 1 and 7).

Gray treefrogs: not observed at all during night-time road searches in 1995 (Table 4). Twelve calling individuals were noted but no choruses (Table 3). Although the number of calling individuals represents an increase over 1994, it still represents a decline over the five years of study. Populations are probably too small to assess trends without many more years of data, but special attention should be given to this species.

Redback salamanders: commonly found in drift fences (Tables 1 and 2). There was a major decrease in 1995 from the previous year (Table 2), returning their numbers to 1993 levels. Of special note is the absence of any young in the drift fences (Table 1), foretelling possible declines in older age classes in the future.

Spotted salamanders: Twenty-five individuals were found in drift fences (Table 1). Egg masses were located in all of the pools and the Lake of the Clouds, with possible successful hatching at the Proctor Maple Research Center and at the Lake of the Clouds (Table 5). The pH of the Lake of the Clouds (4.6-4.8; Table 6) continues to be close to the lethal pH for this species measured in other studies. The number of egg masses has shown a general increase from 1992 (Table 6).

Wood frogs: commonly observed on night-time road searches and in drift fences (Tables 1, 3, and 4). Wood frogs successfully bred in at least two of the four ponds studied, although the number of egg masses observed declined from the previous year (Tables 5 and 6). Their populations appear to have increased from their dramatic decline in 1994 (Table 2).

In general, results of our monitoring in 1995 indicated that:

1. Reproduction in redback salamanders was not successful that year;
2. With the exception of the spring peeper, reproduction in frogs and toads was general good, with 80% or more of the individuals caught in some species (e.g., American toad, pickerel frog, and green frog) being young of the year;
3. All species of salamanders except the redback salamander show population indices similar to previous years. The redback showed a decline from 1994, returning to its 1993 level.
4. All species of frogs and toads show population indices greater than in previous years. This increase is quite dramatic in the pickerel frog and spring peeper

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 continue to focus exclusively on monitoring the populations and breeding success of amphibians in the area.

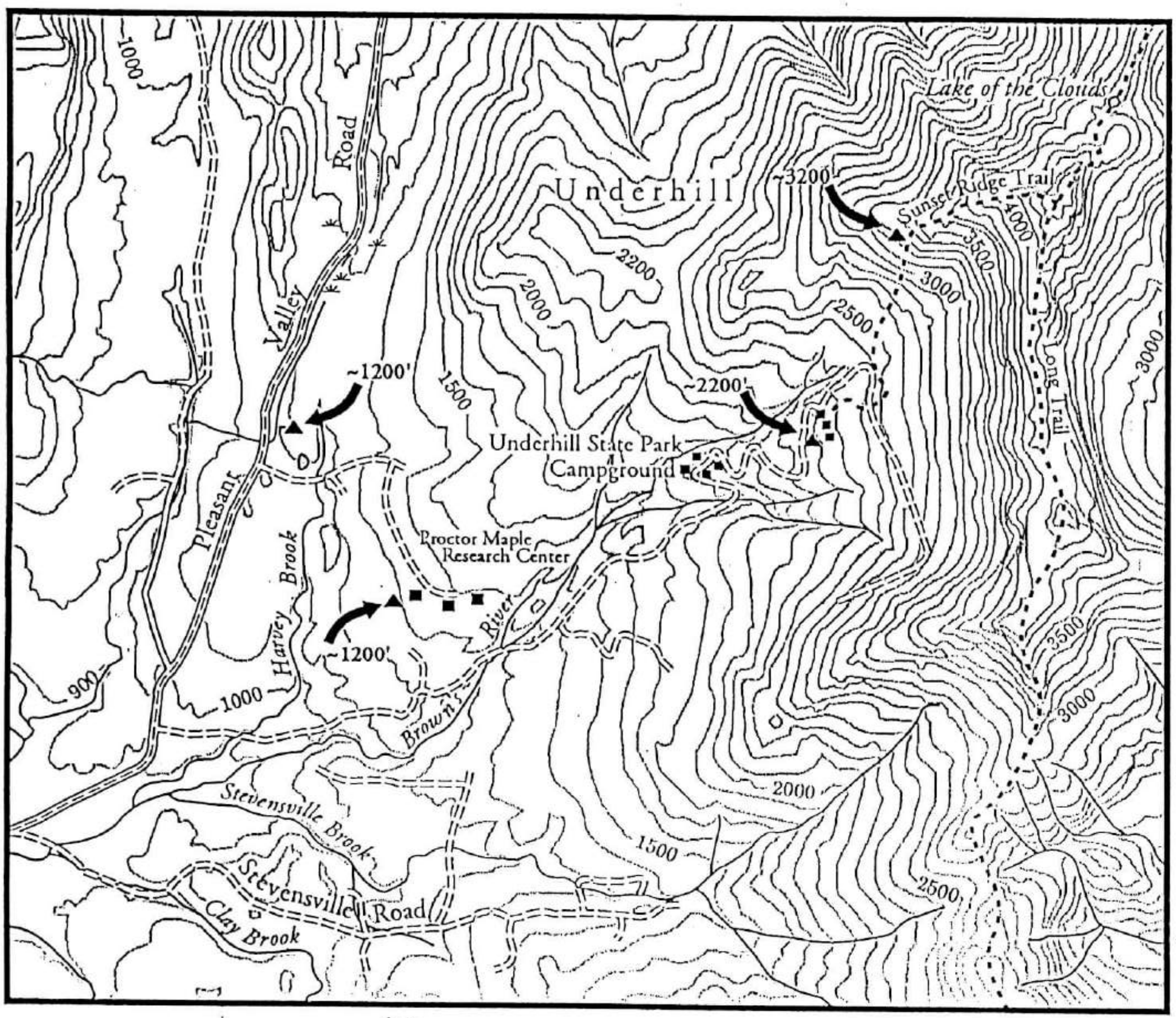
Context

This work on Mount Mansfield is part of a large survey and monitoring effort we are conducting throughout the Green Mountains of Vermont. We have similar sites 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 over many years that long-term trends in the status of amphibian populations over regional spatial scales can be determined.

Acknowledgments

Our work on Mt. Mansfield this year was locally coordinated by Elizabeth Chapek, with the help of Kathleen Ferguson, Theresa Hunt, Josh May, Suzanne Spear, and Kyle Walker. We are extremely grateful for their interest in amphibians at Mt. Mansfield and all their hard work.

Figure 1.



Location of Drift Fences
on
Mount Mansfield
Underhill, Vermont

0 .5 1
kilometers
contour interval 100 feet

▲ Drift fence

N
MN
15°

Figure 2. Night-time road search route; Part 1.

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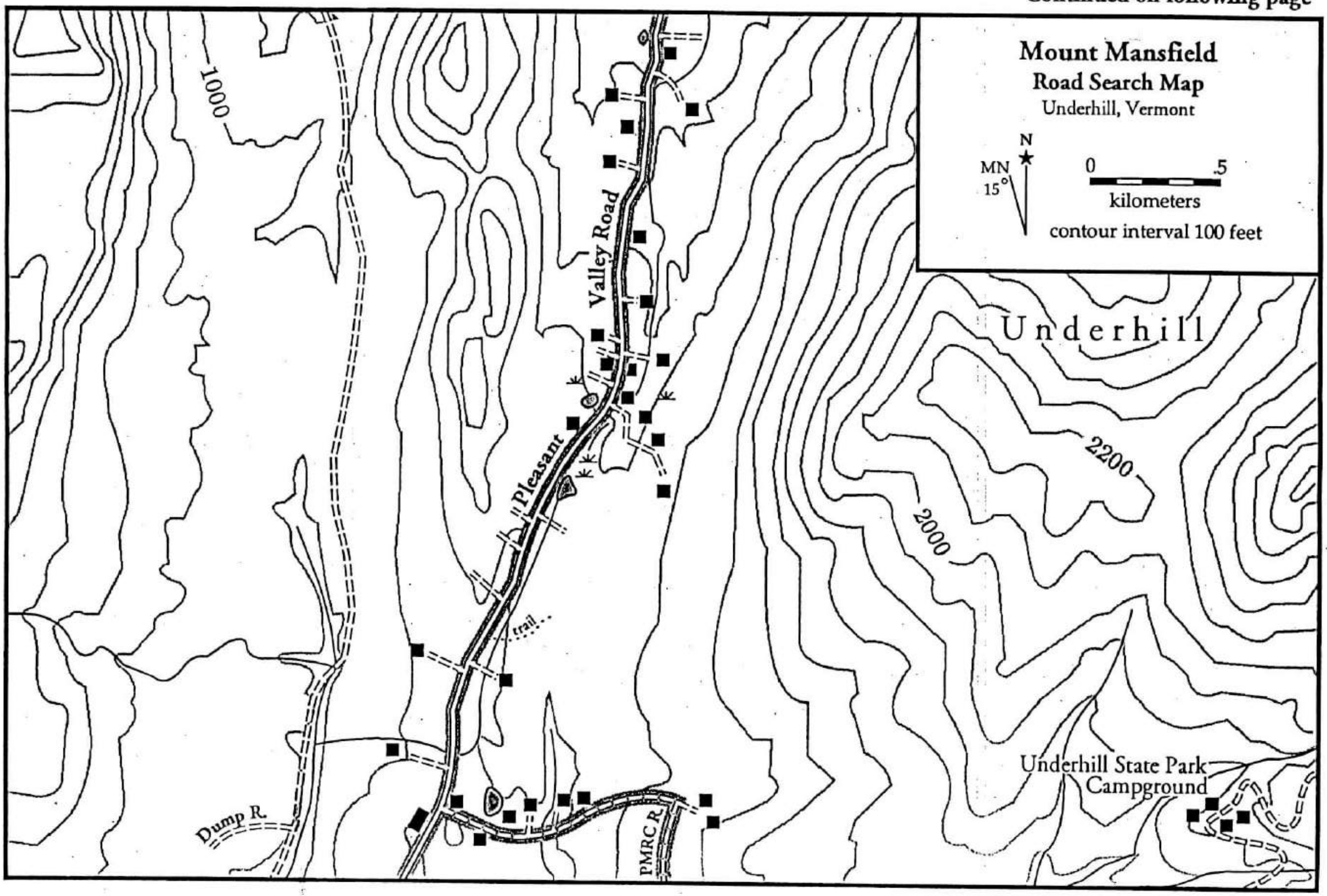

Figure 2. Night-time road search route; Part 2.

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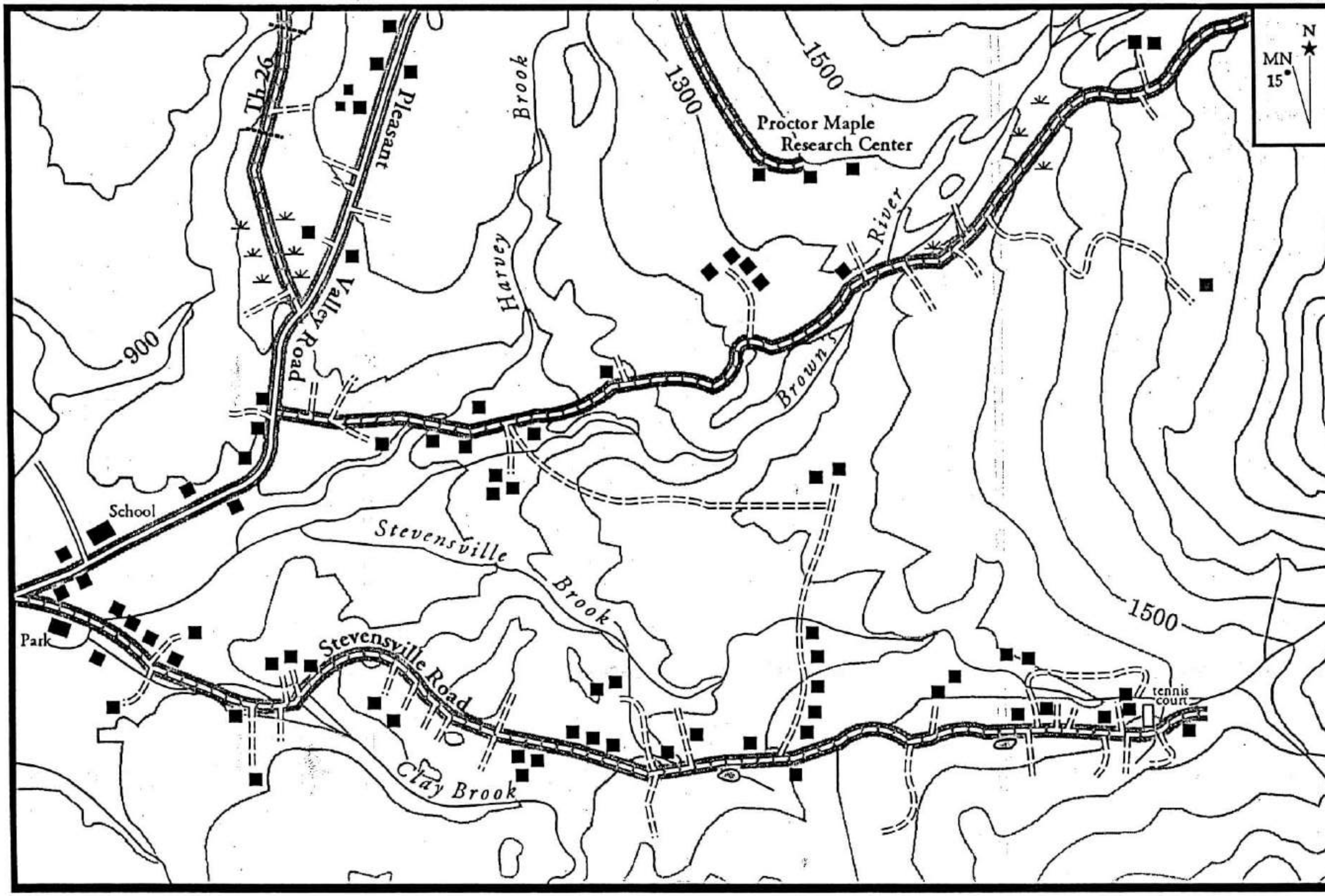

Figure 3. Updated results based on new data gathered since the original 1991 and 1992 amphibian inventory of the western slope of Mt. Mansfield in Underhill and Cambridge Vermont. Thirteen species were located.

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

Underhill State Park

2200 ft. or higher

Ambystoma maculatum
Bufo americanus
Desmognathus fuscus
Eurycea bislineata
Gyrinophilus porphyriticus
Notophthalmus viridescens
Plethodon cinereus
Pseudacris crucifer
Rana sylvatica

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

H. versicolor
R. catesbeiana
R. clamitans
R. palustris

Sunset Ridge

3200 ft. or higher

Ambystoma maculatum
Bufo americanus
Desmognathus fuscus
Eurycea bislineata
Notophthalmus viridescens
Plethodon cinereus
Pseudacris crucifer
Rana sylvatica

Found at 2200 ft. but not located at this elevation or higher.

G. porphyriticus

Lake of the Clouds

3930 ft. or higher

Ambystoma maculatum
Bufo americanus
Desmognathus fuscus
Eurycea bislineata
Notophthalmus viridescens
Pseudacris crucifer
Rana sylvatica

Found at 3200 ft. but not located at this elevation or higher.

P. cinereus

Table 1. Monitoring results from the drift-fences at 1,200 ft. and 2,200 ft. on Mt. Mansfield, Underhill, Vermont during 1995. Three trappings per month in April, May, June, July, September, and October are included (18 trappings).

Species name	# of all ages	# of young of the year	% young of the year[1]	date of first meta-morph[2]	largest adult (total length) in mm	# per trapping[3]	% of group	% of total catch
Salamanders								
Eastern newt	30	13	43	May 25	80	1.7	34	11
Spotted salamander	25	3	12	Sept. 14	204	1.4	28	9
Redback salamander	24	0	0	-----	92	1.3	27	9
Dusky salamander	6	0	0	-----	92	0.3	7	2
Northern two-lined	3	0	0	-----	88	0.2	3	1
Group totals	88	16	18	n/a	n/a	4.9	~100	32
Frogs and Toads								
Wood frog	79	31	39	Sept.6	62	4.4	43	29
Spring peeper	39	3	8	April 29	35	2.2	21	14
American toad	27	25	93	May 13	68	1.5	15	10
Pickerel frog	20	19	95	Sept. 6	50	1.1	11	7
Green frog	17	14	82	July 7	54	0.9	9	6
Group totals	182	92	51	n/a	n/a	10.1	~100	66
Amphibian totals	270	108	40	n/a	n/a	15.0	n/a	~100

[1]For each species individuals under a given total length were considered young of the year. The chosen length was based on the timing of their appearance, gaps in their size continuum and records in the literature. The cutoff sizes used were *A. maculatum* (70 mm). *E. bislineata* (60 mm), *N. viridescens* (45 mm), *P. cinereus* (32 mm), *B. americanus* (32 mm), *P. crucifer* (20 mm), *R. clamitans* (41 mm), *R. palustris* (30 mm), and *R. sylvatica* (33 mm). The maximum size of any year's young is not fixed. However, I have chosen to use these sizes for comparisons.

[2]No trapping took place in August.

[3]Number per trapping are rounded to the nearest 0.1. All other figures are rounded to the nearest whole number.

Table 2. A comparison of drift-fence data from the 1993, 1994, and 1995 field seasons at Mt. Mansfield, Underhill, Vermont using all data from the 1,200 ft. and 2,200 ft. drift fences.

Species name	Common name	# per trapping[1]			% of group catch		
		93	94	95	93	94	95
Caudates (Salamanders)							
Ambystoma maculatum	Spotted salamander	1.7	1.0	1.4	12	10	9
Desmognathus fuscus	Dusky salamander	0.3	0.3	0.3	2	3	2
Eurycea bislineata	Northern two-lined salamander	0.5	0.1	0.2	4	1	1
Gyrinophilus porphyriticus	Spring salamander	< 0.1	0.0	0.0	< 1	0	0
Notophthalmus viridescens	Eastern newt	1.3	1.2	1.7	10	12	11
Plethodon cinereus	Redback salamander	1.2	4.2	1.3	9	40	9
Group totals		5.1	6.8	4.9	38	66	32
Anurans (Frogs and Toads)							
Bufo americanus	American toad	0.7	0.6	1.5	5	5	10
Pseudacris crucifer	Spring peeper	1.7	1.1	2.2	13	10	14
Rana clamitans	Green frog	< 0.1	0.2	0.9	< 1	2	6
Rana palustris	Pickerel frog	0.1	0.0	1.1	1	0	7
Rana sylvatica	Wood frog	5.6	1.7	4.4	42	16	29
Group totals		8.2	3.6	10.1	62	33	66
	Totals	13.4	10.4	15.0	~100	~100	~100

[1]Number per trapping are rounded to the nearest 0.1. All other figures are rounded to the nearest whole number. There were a total of 15 trappings counted in 1993, 14 in 1994, and 18 in 1995. Trappings counted are those nights where at least two of the three lower traps were opened under appropriate weather conditions for amphibian movement.

Table 3. A comparison of the number of choruses and calling anurans surveyed during night-time road searches from April through July in 1993, 1994, and 1995. Data from six searches in 1993, five searches in 1994, and seven searches in 1995 are included.

Species	# of total choruses[1]			size of choruses[2]			# per NTRS[3]			% of total choruses		
	1993	1994	1995	1993	1994	1995	1993	1994	1995	1993	1994	1995
Bufo americanus American toad	0	1	2	C-4 0-0 L-0 M-0 H-0	C-2 0-0 L-1 M-0 H-0	C-15 0-0 L-0 M-0 H-2	0.0	0.2	0.3	0	1	2
Hyla versicolor Gray tree frog	4	0	0	C-7 O-0 L-3 M-1 H-0	C-6 O-0 L-0 M-0 H-0	C-12 0-0 L-0 M-0 H-0	0.7	0.0	0.0	5	0	0
Pseudacris crucifer Spring peeper	73	56	107	C-38 O-5 L-27 M-37 H-4	C-15 O-6 L-12 M-33 H-5	C-12 0-2 L-17 M-49 H-39	12.0	11.2	15.3	89	80	86
Rana catesbeiana Bullfrog	0	0	0	C-0 O-0 L-0 M-0 H-0	C-0 O-0 L-0 M-0 H-0	C-7 0-0 L-0 M-0 H-0	0.0	0.0	0.0	0	0	0
Rana clamitans Green frog	0	0	0	C-3 O-0 L-0 M-0 H-0	C-2 O-0 L-0 M-0 H-0	C-12 0-0 L-0 M-0 H-0	0.0	0.0	0.0	0	0	0
Rana sylvatica Wood frog	5	13	16	C-0 O-0 L-5 M-0 H-0	C-6 O-2 L-7 M-4 H-0	C-12 0-4 L-1 M-6 H-5	0.8	2.6	2.3	5	19	13
Totals	82	70	125	C-52 O-5 L-35 M-38 H-4	C-31 O-8 L-20 M-37 H-5	C-70 0-6 L-18 M-55 H-46	13.6	14.0	17.9	100	100	100

[1]not including calling individuals

[2]C = a calling individual
O = a chorus with occasional vocalizations
L = a continuous chorus of low intensity
M = a continuous chorus of medium intensity
H = a continuous chorus of high intensity

[3]Number per NTRS are rounded to the nearest 0.1. All other figures are rounded to the nearest whole number.

Table 4. Night-time road search data from Mt. Mansfield, Underhill, Vermont, based on surveys from April through June in 1993, 1994, and 1995. All calling anurans are excluded from this table. Six searches took place during this time period in 1993, five during 1994, and seven during 1995.

Species name	# of ind.			# per NTRS[1]			% of total		
	1993	1994	1995	1993	1994	1995	1993	1994	1995
Caudates (salamanders)									
Ambystoma maculatum Spotted salamander	6	3	19	1.0	0.6	2.7	4	2	8
Desmognathus fuscus Dusky salamander	0	0	1	0.0	0.0	0.1	0	0	<1
Eurycea bislineata N. two-lined salamander	0	0	1	0.0	0.0	0.1	0	0	<1
Gyrinophilus porphyriticus Spring salamander	0	1	1	0.0	0.2	0.1	0	1	<1
Notophthalmus viridescens Eastern newt	24	9	29	4.0	1.8	4.1	14	7	12
Plethodon cinereus Redback salamander	0	0	1	0.0	0.0	0.1	0	0	<1
Group total	30	13	52	5.0	2.6	7.4	18	9	21
Anurans (frogs and toads)									
Bufo americanus American toad	25	38	45	4.2	7.6	6.4	15	28	18
Hyla versicolor Gray treefrog	3	4	0	0.5	0.8	0.0	2	3	0
Pseudacris crucifer Spring peeper	44	52	96	7.3	10.4	13.7	26	38	39
Rana catesbeiana Bullfrog	1	0	2	0.2	0.0	0.3	1	0	1
Rana clamitans Green frog	5	3	11	0.8	0.6	1.6	3	2	4
Rana palustris Pickerel frog	3	2	5	0.5	0.4	0.7	2	1	2
Rana sylvatica Wood frog	60	26	34	10.0	5.2	4.9	35	19	14
Group total	141	125	193	23.5	25.0	27.6	82	91	79
Grand total	171	138	245	28.5	27.6	35.0	100	100	100

[1]Number per NTRS are rounded to the nearest 0.1. All other figures are rounded to the nearest whole number.

Table 5. Spring 1995 egg mass data from Mt. Mansfield, Underhill, Vermont.

Location/Date	Number of *A. maculatum* egg masses	Number of *R. sylvatica* egg masses	Mean pH N = 3	Site Notes
West bank of Harvey Brook				
April 13	0	0	-----	beaver dam
May 8	0	0	-----	broken and
June 7	not	checked	-----	deserted
Vernal pool below PMRC				
April 13	0	4	-----	*A. mac.* spermatophores, water level low
May 8	16	36 (some hatched)	5.2	
June 7	13 (on pool bottom)	0	-----	dry, some embryos still alive
June 25	0	0	-----	dry
Pond behind sugar shack at PMRC				
April 13	0	81	-----	some appeared to have been frozen, many nonviable
May 8	4	100 (1000's of tadpoles)	5.5[1]	very shallow
June 7	2	6	5.0	
June 25	0	0	-----	almost entirely dry
Lake of the Clouds[2]				
May 16	0	7	4.8	fresh beaver activity
June 7	32 (hatched)	20 (fresh)	4.7	
June 21	12 (many tadpoles)	2 (some hatched)	4.6	

[1]N=4
[2]Including the adjacent pool along the trail

Table 6. A comparison of egg mass and pH data from 1992-1995 on Mt. Mansfield.

Site	*Ambystoma maculatum*				*Rana sylvatica*				Range of mean pH			
	'92	'93	'94	'95	'92	'93	'94	'95	'92	'93	'94	'95
West Bank, Harvey Brook	7	9	1	0	0	0	0	0	----	6.9	----	----
Vernal Pool below PMRC	18	12	38	16	36	36	72	36	----	4.3-5.1	4.6-5.1	5.2
Sugar Shack Pond at PMRC	3	6	6	4	----	82	150	100	4.4	4.8-6.2	5.2-5.6	5.0-5.5
Lake of the Clouds	2	12	14	32	22	46	6	20	4.6	4.9-5.0	4.7-4.9	4.6-4.8
Combined totals[1]	30	39	59	52	58	164	228	156	4.4-4.6	4.3-6.2	4.6-5.6	4.6-5.5

[1]Not including pH data from Harvey Brook

Table 7. Species for which all indices indicated nonconflicting population trends between 1994 and 1995. Only those species whose populations were measured by more than one index are shown.

Species	Drift fences	NTRS choruses	NTRS individuals
Caudates (salamanders)			
Notophthalmus viridescens Eastern newt	up 0.5	n/a	up 2.3
Anurans (Frogs and Toads)			
Pseudacris crucifer Spring peeper	up 1.1	up 4.1	up 3.3
Rana palustris Pickerel frog	up 1.1	no change	up 0.3

FALL MIGRANT LANDBIRD STOPOVER IN SUBALPINE SPRUCE-FIR FOREST, MOUNT MANSFIELD, VERMONT

Progress Report 1995

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Abstract: The stopover ecology of fall migrant landbirds on Mt. Mansfield, Vermont was examined through standardized mist-netting and banding in 1995. We captured 948 individuals of 51 species during 11 weeks of banding. Peak waves of migrants occurred from late September through mid-October. 1). Over 77% of captures were of HY (hatching year) birds. Blackpoll Warbler (*Dendroica striata*) was the only species not exhibiting a strong HY bias. Unexpectedly high numbers of immature Black-throated Blue Warblers *(Dendroica cearulescens)*, a species that breeds in northern hardwoods forests, were captured during August and September. Regular searches of areas below tranmission towers on Mt. Mansfield and Mt. Ascutney yielded only three dead birds, a Myrtle Warbler (*Dendroica coronata*) and a Hairy Woodpecker *(Picoides villosus)* on Mt. Mansfield, and a Blackpoll Warbler on Mt. Ascutney.

Introduction

Most passerines breeding in eastern Canada and the northeastern U.S. migrate to lower latitudes during late summer and fall. The ability of migrants to offset the energetic costs of migration may depend on the availability and quality of suitable stopover habitat to satisfy intensive energy demands, successfully avoid predators, and survive inclement weather conditions (Moore and Simons 1992). Few studies have examined the use and importance of subalpine forests in the northeastern U. S. for post-breeding dispersal and migratory stopover by landbirds. During the fall of 1995 we examined the diversity and relative abundance of migrant landbirds using the subalpine spruce-fir forest of Mt. Mansfield, Vermont.

Methods

The study area (ca. 10 ha) was located on the summit ridgeline of Mt. Mansfield, Vermont in subalpine spruce-fir at 1,095 to 1,160m elevation. A narrow dirt access road, small dirt parking lot and several hiking trails transversed the area. Several small, open grassy areas were located around the parking lot. During the fall of 1995 (2 Aug through 13 Oct) we operated 10-15 nylon mist nets (ATX, 12 x 2.6m, 4 panels, 36 mm extended mesh) at fixed locations. Nets were opened five days a week for six hours, beginning 0.5 hr before sunrise. Nets were closed under adverse weather conditions. Frequent high winds on the ridgeline forced the regular closure of some nets in exposed sites and on the western slope of the study area. Each captured bird was banded with a USFWS metal band. Detailed mensural (e.g., wing chord, weight) and body condition (e.g., subcutaneous fat, molt, feather wear) data, as well as sex and age, were recorded for all captured birds. Records of net opening and closing times, weather, and general levels of avian activity were kept.

We monitored two transmission tower sites on the ridge for possible migrant collisions. One tower was situated on a high point of the ridgeline and rose approximately 25m high. The second tower was located near the base of a north-facing cliff on the ridgeline and was about 45m high. Neither tower was lighted. At dawn on each morning of mist net operation, observers systematically searched areas under the towers for dead or injured birds. Searches were conducted at dawn to avoid the possible loss of downed birds from predators or scavengers. For comparative purposes, we also searched two transmission towers on Mt. Ascutney in central Vermont on 8 mornings in September and early October. One tower was located on the summit and rose approximately 20m high and another tower was at a slightly lower elevation on the southeast side of the mountain. It had several red flashing lights and was approximately 50m tall.

Results and Discussion

We captured 948 individuals of 51 species during 11 weeks of banding (Table 1). Peak waves of migrants occurred at the end of September and through mid-October (Fig. 1). Over 77% of captures were of HY (hatching year) birds. The only species not exhibiting a strong HY bias was the Blackpoll Warbler. During August 88% of Blackpoll Warblers captured were HY individuals, but during this species' main migration period in September 59% of captures were of AHY birds. This suggests that most Blackpoll Warblers captured during August were locally-fledged or undergoing post-fledging dispersal. Alternatively, HY Blackpoll Warblers may initiate southward migration earlier than adults or may follow different migratory routes. Another noteworthy result was the relatively high proportion of Black-throated Blue Warblers in our overall sample (Table 1). This species, which nests in northern hardwoods forests, appeared to undergo a pronounced post-breeding dispersal into Mt. Mansfield's subalpine zone. HY birds outnumbered AHY individuals 68 to 3.

Based on a single morning's mist-netting on Mt. Mansfield during the fall of 1994 we expected to encounter greater numbers of passage migrants in 1995. On 14 September 1994, following a night of low clouds, rain and warm southerly air flow, we noted a major influx of migrants on the ridgeline. We captured >100 birds of 20 species using 13 nets for less than 4 hours. We observed hundreds of birds moving through the forest, with activity especially prominent about two hours after dawn. In 1995, despite netting on 4-5 mornings per week into mid-October, we did not observe a similar large influx of passage migrants. We did note that berry crops, especially of mountain ash (*Pyrus americana*), were abundant in 1994 and scarce in 1995. While it is possible that the influx of migrants we observed in 1994 may have sought out the food resources on Mt. Mansfield's ridgeline after making dawn landfall in other habitats, we suspect that we witnessed a true "fall out" event. However, we do not know whether this was an isolated, atypical occurrence, or whether fluctuating food resources in subalpine forests may determine their use by fall migrants. More detailed data collection over a longer time period will be necessary to examine the stopover ecology of migrant landbirds at high elevations.

Our searches of areas below transmission towers on Mt. Mansfield and Mt. Ascutney yielded only three dead birds. On Mt. Mansfield a Myrtle Warbler was found on 12 October, and a Hairy Woodpecker was found on 1 August. A Blackpoll Warbler was found dead on Mt. Ascutney on 21 September under the lower elevation tower. Although preliminary evidence suggests that high elevation communications towers may not be a significant source of mortality to migrating landbirds, we believe that more data are needed. We plan to expand our searches on Mt. Mansfield to include several other towers in 1996.

Future Plans

We plan to continue operation of the fall migration banding station on Mt. Mansfield, with an increase in the number of mist nets used to 20. We will expand the communications tower mortality study on Mt. Mansfield to include several additional existing towers south of the "Forehead". An effort will be made to enlist volunteer observers to conduct regular surveys below towers on other Vermont peaks during the fall of 1996.

Acknowledgments

We thank Dan Lambert and Jim Chace for field assistance. Rob Apple of the Mt. Mansfield Company provided logistical assistance, and the staff of Ascutney State Park allowed us access to the Mt. Ascutney toll road. Funding for this work was provided by the U.S. Fish and Wildlife Service, the U.S. Forest Service Northeast Experimental Station, the National Fish and Wildlife Foundation, and the Vermont Community Foundation.

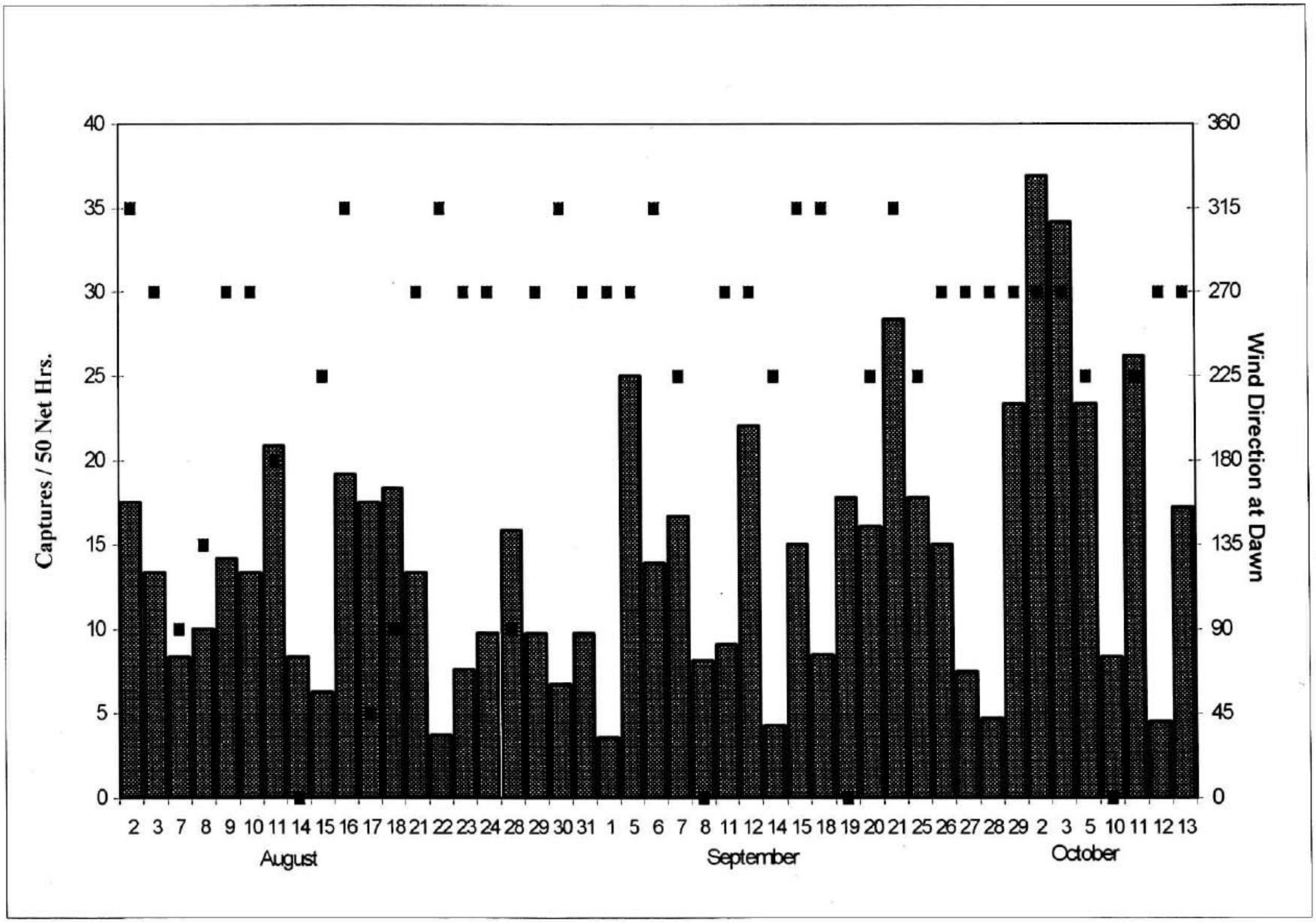

Figure 1. Number of captured individuals each day per 50 net hours (left axis, bars) and wind direction at sunrise (right axis, squares).

Table1. Fall migrant capture data presented by month and age on Mt. Mansfield, Vermont, 1995.

	August				September				October				Grand Total
Species	0	1	2	Total	0	1	2	Total	0	1	2	Total	
Myrtle Warbler	1	8	16	25	1	13	63	77	1	12	53	66	168
Blackpoll Warbler	0	7	54	61	0	44	31	75	1	0	0	1	137
Slate-colored Junco	0	0	23	23	0	6	36	42	0	24	18	42	107
Ruby-crowned Kinglet	0	2	3	5	1	20	23	44	30	1	13	44	93
Black-throated Blue Warbler	2	2	42	46	1	1	26	28	1	0	0	1	75
Golden-crowned Kinglet	0	1	5	6	1	1	26	28	9	1	25	35	69
White-throated Sparrow	0	4	7	11	0	14	18	32	13	0	7	20	63
Black-capped Chickadee	1	0	1	2	3	0	20	23	0	0	6	6	31
Black-thr. Green Warbler	0	1	9	10	0	0	8	8	0	0	0	0	18
Ovenbird	0	0	11	11	0	1	4	5	0	0	0	0	16
Swainson's Thrush	0	1	4	5	0	1	9	10	0	0	0	0	15
Magnolia Warbler	0	1	5	6	0	1	6	7	0	0	0	0	13
Red-breasted Nuthatch	0	5	3	8	0	3	0	3	0	0	1	1	12
Hermit Thrush	0	1	1	2	1	0	0	1	0	5	4	9	12
Red-eyed Vireo	0	0	3	3	0	0	9	9	0	0	0	0	12
American Robin	0	1	1	2	0	0	0	0	0	4	3	7	9
Blackburnian Warbler	0	0	4	4	0	0	4	4	0	0	0	0	8
Nashville Warbler	1	0	2	3	0	1	3	4	0	0	0	0	7
Chestnut-sided Warbler	0	0	4	4	0	0	2	2	0	0	0	0	6
Black and White Warbler	0	0	5	5	0	0	1	1	0	0	0	0	6
Canada Warbler	0	1	4	5	0	0	0	0	0	0	0	0	5
Downy Woodpecker	1	1	0	2	0	1	0	1	0	1	0	1	4
Brown Creeper	0	0	0	0	0	1	1	2	2	0	0	2	4
Bicknell's Thrush	0	0	0	0	0	1	3	4	0	0	0	0	4
Rose-breasted Grosbeak	0	0	4	4	0	0	0	0	0	0	0	0	4
White-crowned Sparrow	0	0	0	0	0	1	2	3	0	1	0	1	4
Blue Jay	0	0	0	0	0	1	2	3	0	0	0	0	3
Veery	0	0	1	1	0	0	2	2	0	0	0	0	3
Solitary Vireo	0	0	0	0	0	0	3	3	0	0	0	0	3
American Redstart	0	0	3	3	0	0	0	0	0	0	0	0	3
Purple Finch	0	1	2	3	0	0	0	0	0	0	0	0	3
Yellow-bellied Sapsucker	0	0	0	0	0	0	0	0	2	0	0	2	2
Hairy Woodpecker	0	0	0	0	1	0	1	2	0	0	0	0	2
Northern Flicker	0	0	0	0	0	2	0	2	0	0	0	0	2
Yellow-bellied Flycatcher	0	0	1	1	0	0	1	1	0	0	0	0	2
Winter Wren	0	1	1	2	0	0	0	0	0	0	0	0	2
Cedar Waxwing	0	2	0	2	0	0	0	0	0	0	0	0	2
Yellow Palm Warbler	0	0	0	0	0	0	0	0	0	0	2	2	2
Mourning Warbler	0	0	2	2	0	0	0	0	0	0	0	0	2
Song Sparrow	0	0	2	2	0	0	0	0	0	0	0	0	2
Lincoln Sparrow	0	0	0	0	0	0	2	2	0	0	0	0	2
Baltimore Oriole	0	0	2	2	0	0	0	0	0	0	0	0	2
Sharp-shinned Hawk	0	0	0	0	0	0	1	1	0	0	0	0	1

Table 2. Continued.

Species	August 0	August 1	August 2	August Total	September 0	September 1	September 2	September Total	October 0	October 1	October 2	October Total	Grand Total
White-breasted Nuthatch	0	0	0	0	0	0	1	1	0	0	0	0	1
American Pipit	0	0	0	0	0	0	1	1	0	0	0	0	1
Tennessee Warbler	0	1	0	1	0	0	0	0	0	0	0	0	1
Northern Parula	0	0	0	0	0	0	1	1	0	0	0	0	1
Bay-breasted Warbler	0	0	0	0	0	0	1	1	0	0	0	0	1
Common Yellowthroat	1	0	0	1	0	0	0	0	0	0	0	0	1
Chipping Sparrow	0	0	1	1	0	0	0	0	0	0	0	0	1
White-winged Crossbill	0	0	1	1	0	0	0	0	0	0	0	0	1
Total Captures	7	41	227	275	9	113	311	433	59	49	132	240	948
Total Net Hrs.	1088				1450.5				576				3114.5
Captures/500 Net Hrs.	3.2	18.8	104.3	126.4	3.1	39.0	107.2	149.3	51.2	42.5	115.0	208.3	152.2

Literature Cited

Moore, F.R. and T.R. Simons. 1992. Habitat suitability and stopover ecology of neotropical landbird migrants. Pages 143-171 in Ecology and Conservation of Neotropical Migrant Landbirds, Hagan, J.M. and D.W. Johnston, eds. Washington: Smithsonian Inst. Press.

FOREST BIRD SURVEYS ON MT. MANSFIELD AND UNDERHILL STATE PARK

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Abstract: Censuses of breeding bird populations on two Mount Mansfield sites were conducted for a fifth year in 1995. One site in Underhill State Park at ca. 2200 ft elevation consisted of mature northern hardwoods, while the second site on the Mt. Mansfield ridgeline at ca. 3800 ft elevation consisted of subalpine spruce-fir. Ten-minute counts at each of 5 sampling points in the two habitats were conducted twice during June. Nineteen species were recorded at Underhill State Park, with a maximum of 141 individuals (101 in 1994) on 23 June and a mean of 127.5 (90.5 in 1994) for both visits. Thirteen species were recorded on Mt. Mansfield, with a maximum of 115 individuals (81 in 1994) on 9 June and a combined mean of 106.5 (68 in 1994). Species diversity and numerical abundance were significantly higher at both Underhill State Park and Mt. Mansfield in 1995 than in 1994. The reasons for these changes, whether reflecting actual changes in bird populations or an artifact of differing sampling conditions between the two years, are not entirely clear.

FOREST BIRD SURVEYS ON MT. MANSFIELD AND UNDERHILL STATE PARK

1995 REPORT TO THE VERMONT MONITORING COOPERATIVE

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In 1995, breeding bird censuses were conducted for a fifth consecutive year at 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 1995, VINS has selected, marked and censused 17 permanently protected sites of mature forest habitat in Vermont (Appendix 1). 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.

Survey methods were identical to those in previous years. 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 Microsoft Excel 5.0. Vegetation sampling was completed at each census point on the Mt. Mansfield plot using a technique modified after the standard James and Shugart method. In 1995 this sampling technique was initiated at six other FBMP sites, and will be used at the Underhill State Park site as well as at VINS' nine other monitoring sites over the next two years.

On Mt. Mansfield, overall numerical abundance and species diversity were up from last year's four-year minimum (Table 1). Thirteen species were recorded on 22 June, with a maximum of 115 individuals (81 in 1994) on 9 June and a mean of 106.5 (68 in 1994) for both visits (Table 2). However, it should be noted that Pine Siskin and White-winged Crossbill, which are irregular breeders in this habitat and may have been non-breeders when counted, inflated the totals. By removing these two species from the 1995 totals (n=30), overall numbers were the second lowest since 1991. Of the ten species recorded in each year since 1991, six showed increases over 1994 totals, but only five were above the four-year average. Numbers of three of the five most common species, Winter Wren, Bicknell's Thrush, and White-throated Sparrow increased over 1994's totals (Table 1). Blackpoll Warbler numbers however, remained at a five-year low for the second consecutive year, and Yellow-rumped Warbler numbers dropped to equal the previous low of 1993. Purple Finch was absent from the census for the first time in 1995, while White-winged Crossbill was recorded for the first time.

Winter Wren populations rebounded slightly from a downward trend recorded between 1991-1994 on Mt. Mansfield. Similarly, at Underhill State Park, the species recovered dramatically from a two-year decline. Winter Wren numbers at VINS' other high elevation spruce-fir site on Camel's Hump however, continued on a downward trend that began in 1991. Both Blackpoll and Yellow-rumped warblers have shown steady downward trends since 1991 on Mt. Mansfield (Fig. 1). The decline for Blackpoll Warbler was significant (P=0.01).

At Underhill State Park, overall numerical abundance and species diversity were at a five-year high in 1995 (Table 3). Twenty species were recorded, with a maximum of 141 individuals (101 in 1994) on 23 June and a mean of 127.5 (90.5) for both visits (Table 4). Only Canada Warbler was below its 1991-1994 average, while 13 species were above their average for this period. Of the five species that have been recorded in each year since 1991, three were observed at or above their maximum counts. Populations of both Red-eyed Vireo and Ovenbird have increased significantly over the last five years (Fig. 1), P=0.01 and P=0.05, respectively. Canada Warbler, which had increased steadily since 1991, dropped to a five-year low in 1995. Winter Wren however, which had shown an average annual decline of 59% at Underhill State Park since 1992, increased significantly in 1995.

Both the declines on Mt. Mansfield and the increases at Underhill State Park must be interpreted cautiously. With only 5 years of data available, detection of meaningful population trends is not yet possible. Changes in population trends may simply reflect natural fluctuations and/or variable detection rates. Census data may be particularly susceptible to variation in detectability on Mt. Mansfield, where weather conditions are often extreme or subject to rapid change. Natural populations are also dependent on a variety of dynamic factors, such as local prey abundance, overwinter survival, and habitat change. However, the steady decline recorded among most high elevation species on Mt. Mansfield warrants concern in light of documented threats to subalpine spruce-fir forests throughout the Northeast. Several years of additional data collection, their correlation with other VMC data, and comparison with census data from other ecologically similar sites will be necessary to elucidate population trends of various species at the Mansfield and Underhill sites.

Future plans include continued monitoring at both sites, as well as detailed sampling of habitat characteristics at Underhill State Park. Analysis of VINS' seven-year forest bird monitoring database was initiated in 1995 and will be completed in 1996. This should enable future comparisons among sites and habitat types, information that will be critical to evaluating the significance of results from Mt. Mansfield and Underhill State park. Funding for VINS' 1995 work at these two sites was provided in large part by the VMC. Support for monitoring at VINS' additional 15 Vermont forest bird study sites was provided by VINS' general operating budget.

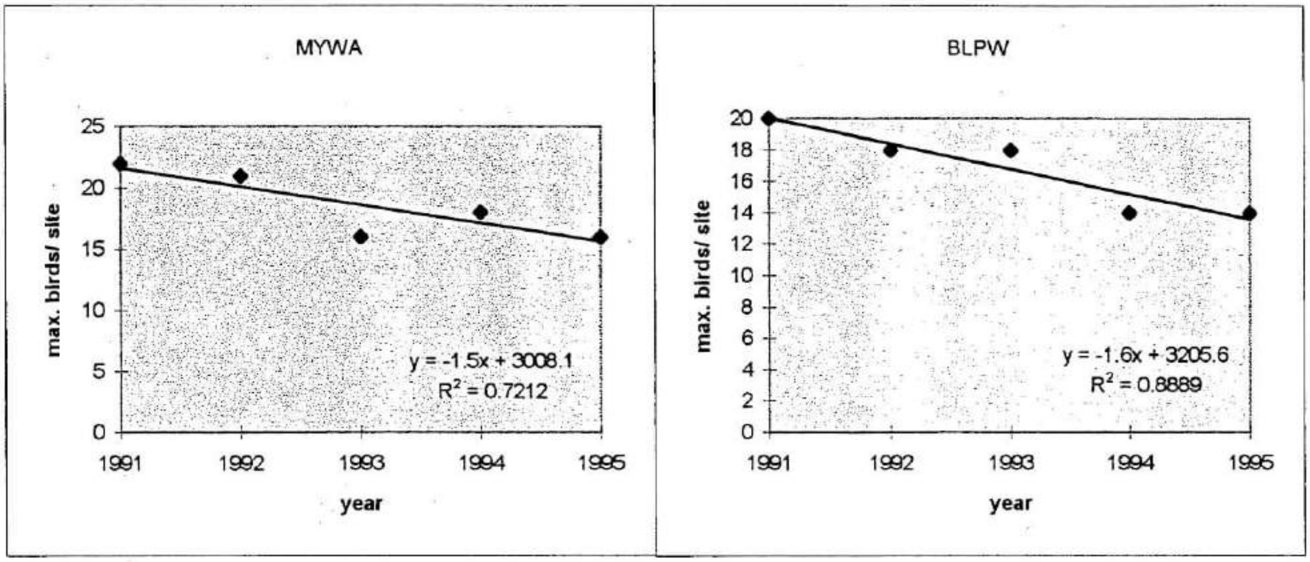
Appendix 1. Vermont Forest Bird Monitoring Sites - 1995

Site	Town	Habitat	Observer
1. Sandbar WMA	Milton	Floodplain	M. LaBarr
2. Pease Mountain	Charlotte	Oak-hickory	S. Staats
3. Cornwall Swamp	Cornwall	Maple Swamp	C. Darmstadt
4. Shaw Mountain	West Haven	Oak-hickory	S. Morrical
5. Galick Preserve	West Haven	Hemlock-pine	N. Swanberg
6. Sugar Hollow	Pittsford	N. Hardwoods	S. Faccio
7. The Cape	Chittenden	N. Hardwoods	S. Faccio
8. Dorset Bat Cave	E. Dorset	N. Hardwoods	R. Stewart
9. Roy Mountain WMA	Barnet	Cedar-spruce	C. Rimmer
10. Concord Woods	Concord	N. Hardwoods	C. Rimmer
11. May Pond Preserve	Barton	N. Hardwoods	T. Gaine
12. Wenlock/Buxton's	Ferdinand	Spruce-fir	C. Darmstadt
13. Bear Swamp	Wolcott	Spruce-fir	B. Pfeiffer
14. Underhill S.P.	Underhill	N. Hardwoods	C. Darmstadt
15. Mt. Mansfield	Stowe	Subalpine	C. Rimmer
16. Camel's Hump	Huntington	Subalpine	C. Fichtel
17. Merck Forest	Rupert	Maple-beech-oak	T. Johansson

Table 1. Maximum counts of individual birds recorded on Mt. Mansfield site, 1991-1995.

Species	Mansfield 91	92	93	94	95
Northern Flicker			1		
Hairy Woodpecker				1	
Yellow-bellied Flycatcher			2		1
Blue Jay		1			
Common Raven			1		
Red-breasted Nuthatch		2	3	1	3
Winter Wren	20	18	14	8	10
Ruby-crowned Kinglet		4			2
Bicknell's Thrush	10	23	15	9	15
Swainson's Thrush	6	16	2	2	5
American Robin	2	7	2	4	4
Cedar Waxwing		1	4		
Nashville Warbler	4				
Magnolia Warbler	2	4			
Yellow-rumped Warbler	22	21	16	18	16
Blackpoll Warbler	20	18	18	14	14
Ovenbird			2		
Lincoln's Sparrow	4				
White-throated Sparrow	14	28	26	21	24
Dark-eyed Junco	8	17	10	4	10
Purple Finch	2	8	2	4	
White-winged Crossbill					8
Pine Siskin		1			22
Evening Grosbeak		2			
Number of individuals	114	171	118	86	134
Number of species	12	16	15	11	13

Mt. Mansfield Forest Bird Monitoring Site



Underhill State Park Forest Bird Monitoring Site

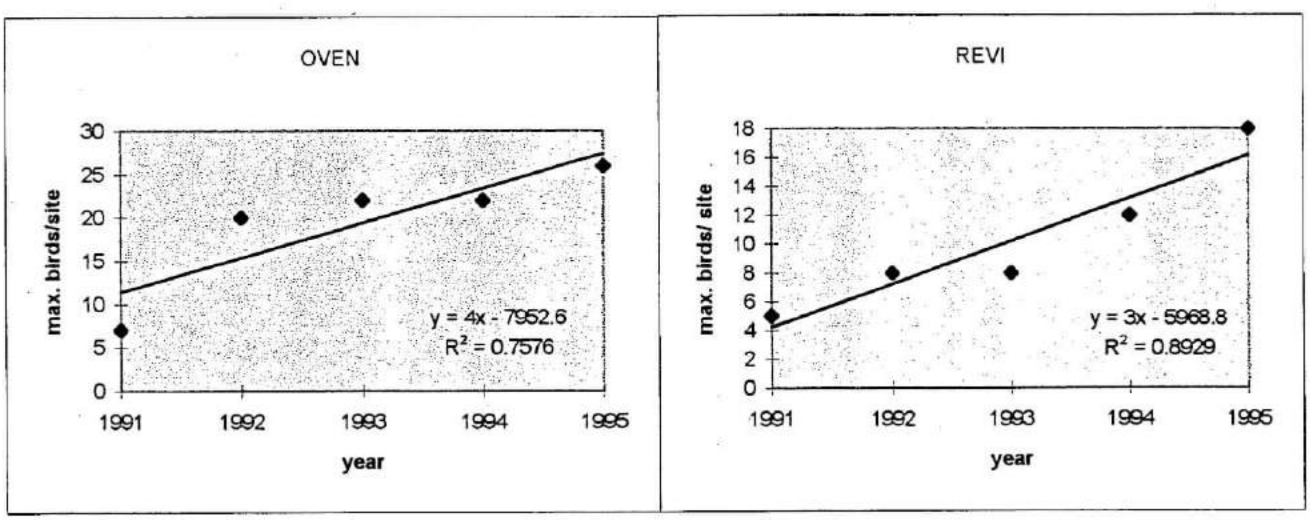


Fig. 1. Population trends of Yellow-rumped Warbler (MYWA) and Blackpoll Warbler (BLPW) on Mt. Mansfield, and Red-eyed Vireo (REVI) and Ovenbird (OVEN) at Underhill State Park, VT.

Table 2. Numbers of individual birds recorded on Mt. Mansfield in 1995. Maximum count for each species represents relative abundance index to be used in future analyses.

Species	9 June	22 June
Ruby-crowned Kinglet	2	2
Red-breasted Nuthatch	1	3
Winter Wren	6	10
Bicknell's Thrush	15	5
Swainson's Thrush	5	4
American Robin	4	
Yellow-rumped Warbler	16	16
Blackpoll Warbler	12	14
White-throated Sparrow	24	18
Dark-eyed Junco	6	10
Purple Finch	2	6
Pine Siskin	22	1
Yellow-bellied Flycatcher		1
White-winged Crossbill		8
Number of individuals	115	98
Number of species	12	13

Table 3. Maximum counts of individual birds recorded at Underhill State Park, 1991-1995.

Species	Underhill 91	92	93	94	95
Northern Flicker			2		
Yellow-bellied Sapsucker		2		2	2
Hairy Woodpecker				1	
Blue Jay				1	
Common Raven				4	1
Brown Creeper				1	
Black-capped Chickadee		2	1		4
Winter Wren		12	4	2	10
American Robin					5
Veery	2	2			
Swainson's Thrush		2		4	8
Hermit Thrush		7	2	11	14
Wood Thrush	1	2			
Solitary Vireo	1	4			
Red-eyed Vireo	5	8	8	12	18
Black-throated Blue Warbler	11	17	10	12	14
Yellow-rumped Warbler			4	4	
Magnolia Warbler					2
Black-throated Green Warbler	9	14	12	14	14
Black-and-white Warbler		6	4	4	8
American Redstart		6			2
Ovenbird	7	20	22	22	26
Canada Warbler	5	8	8	10	4
Rose-breasted Grosbeak	7	3		2	6
White-throated Sparrow	2		2	2	2
Dark-eyed Junco		6	2	6	8
Pine Siskin					1
Scarlet Tanager					2
Number of individuals	52	112	83	114	151
Number of species	11	18	14	18	20

Table 4. Numbers of individual birds recorded at Underhill State Park in 1995. Maximum count for each species represents relative abundance index to be used in future analyses.

Species	9 June	23 June
Yellow-bellied Sapsucker	2	
Common Raven		1
Black-capped Chickadee	4	2
Winter Wren	2	10
American Robin	2	5
Swainson's Thrush	6	8
Hermit Thrush	9	14
Red-eyed Vireo	14	18
Black-and-white Warbler	8	6
Black-throated Blue Warbler	6	14
Yellow-rumped Warbler	4	4
Magnolia Warbler	2	2
Black-throated Green Warbler	14	13
Ovenbird	26	22
American Redstart		2
Canada Warbler	4	4
Rose-breasted Grosbeak		6
White-throated Sparrow	2	2
Dark-eyed Junco	8	6
Pine Siskin	1	
Scarlet Tanager		2
Number of individuals	114	141
Number of species	17	19

Insect Diversity on Mount Mansfield

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March 1996

Abstract

Insect surveys for 1995 were done at three elevations. Two lower elevation sites, Proctor Maple Research Center at 400 m (PMRC), and Underhill State Park at 640 m (USP640) were the same as for 1990-1994. The high elevation site at 1160 m was discontinued, and an additional site at 715 m was chosen in Underhill State Park (USP715) to examine the Lepidoptera fauna immediately below the spruce/fir zone. Ground beetle (Carabidae) surveys were continued at the two lower elevation sites as for earlier years. Patterns of overall abundance, and abundance of selected species (including current or potential pests) in relation to elevation are presented here for the Lepidoptera, and new species records for the Mt Mansfield survey are listed.

Introduction

This report concludes the fifth consecutive year of insect surveys on Mount Mansfield. The purpose of this program is to develop information on taxonomic diversity and species abundance of selected insect groups in the forest ecosystem at different elevations. This information will contribute a taxonomic foundation for future work on the ecological relationships between invertebrate biodiversity and forest management.

The first three years of the insect survey included Hymenoptera and Diptera from canopy malaise traps, ground beetles (Carabidae) from pitfall traps and Lepidoptera from light traps. The canopy study was discontinued after the first three years, and the data from this and ground surveys are being analyzed for statistical comparisons of diversity variation among the three study sites.

Comparisons are presented in this report for general between-site diversity, individual pest species, and examples of elevation differences for individual species. The potential ecological significance of these patterns for forest management is briefly discussed.

Methods

In 1995 the Lepidoptera and ground beetle surveys continued at established sampling plots in a sugar maple forest (Proctor Maple Research Center, 400 m), and a mixed hardwood forest (Underhill State Park, 640 m). A new Lepidoptera sampling site was established in a birch-mixed-hardwood forest at 715 m in Underhill State Park.

The established survey sites comprise five permanent 20 m diameter plots with six pitfall traps located around each plot at 60° intervals. In previous years a single light trap was located in the center plot, but in 1995 two additional light traps were included and located outside the permanent plot no less than 30 m apart. At Proctor Maple Research Center and Underhill State Park traps two and three correspond to the single trap used in previous years. Three traps were also established at the 715 m site.

The 1995 Lepidoptera survey was limited to Noctuidae, Geometridae, Notodontidae, Arctiidae, Saturniidae, Lasiocampidae, Drepanidae, Sesiidae, and Limacodidae. These groups were selected because it was possible to provide accurate identifications for most specimens within the time constraints of the study, with the exception of Limacodidae which turned out to be impractical because of similarities among some species.

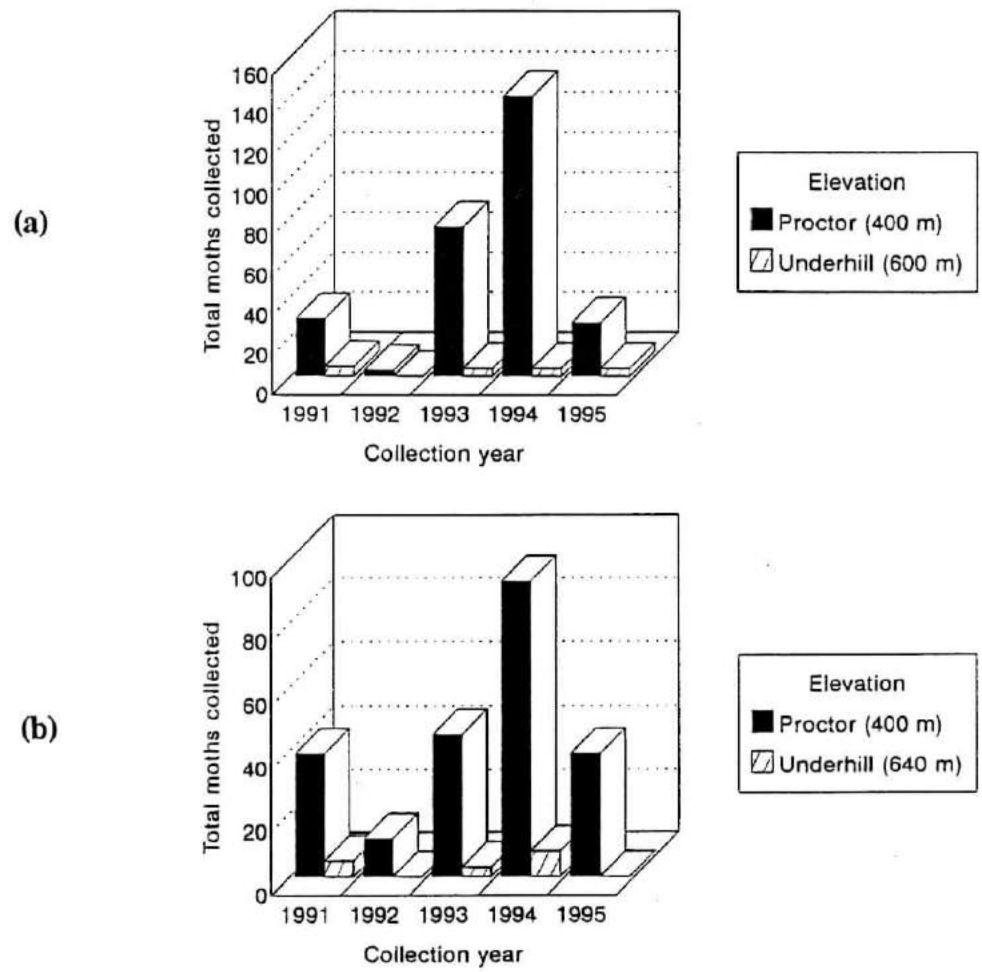
Results

(A) Pest species

A few specimens of the gypsy moth (*Lymantria dispar*) were recorded for the first time in this survey (Table 1). The survey area is not prime gypsy moth habitat, so its low level of occurrence is anticipated.

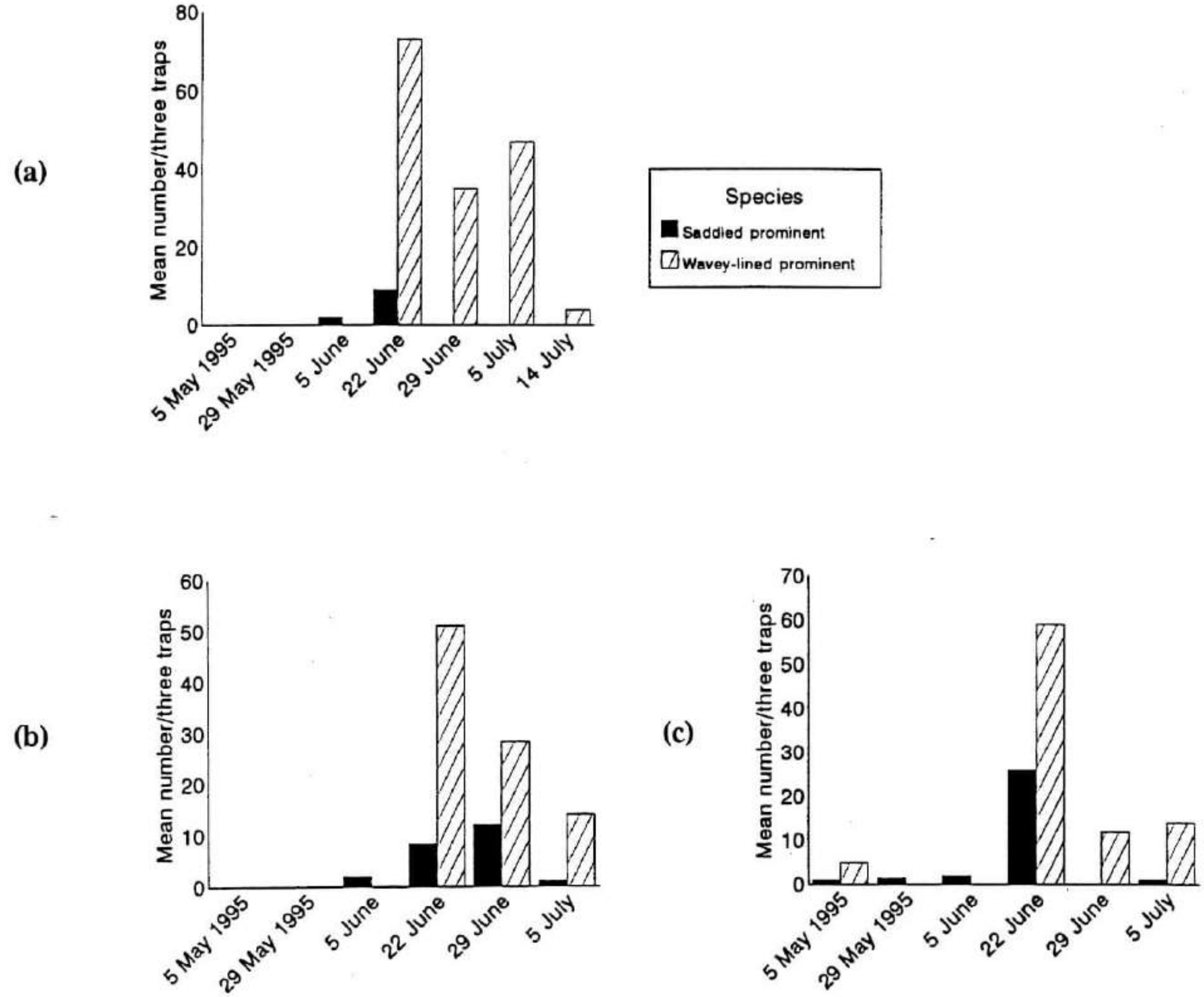
A considerable increase in numbers of forest tent caterpillar *Malacosoma disstria* and eastern tent caterpillar *M. americanum*, were observed in 1994, but numbers collected for both species in 1995 were no higher than for any of the first three years of collecting (Fig. 1). The highest numbers of both species continued to be collected at PMRC. Neither species was collected from the new USP715, and no specimens of the eastern tent caterpillar were collected from USP640.

Figure 1. Annual total number of adults of (a) forest tent caterpillar, *Malacosoma disstria* and (b) eastern tent caterpillar, *M. americanum*, collected over a five-year period on Mount Mansfield at Proctor Maple Research Center and Underhill State Park (640 m).



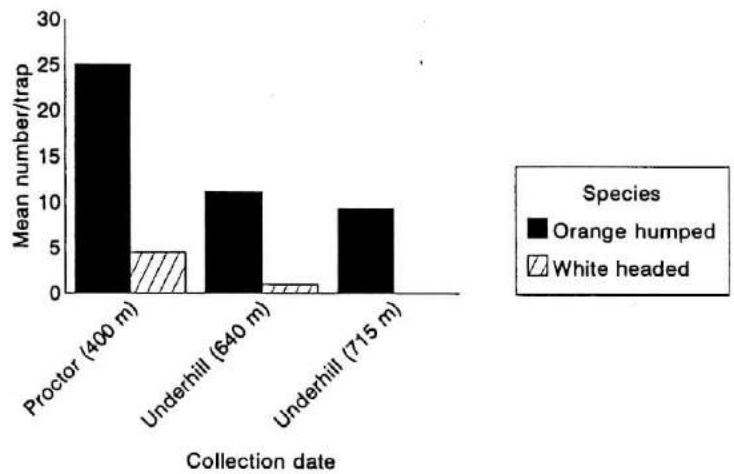
Specimens of saddled prominent, *Heterocampa guttivita* (Notodontidae) were noted during the 1990-1994 survey, but were not counted because they could not be easily distinguished from the wavy-lined prominent, *H. biundata*. This problem was overcome in 1995 by removing scales from the terminal portion of the ventral abdominal surface and comparing the size of sensory pits for males in the two species (relatively few females were collected). Numbers of wavy-lined prominents greatly exceeded those of saddled prominents at all sites, with emergence of saddled prominent begining earlier in the season (Fig. 2). The results indicate that saddled prominent abundance is not cause for concern on Mt Mansfield. If larval feeding by wavy-lined prominents is also destructive to host trees, its greater abundance may suggest that its population trends should also be monitored on a regular basis. The last major outbreak of saddled prominent in Vermont occurred in the early 1980's (Parker et al. 1989).

Figure 2. Seasonal abundance of saddled prominent, *Heterocampa guttivita*, and wavy-lined prominent, *H. biundata*, at (a) Underhill State Park (715m), (b) Underhill State Park (640 m), and Proctor Maple Research Center (400 m) in 1995.



Orange-humped mapleworm (*Symmerista leucitys*) is a minor pest in most parts of its range although it is also responsible for local severe defoliations (Allen 1979, Houston et al. 1990) including Vermont (Teillon et al. 1978). External features do not separate the different species of *Symmerista* so systematic counts were not included in earlier years of the survey. For the 1995 samples species were identified by examination of male genitalia following descriptions provided by Franclemont (1946). The orange-humped maple-worm was more common than the white-headed maple-worm (*S. albifrons*) (Fig. 3), but both were present in relatively low numbers.

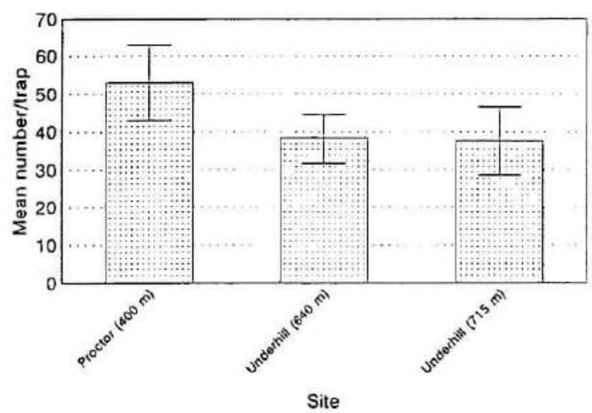
Figure 3. Abundance of adults of orange-humped mapleworm, *Symmerista leucitys*, and white-headed mapleworm (*S. albifrons*) on Mt Mansfield, 1995.



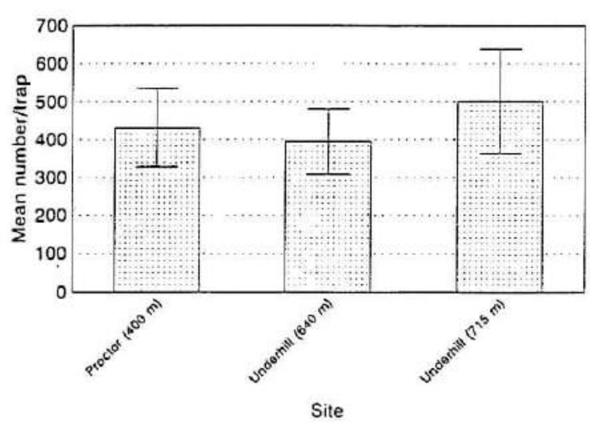
(B) Elevation Patterns
Average numbers of moth individuals and species did not show a large amount of variation between sites. PMRC supported slightly higher numbers of species than the higher elevations (Fig. 4), but was similar to USP640, both of which were lower than USP715.

Figure 4. Mean numbers of (a) species, and (b) individual moths collected at each site on Mt. Mansfield in 1995.

(a)



(b)



Large numbers of the lesser maple spanworm (*Itame pustularia*, Geometridae) were noticed at all sites, including around lights on buildings at PMRC. As the common name implies, the lesser maple spanworm is a maple feeder of several species and it is also sometimes a pest (Covell 1984). It is no surprise to see its highest abundance at PMRC, with less than half as many at the higher elevations (Fig. 5). The opposite pattern is found for the Welsh wave (*Venusia cambrica*, Geometridae) which is recorded from a range of trees, including alders, birch, mountain ash, and willow. The higher numbers present at the higher elevation sites (Fig. 6) may reflect these host-plant associations, particularly for USP715 where birch and ash are common.

Figure 5. Mean abundance of lesser maple spanworm, *Itame pustularia* (Geometridae), on Mt Mansfield in 1995.

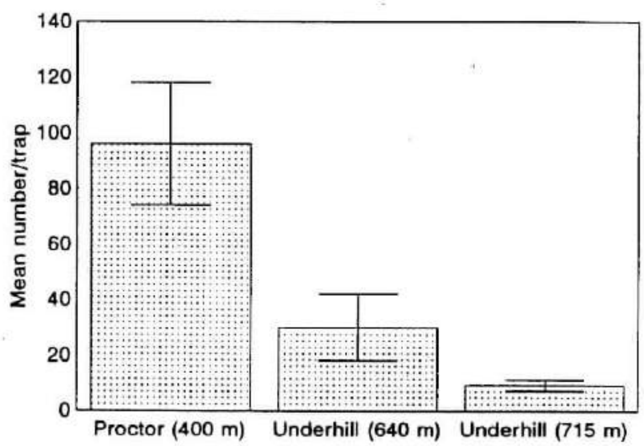
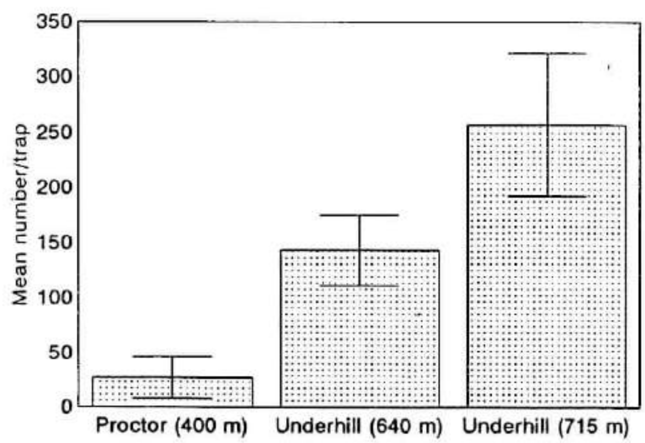


Figure 6. Mean abundance of welsh wave, *Venusia cambrica* (Geometridae), on Mt Mansfield in 1995.



project is to relate the taxonomic biodiversity of Mt Mansfield Lepidoptera to its ecological and management significance. The first step, already initiated, is the development of a general host-plant list for representative groups of Mt Mansfield Lepidoptera. This project could also be complemented by a targeted program to rear Lepidoptera larvae from trees, shrubs and herbs as host-plant relationships may vary with geography and elevation.

Host-plant documentation will allow general predictions about the ecological and potential forest management significance of the Lepidoptera biodiversity structure on Mt Mansfield. It will be important to identify and understand the range of host-plant relationships present on the Mountain and how these may vary over elevation and between habitats. Questions concerning the relative significance of rare and common moths in relation to the distribution and abundance of trees and other plants may be assessed. These relationships, once identified, will provide an ecological context against which testable predictions may be made about the ecological impact of different forest management practices on insect biodiversity in mixed northern hardwoods characteristic of Mt Mansfield.

References

Allen, D. C. 1979. Observations on biology and natural control of the orangehumped mapleworm, *Symmerista leucitys* (Lepidoptera: Notodontidae), in New York. The Canadian Entomologist 111: 703-708.

Covell, C. V. Jr. 1984. Eastern Moths. Houghton Mifflein Company, Boston.

Franclemont, J. G. 1946. A revision of the species of *Symmerista* Hübner known to occur north of the Mexican border (Lepidoptera, Notodontidae). The Canadian Entomologist 78:97-103.

Houston, D. R., D. C. Allen, and D. Lachance. 1990. Sugarbush management: a guide to maintaining tree health. Northeastern Forest Experiment Station General Technical Report NE-129.

Parker, B. L., K. E. McGrath, S. Moulton, and H. B. Teillon. 1989. History of the major forest insect pests in Vermont. A joint VT Agricultural Experiment Station and State of VT publication. RR 57. University of Vermont, Burlington.

Rockburne, E. W., and J. D. Lafontaine. 1976. The cutworm moths of Ontario and Quebec. Canada Department of Agriculture Publication 1593.

Teillon, H. B., R. S. Kelly, and E. E. Keenan. 1978. Forest and insect disease conditions, 1977. Department of Forests, Parks, and Recreation. Montpelier, Vermont.

(c) New records

Collecting during earlier years was confined to one trap per site with a total of three altogether. This limited sampling is likely to miss some species due to sampling error arising from factors such as abundance and distribution, or attraction to light. A total of 20 species were recorded for the first time in 1995, and all were in low numbers (Table 1). Some are likely to be the result of identification error between similar species, and some are probably non resident in the local habitat. Two of the new Mansfield species records were also new for the State (under the current State inventory, Grehan et al. 1995). One specimen of *Syngrapha selecta* (Noctuidae: Plusiinae) was collected from USP640, and another from South Burlington in 1995. The species feeds on spruce, balsam fir, and pines (Rockburne and Lafontaine 1976). The second new State record was the dagger moth *Acronicta funeralis* (Noctuidae: Acronictinae) regarded as a widespread, but uncommon species that feeds on a range of deciduous tees including birch and maple (Rockburne and Lafontaine 1976).

Table 1. New species records in 1995 of Mount Mansfield Lepidoptera.

Species	Number
Arctiidae	
Lophocampa caryae	1
Haploa confusa	3
Drepanidae	
Oreta rosea	3
Geometridae	
Eulithis explanata	5
Lobophora nivigerata	2
Lomographa semicolorata	5
Semiothisa fissinotata	10
Lasiocampidae	
Tolype laricis	2
Lymantriidae	
Lymantria dispar	7
Noctuidae	
Acronicta funeralis	1
Antiecarsia gemmatalis	1
Baileya dormitana	2
Bomolocha maedefactalis	1
Caeurgina erechtea	2
Chrysanympha formosa	1
Eudrya grata	1
Nola cilicoides	1
Papaipema ptersii	1
Syngrapha selecta	1
Notodontidae	
Clostera apicalis	1
Sphingidae	
Porcella gordius	1
Sphecodia abboti	2

Discussion: Relevance to Forest Management

We are now in a position to have a reasonably accurate picture of the macro-Lepidoptera biodiversity representative of mixed hardwood forest stands on Mount Mansfield, and some indication of how these species are distributed over elevation despite statistically inadequate replicated sampling. There will inevitably be some variation with sampling of rare species, and even common species with localized distributions. Inferences made about this biodiversity are referable only to that part of the biota attracted to black-lights, and those sampled through baiting (see 1994 Annual Report). Of those macro-lepidoptera not attracted to light, some common species are considered likely to be present and remain to be sampled.

The next key development in this

Inventory and Monitoring of Amphibian Biodiversity in the Lye Brook Wilderness Region of the Green Mountain National Forest
March 1993-October 1995

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Abstract

An inventory of amphibians in the Lye Brook Region of the Green Mountain National Forest in Bennington County was begun in 1993 and completed in 1995. Monitoring of resident amphibians began in 1994. The goals of this inventory and monitoring effort were to determine which amphibians were present in the region and begin monitoring selected species. Six species of salamander (Dusky salamander, Eastern newt, Northern two-lined salamander, Redback salamander, Spotted salamander, Spring salamander) and seven species of frog (American toad, Bullfrog, Gray treefrog, Green frog, Pickerel frog, Spring peeper, Wood frog) were located. The most abundant species of salamander in this region is the Eastern newt. The most abundant species of frog appears to be the Spring peeper. The species found in this region are typical of what has been found at other mid- to high-elevation sites in the central Green Mountains. A monitoring scheme has been developed for this region using drift-fences, egg-mass counts, and stream surveys. One year of monitoring data has been gathered at drift-fences. Two years of monitoring data have been gathered using egg-mass counts and stream surveys.

Introduction

Overview

This report presents the results of three field seasons of work in the Lye Brook Wilderness (LBW) Region of the Green Mountain National Forest in Vermont. The results are reported and discussed in two sections: a review of that work done in 1993 and reported on in a preliminary report (Andrews 1994) and that work done in 1994 and 1995. The intent of this study was to do an inventory of the amphibians located in the region and begin long-term monitoring of its amphibian populations. Concurrent with this effort was an inventory and monitoring program at another site within the main range of the Green Mountains in the Abbey Pond / Beaver Meadows (AB / BM) Region outside of Middlebury, Vermont. In the preliminary report (Andrews 1994) I compared the inventory data from these two sites. That comparison is included here in a slightly altered form.

Study site

The region surveyed spans roughly 40 mi^2 and 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

The methods used in 1993 were designed to inventory the amphibians of the region and to lay the groundwork for gathering amphibian monitoring data in 1994. A limited number of amphibian inventory methods were continued in 1994 at selected sites. Since no additional species were located in 1994, the inventory results from that year were not combined with the 1993 totals. Monitoring began in 1994 using two methods and in 1995 three methods were used to gather baseline data for long-term monitoring.

Methods used during 1993

In 1993 six different inventory methods were used in the LBW Region.

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 lasted 1.5 hours.

Canoe searches are used to do a visual search of a lake or pond margin from the water.

Drift fences are semi-permanent structures built to interrupt the feeding and migratory movements of amphibians on rainy nights or nights immediately after rains. The three used are constructed of 30 m lengths of aluminum flashing (Figure 1). 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. A small piece of plywood is used to provide shade for any reptiles and amphibians trapped in them. The traps are only opened during, after, or in anticipation of, rainy weather. They are always checked the following day when all amphibians are identified, recorded, and released. Three fences were built in the area. I refer to the drift-fence locations as Falls Access, LBW Fence #1, and LBW Fence #2 (Figures 2 & 3). The Falls Access fence is located at 800 ft. in elevation in a second growth hardwood stand. It is over 200 meters from the nearest standing water. LBW Fence #1 is located at 2400 ft. and LBW Fence # 2 is at an elevation of 2700 ft. Both of these upper elevation sites are entirely wooded with a mix of northern hardwoods and some spruce and fir. The upper elevation sites are located close enough to standing water to interrupt breeding movements of pond-breeding amphibians. LBW #1 is located on an upland ridge within foraging distance of two breeding locations.

Night-time visits are made to selected sites in an effort to hear the calls of breeding and territorial anurans (frogs). The time of the year and the weather conditions are chosen specifically to locate species not already located using other methods.

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.

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

Accidental discoveries are often made while employing a method not intended to locate that specific species or while scouting or working at a site. Individuals located accidentally are identified as such in the data base and in the tables. I often found Eastern newts in large numbers while I was counting egg masses, building drift fences, or using a method

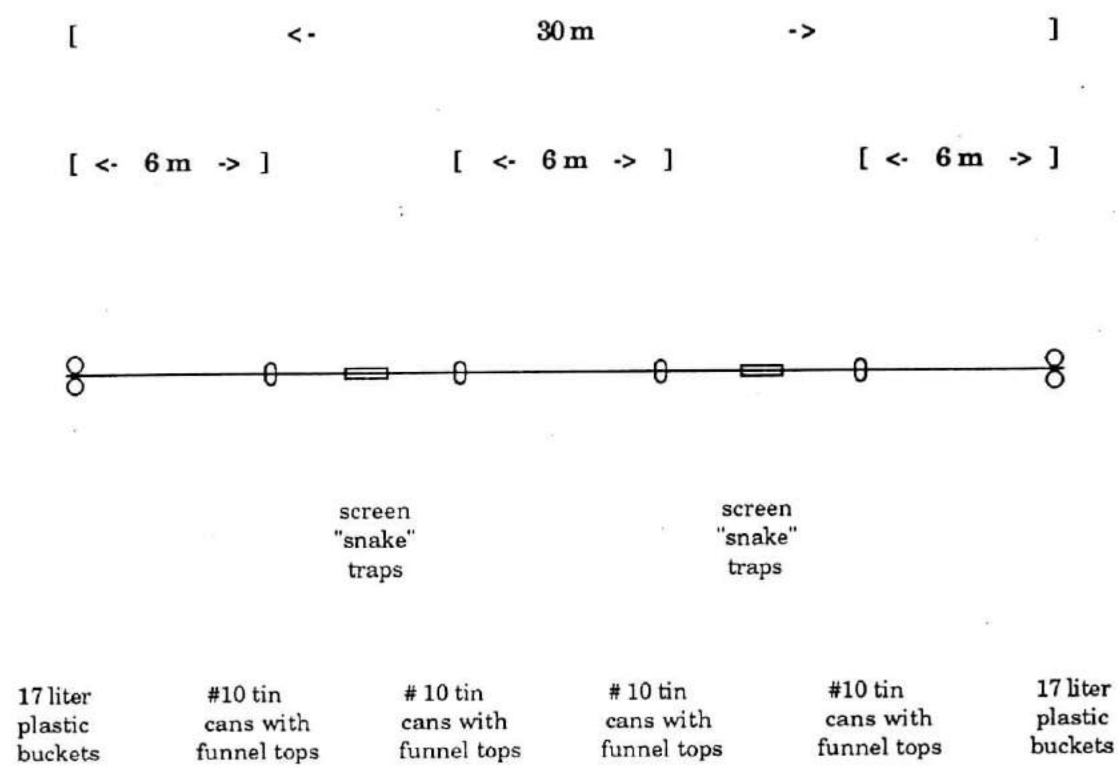

Figure 1. Design of the drift fences used for inventory and monitoring in the Lye Brook Wilderness Region.

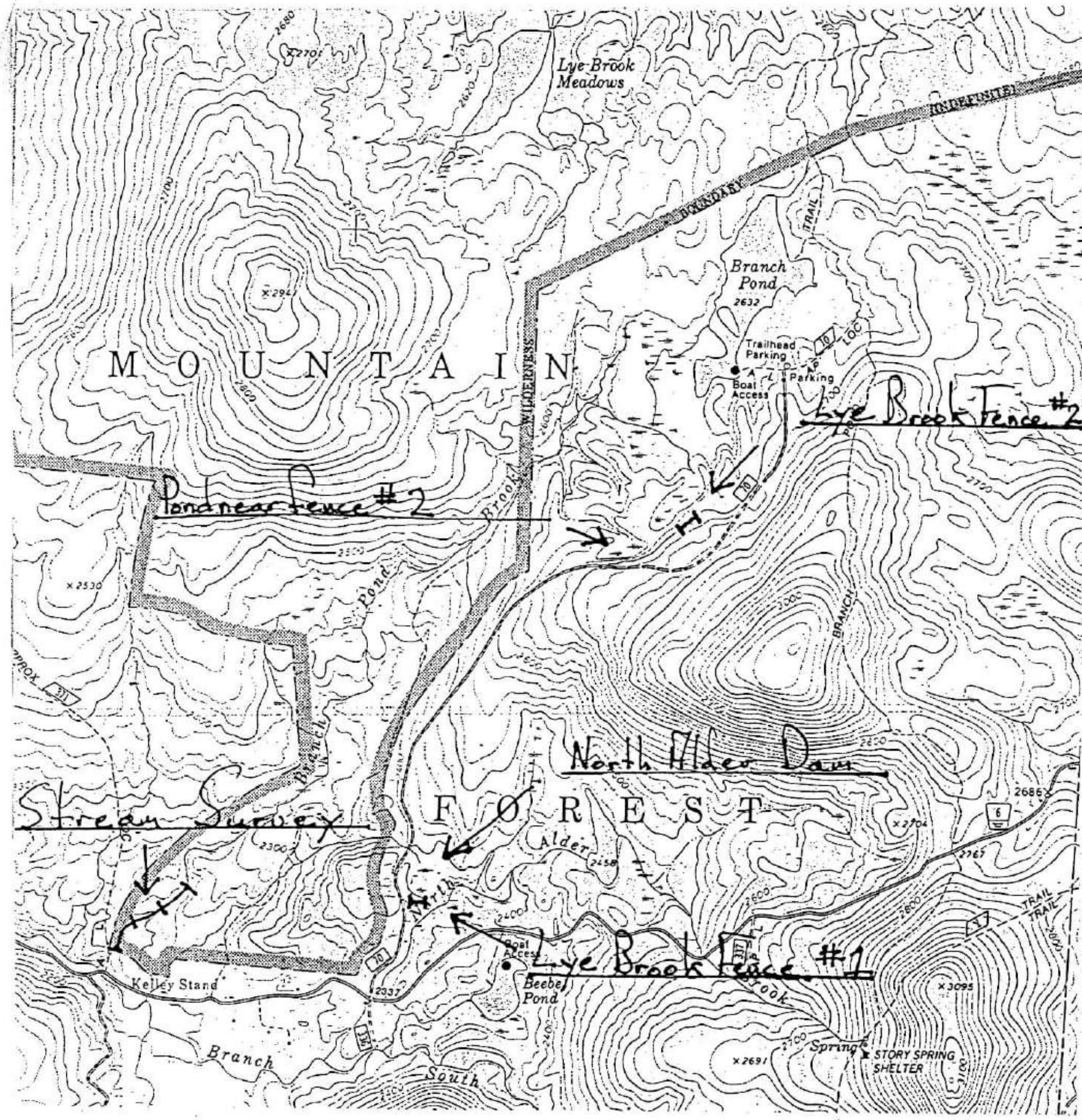

Figure 2. Upper-elevation amphibian-monitoring sites in the Lye Brook Wilderness Region. Two drift-fence sites, two egg-mass count locations, and the stream-survey site are shown.

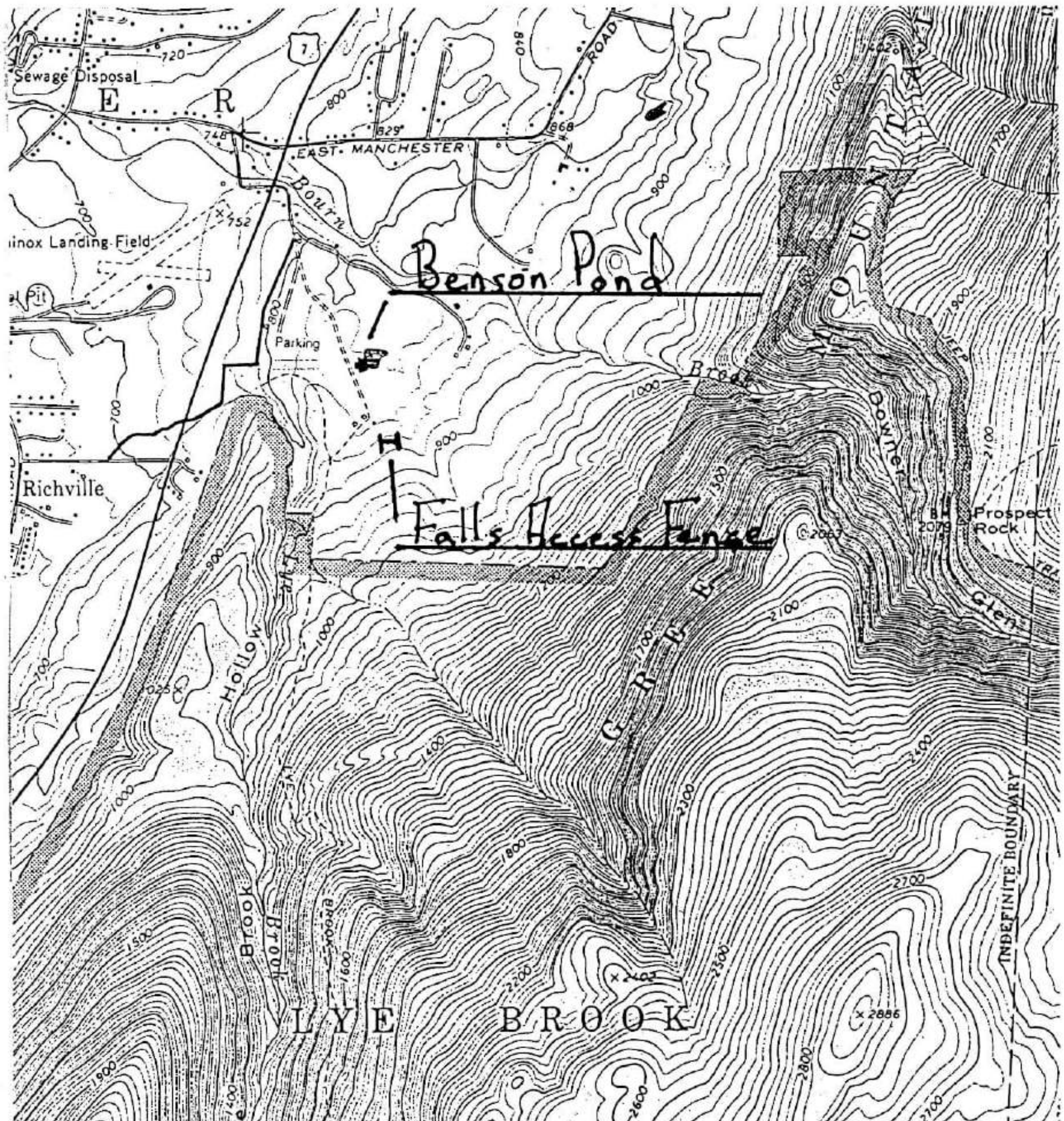

Figure 3. Lower-elevation amphibian-inventory and -monitoring sites in the Lye Brook Wilderness Region. One drift-fence site and one egg-mass count location are shown.

designed to locate a different species. Occasionally these were entered simply as "many" in the database. In the Preliminary Report (Andrews 1994) and in the 1993 data reported here, each reference to "many" was counted as 10 individuals in the data analysis. I have since decided that this was too conservative a treatment of these entries. In all subsequent data "many" was interpreted as fifty individuals.

None of these methods alone will survey all species of amphibian that may occur in an area. A combination of these methods must be employed in an initial inventory effort.

Other data

Soil and water pH were measured with a Nester Instruments portable pH meter. A planar Duraprobe designed for measuring the pH of surfaces was pushed into the soil one to two cm after the litter was removed. Soil pH was measured in at least three locations at any site where it was recorded. A separate probe was used to measure the pH of breeding ponds in at least three locations in each water body and at a depth of approximately 15 cm. The pH meter was calibrated with 4.0 and 7.0 buffer solutions at least once daily.

Other data were gathered and entered into the data base but are not included in this report. They include natural history notes, weather, time of day, and air and water temperatures.

Methods used during 1994 and 1995

During the 1994 field season, site checks, night-time visits and drift-fences were continued as inventory methods. The night-time visits were used specifically to locate Gray treefrogs. Two new methods (egg-mass counts and stream surveys) were added to acquire baseline monitoring data.

In 1995 three methods were used to gather monitoring data and one to gather inventory data. The two upper elevation drift-fences, egg-mass counts, and stream surveys were used for monitoring purposes. Only the low-elevation drift-fence was used to gather inventory data.

Drift-fences were used as an inventory method in 1993 and 1994. In 1995 the upper two fences were used as a monitoring tool. They are more easily standardized than many other methods and hence I feel they are a useful method for this purpose. I followed the protocol in Appendix A. They were opened three times per month from April through October with the exception of August. Since field technicians need to be continually on call for rainy conditions, I decided that there needed to be one month during the summer when they could make other plans. I chose August based on previous survey and drift-fence results which showed it to be a month of limited amphibian activity. Occasionally the fences were opened in anticipation of a rain that did not materialize or during which very little rain fell. When this happened the fences were opened an additional time during the month. If the fences were opened more than three times per month, data are used from only the three most productive nights (greatest number of amphibians caught). Occassionally, heavy rains do not occur three times during a month. In these cases, if a heavy rain occurs at the beginning of the following month (first ten days), or the end of the previous month (last ten days), and three other heavy rains also occur during that month, then the data are shifted to the dry month. The data used from the upper two drift fences in 1995 were gathered on April 19, 28, May 6, 11, 12, 25, June 3, 16, 25, July 2, 8, 18, Sept. 8, 10, 14, 23, and Oct. 6 and 15.

During 1994 a sub-sampling protocol was established (Appendix A) and size-class data were collected for the first time. For each species, individuals under a given total length were considered young of the year. The chosen length was based on the timing of their appearance, gaps in their size continuum (from AP / BM data in 1994) and records in the literature. Although, I realize that the size to which young will grow in the course of one season will differ from year to year, I picked a standard size to use in comparisons. The cutoff sizes used were: Spotted salamander (70 mm), Northern two-lined salamander (60 mm), Eastern newt (45 mm), Redback salamander (32 mm), American toad (30 mm), Spring peeper (20 mm), Green frog (41 mm), Pickerel frog (30 mm), and Wood frog (25 mm).

Egg mass counts took place at three sites that I refer to as near Benson Pond, North Alder Dam, and the pond near fence # 2 (Figures 2 & 3). These counts followed monitoring protocols that were tailored for the sites at which they were used. At all the sites the index that is presented is the highest count of egg-masses on any one day for each of the two species monitored. These counts are not cumulative nor do they have to be from the same day for different species.

At the site near Benson Pond I monitor a small beaver pond that lies approximately 20 m west of the southwest corner of Benson Pond. Benson Pond itself is a large man-made pond. The monitoring site is northwest of the small inlet stream entering Benson Pond and extends into the edge of the woods. The beaver pond measures approximately 10 m across on its longest axis and has a maximum depth of approximately 1 m. The entire pond is searched for egg-masses.

The North Alder Dam is a large beaver dam directly north of drift-fence # 1. At this site a four-meter strip around all of the pond except the northern end is surveyed. Due to the very irregular and swampy shoreline along the northern end it would be very difficult to survey.

The pond near drift-fence # 2 is also a large beaver dam. It is located southwest of the drift-fence and is visible from USFS road # 70. At this site a four-meter strip around the entire margin of the pond is surveyed. This site was chosen in 1994 to replace the Kelly Stand Dam site which I had anticipated using. Recent beaver activity at the latter site made it unsuitable for egg-mass surveys.

All surveys are performed under conditions that allow the viewer to see easily into the pond (limited wind, no rain, and adequate light from a high angle). Polarized glasses are sometimes helpful. The counts are designed to take place in habitats where Wood frog and Spotted salamander have been previously located and during or shortly after their breeding period. Eggs were counted on three occasions beginning as soon as the snow and ice melted enough to allow access to the ponds and continuing until all egg laying activity ended in the end of May or beginning of June. At the Benson Pond site in 1995 only two counts were run in 1995. At its low elevation I do not believe that any additional egg-laying activity took place after my last visit on May 12.

Stream surveys were run on one day per year along one brook (Branch Pond Brook, Figure 2). Ideally surveys would take place more frequently along more brooks but funding limitations did not allow it. Branch Pond Brook was chosen because of the relative abundance of Spring salamanders that were found there during the inventory. It had the highest concentration of this species that I was able to locate in the Lye Brook Wilderness Region.

The surveys consist of three contiguous transects of 50 m each. The first transect begins approximately 100 m upstream from the point where the brook is crossed by an old wood-road which runs north from Kelly Stand Road. The width of the transects is defined by the normal high water marks on either side of the brook. These are quite obvious and are marked by a vertical rise of approximately 30 cm. This line is also marked by the appearance of vascular plants. The transects are divided into three regions one-third the width of the stream. Each transect is searched by three people (one per region) for 20 minutes apiece (1 person-hour). Only rocks that are partially or entirely above the water level are turned. The second and third transects take place immediately upstream of and contiguous with the preceding transects.

Water testing was continued during the 1994 and 1995 field seasons. However in 1994 additional samples were sent to Jim Kellogg at the Vermont Department of Environmental Conservation Laboratory to test alkalinity, total color, pH and conductivity using their protocols. I recorded pH and temperature using a new Cole-Parmer hand-held pH meter (microcomputer pH vision model #6009). Three measurements were taken from shore at three widely separated locations at an approximate depth of 15 cm. Calibration was checked at each site using premixed buffer solutions of pH 4.0 and 7.0.

Results

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 (Table 1). Field teams visited ~28 sites in the region (Figures 4a-e) and located 764 individuals of 13 species. In addition, 91 egg

Table 1. The results of the 1993 amphibian inventory of the Lye Brook Wilderness Region in Bennington County, Vermont. Six species of salamander and seven species of frog were located. The table shows the combined data gathered using six different methods. Included are all metamorphosed individuals (no eggs or larvae). Chorusing data are not included. Percent individuals are out of a total of 564 caudates and 200 anurans located.

Species	**Common name**	**% of individuals**
Caudates (salamanders)		
Notophthalmus viridescens	Eastern newt[1]	53%
Eurycea bislineata	N. 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 and toads)		
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 treefrog	0.5%
Rana catesbeiana	Bullfrog	0.5%

[1]I often found this species in large numbers while I was 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. In the data reported here each reference to "many "was counted as 10 individuals in the data analysis.

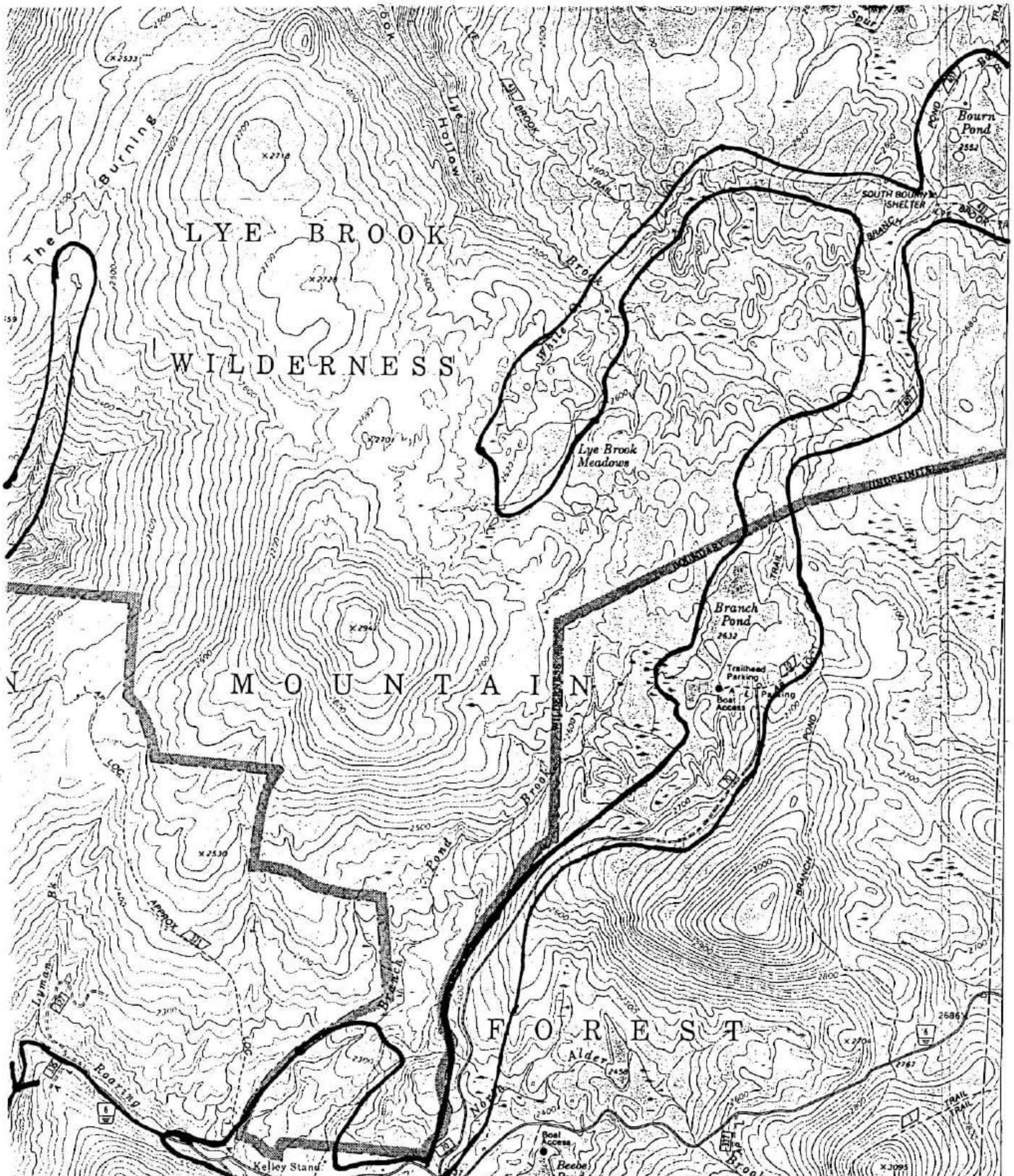

Figure 4a. Areas surveyed during the amphibian inventory of the Lye Brook Wilderness Region.

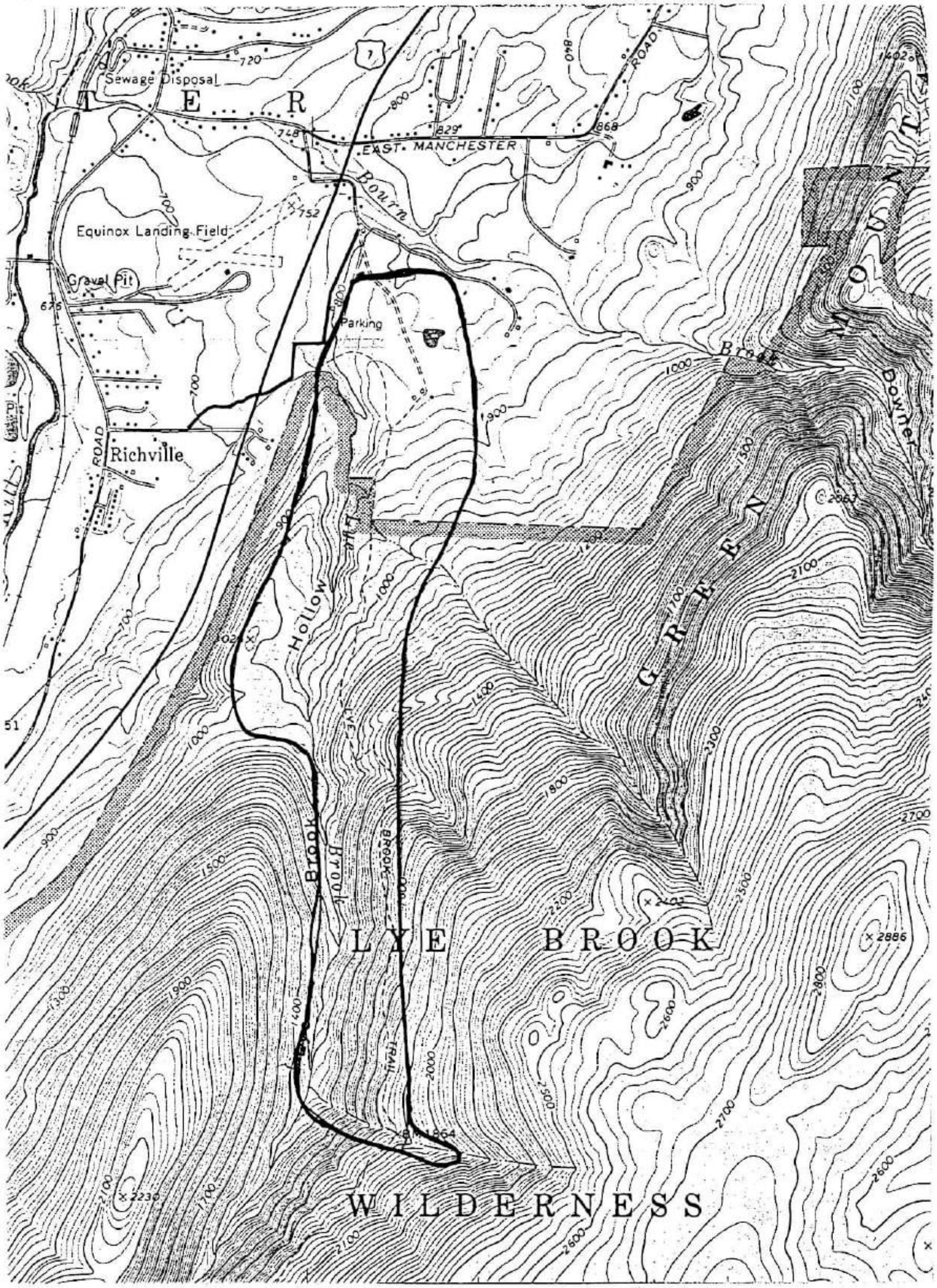

Figure 4b. Areas surveyed during the amphibian inventory of the Lye Brook Wilderness Region.

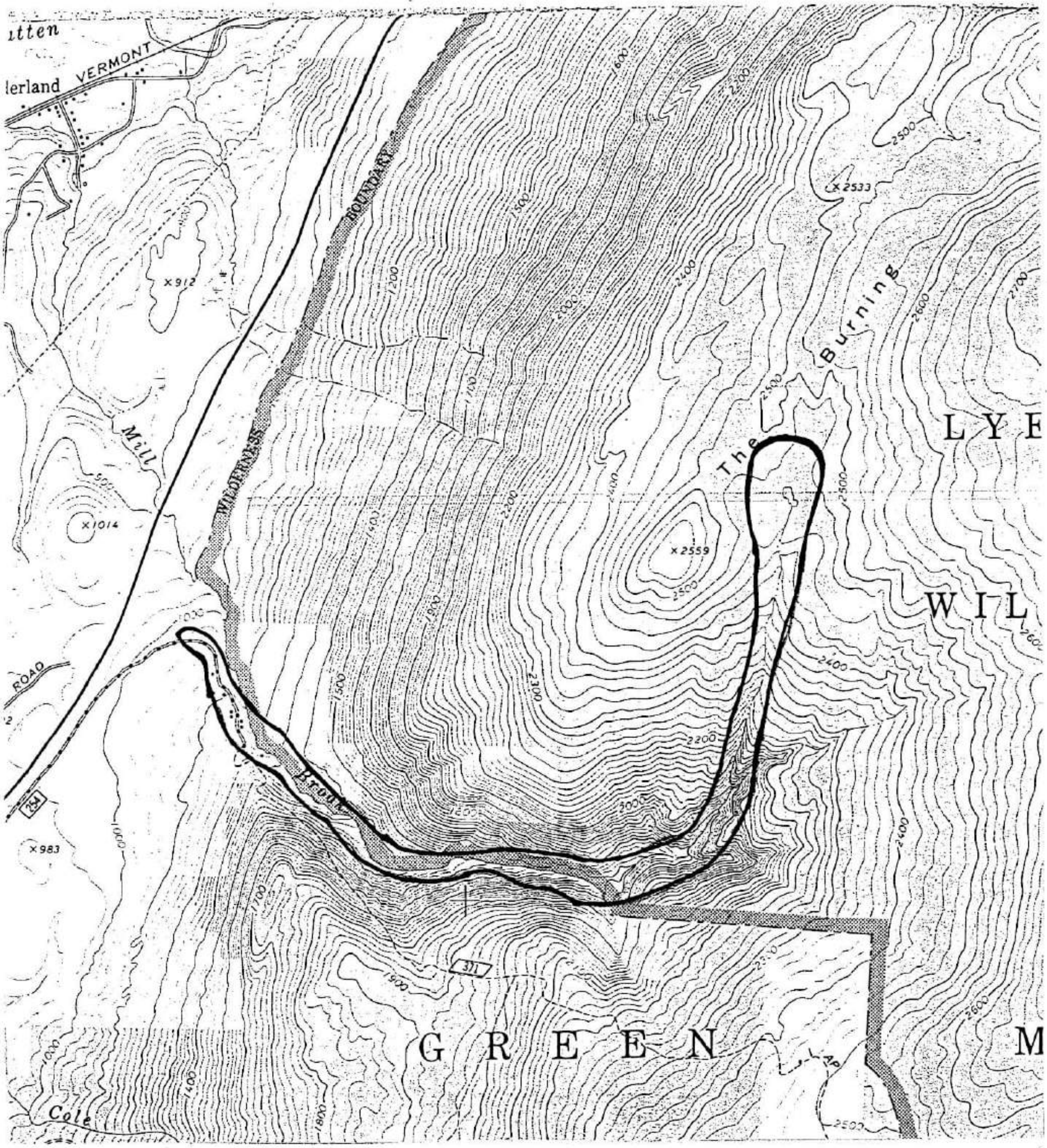

Figure 4c. Areas surveyed during the amphibian inventory of the Lye Brook Wilderness Region.

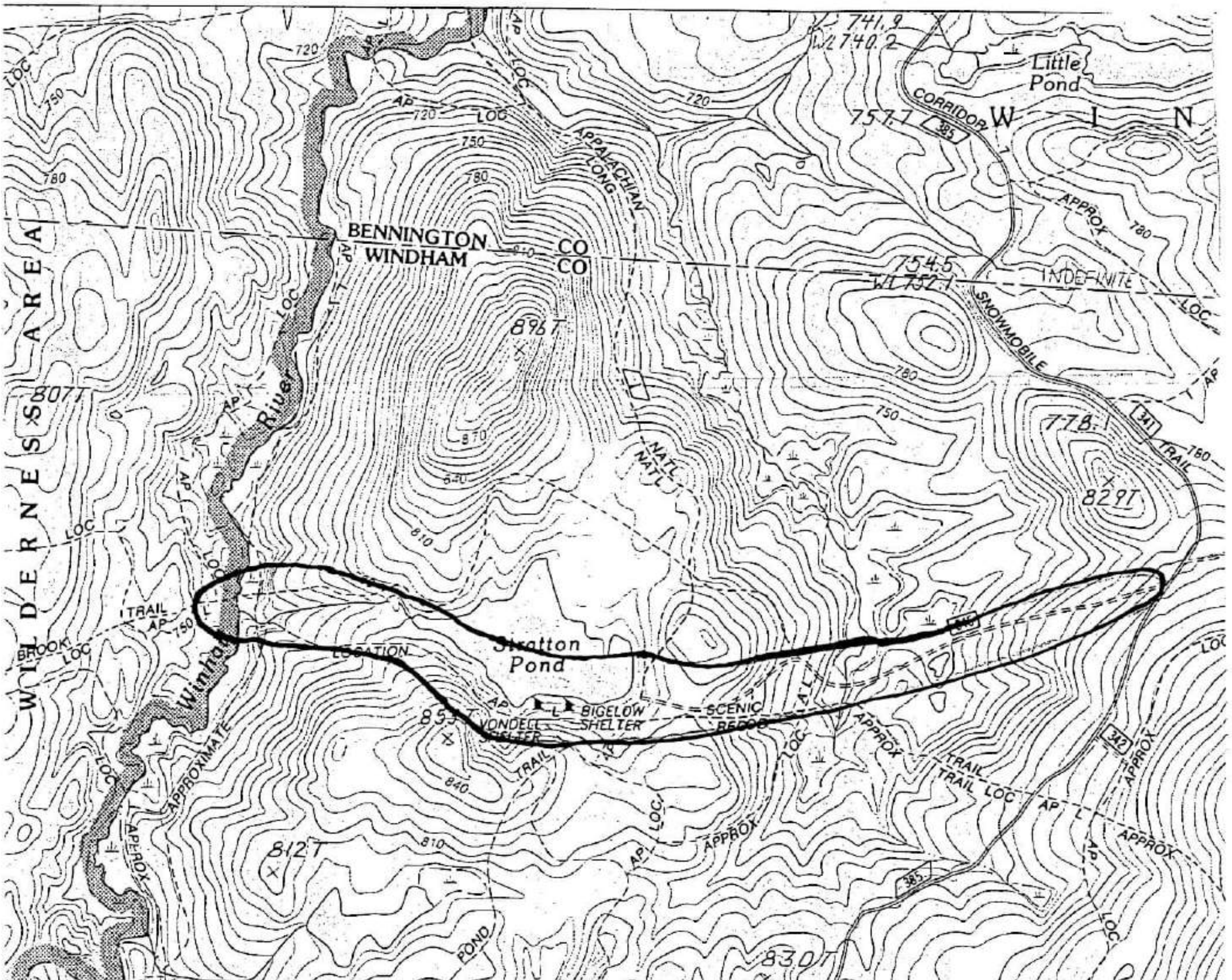

Figure 4d. Areas surveyed during the amphibian inventory of the Lye Brook Wilderness Region.

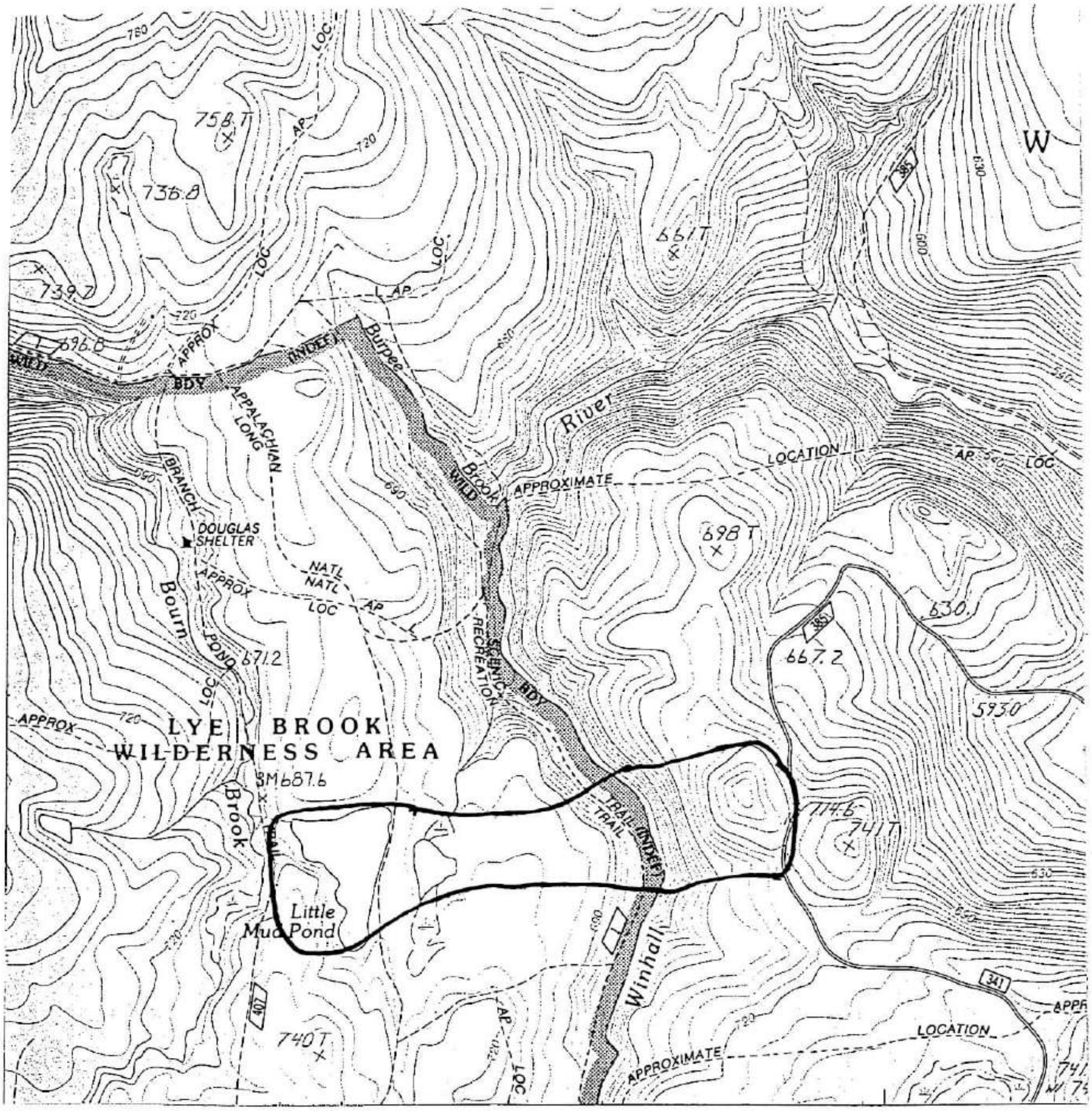

Figure 4e. Areas surveyed during the amphibian inventory of the Lye Brook Wilderness Region.

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.

If amphibian choruses are added into the total number of individuals at the rate of 10 individuals per chorus a more realistic estimate of the relative abundances of the species at this site is generated (Table 2). It is important to keep in mind that these percentages are affected by the relative amounts of effort spent using the different methods. In addition, the time of year during which each method was used also has an effect on which species are most likely to be located. In Appendix B I have shown 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 standardized for the number of sites and 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 were 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 were 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. Although a lot of useful data were collected from the fences in the fall of 1993 and during the 1994 field season, it is inventory data, not baseline monitoring data. In order for data to be useful for monitoring purposes they need to be collected according to a rigid protocol. The 1995 data from the upper two drift fences satisfy this requirement.

Of the many potential breeding sites visited, three sites were selected for long-term monitoring of egg masses. Egg masses of Wood Frog and Spotted salamander were located at these sites. These species are both early spring breeders with obvious and easily identified egg masses. I refer to the original sites selected 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. I did not locate sites that meet the criteria of a classic vernal pool in this area. I was not totally satisfied with the sites that I selected, since they were associated with beaver dams or meadows that were subject to manipulation and change over time. Kelly Stand Dam was subsequently inundated due to beaver activity and an alternative site (the pond near drift fence # 2) was selected.

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 were located outside of the wilderness area boundaries. My inventory efforts sampled a wide variety of sites inside the wilderness area and to the best of my knowledge the count sites are representative of the habitats found within it.

Table 2. Relative percentages of frogs from the 1993 amphibian inventory of the Lye Brook Wilderness Region in Bennington County, Vermont. Chorusing results are included. Each chorus is counted as 10 individuals and combined with the individual tally. Those species which call for a limited time (Gray treefrog, Woodfrog), under limited conditions (Gray treefrog), or have a weak call (Pickerel frog) are probably under-sampled. The table shows the combined data gathered using six different methods. Included are all metamorphosed individuals (no eggs or larvae). Percent individuals are out of an estimated total of 400 anurans heard or located.

Species	Common name	% of individuals
Anurans (frogs and toads)		
Pseudacris crucifer	Spring peeper	41.0%
Rana clamitans	Green frog	29.0%
Bufo americanus	American toad	19.0%
Rana sylvatica	Wood frog	8.5%
Rana palustris	Pickerel frog	2.0%
Hyla versicolor	Gray treefrog	0.3%
Rana catesbeiana	Bullfrog[1]	0.3%

[1]Found only at low elevations.

Table 3. Water test results from the egg-mass counting sites in the Lye Brook Wilderness Region in 1994. A single water sample was taken from each site on the day listed in the table. Water samples were analyzed by Jim Kellogg of the Vermont DEC. The right column shows the mean pH as measured by me for comparison.

Site	Alkalinity - Gran (mg/l)[1]	Color, Total Visual (Pt-Co)[1]	Conductivity (umhos/cm)	pH from DEC	pH from my data
Near Benson Pond					
sample date: 4/26/94	57.0	25	11.5[1]	7.45	7.3 N = 1
North Alder Dam					
sample date: 5/11/94	0.07	70	16.5	5.03	5.0 ± 0.3 SD N = 2
Pond near drift-fence #2					
sample date: 5/11/94	0.89	30	19.2	5.86	5.7 ± 0.3 SD N = 2

[1]According to Jim Kellogg this low conductivity is a result of the "dilutional effect of spring run-off".

Table 4. Water and soil pH values other than those reported previously with the egg-mass counts and stream-surveys. Sites are organized in descending order according to the pH of the water.

Site	Date tested	pH of water, SD	pH of soil, SD
Winhall Brook	5/27/93	6.7 ± 0.8 (N = 4)	
North Alder Brook	7/9/93	5.2 ± 0.6 (N = 4)	
Mill Brook (2nd site)	7/2/93	5.1 ± 0.6 (N = 4)	
The Burning	7/2/93	4.9 ± 0.4 (N = 3)	4.2 ± 0.3 (N = 3)
Small Brook on Trail to Lye Brook Falls	7/8/93	4.9 (N = 1)	5.8 ± 0.7 (N = 3)
Mill Brook (Upper East Branch)	7/2/93	4.7 ± 0.4 (N = 4)	4.8 ± 0.8 (N = 4)
Mill Brook (1st site)	7/2/93	4.7 ± 0.4 (N = 4)	4.8 ± 0.8 (N = 4)
Mud Pond	5/27/93	4.6 ± 0.7 (N = 5)	
Branch Pond	5/11/93	4.4 ± 0.8 (N = 3)	
Small Stream on Branch Pond Trail	5/12/93	4.0 ± 0.4 (N = 5)	3.7 ± 0.5 (N = 5)
Branch Pond Brook	7/1/93	3.8 ± 0.5 (N = 8)	
Lye Brook Falls Brook (above Lye Brook)	7/8/93	3.6 ± 0.4 (N = 3)	
Grand mean		**4.7 ± 0.9 (N = 12)**	**4.7 ± 0.9 (N = 5)**

Table 5. Amphibians caught in 1994 in three drift fences in the Lye Brook Wilderness Region in Bennington County, Vermont. Four species of salamander and five species of frog were caught. Percent individuals are out of a total of 160 caudates and 85 anurans caught. These data are not meant to be used as baseline monitoring data.

Species	Common name	# caught	% of group	% of all amphibians
Caudates (salamanders)				
Notophthalmus viridescens	Eastern newt	62	39%	25%
Ambystoma maculatum	Spotted salamander	49	31%	20%
Plethodon cinereus	Redback salamander	47	29%	19%
Eurycea bislineata	N. two-lined salamander	2	1%	1%
Total caudates		160	100%	65%
Anurans (frogs and toads)				
Rana clamitans	Green frog	37	44%	15%
Rana sylvatica	Wood frog	35	41%	14%
Pseudacris crucifer	Spring peeper	7	8%	3%
Bufo americanus	American toad	5	6%	2%
Hyla versicolor	Gray treefrog	1	1%	≤1%
Total anurans		85	100%	34%
Total amphibians		**245**		

Water and soil tests

Although the buffering potential of the upper two egg-mass sites is very low (alkalinities of 0.07 and 0.89), the buffering potential from the low elevation site near Benson Pond is high (57.0, Table 3). Consequently the pH of the site near Benson Pond (7.3) is well within the safe range for all Vermont amphibians (Freda 1986). The pH of the pond near drift-fence #2 (5.7) is within the safe range for those amphibians presently breeding there, but is approaching the limit for less acid tolerant species found elsewhere in Vermont (e.g., Jefferson salamander). The North Alder Dam egg-mass site, which has essentially no buffering capacity, has a pH of 5.0. This is the pH at which the least acid tolerant species have been shown to be negatively affected. The pH of other surface waters ranged from a low of 3.6 to a high of 6.7 with a mean of 4.7 (Table 4).

The mean pH of all soil measurements was also 4.7 (Table 4). The soil pH was measured at 5 sites and ranged from 3.7 to 5.8. This is higher than the pH measured at other Green Mountain sites in Addison County. The mean pH from three upland sites in the AP / BM Region was 3.6 ± 0.0 SD, N = 3. At another study site of mine in the Green Mountain National Forest in Ripton (Andrews 1995b) the mean pH was 3.5 ± 0.4 SD, N = 60. However, one set of samples was measured in a wetland seepage area in the AP / BM Region. At this site the mean pH was 6.5 ± 0.4 SD, N = 3. The mean soil pH from a study site in the northern Taconic Mountains in Orwell, Vermont was 4.5 ± 0.7 SD, N = 60 (Andrews 1995b). Soil pH values from within the Lake Champlain Basin in Addison County were less acidic. The mean soil pH from one study site on the south end of Snake Mountain in Bridport was 5.7 ± 0.9 SD, N = 45.

Inventory results from the 1994 and 1995 field season

Drift fences

Four species of salamander and five species of frog were caught in the drift-fences in 1994 (Table 5). Eastern newt, Spotted salamander and Redback salamander made up 99% of the salamander species caught. Green frog and Wood frog made up 85% of the frogs and toads caught. All species had been found previously in 1993. Drift fences like any method create biases in the relative numbers of each species caught and results should only be compared to other drift-fence data sets collected according to the same protocol. The 1994 data from the drift-fences was not collected according to monitoring protocols (Appendix A) and hence it is not meant to be used as baseline monitoring data nor is it directly comparable to drift-fence data from other sites.

The 1995 results from the low-elevation drift fence (Table 6) show a species of frog (Pickerel frog) that was not seen at any fence in 1994. Also shown is a low percentage of Green frogs and a complete absence of the Northern two-lined salamanders. This fence is much farther away from water than the other two drift fences. I suspect that the latter two species don't travel as far from their breeding sites as the other water-breeding amphibians which were caught.

Table 6. Amphibians caught in 1995 in the low-elevation drift fence in the Lye Brook Wilderness Region in Bennington County, Vermont. Three species of salamander and five species of frog were caught. These data are not meant to be used as baseline monitoring data.

Species	Common name	# caught	% of group	% of all amphibians
Caudates (salamanders)				
Notophthalmus viridescens	Eastern newt	87	62%	54%
Plethodon cinereus	Redback salamander	49	35%	30%
Ambystoma maculatum	Spotted salamander	4	3%	2%
Total caudates		140	100%	87%
Anurans (frogs and toads)				
Rana palustris	Pickerel frog	11	52%	7%
Rana sylvatica	Wood frog	4	19%	2%
Bufo americanus	American toad	4	19%	2%
Pseudacris crucifer	Spring peeper	1	5%	<1%
Rana clamitans	Green frog	1	5%	≤1%
Total anurans		21	100%	13%
Total amphibians		161		

Table 7. Combined totals by species from accidental finds, night-time visits, and site checks in the Lye Brook Wilderness Region from April 1994 through September 1995. Individual amphibians may have been counted more than once as a result of repeated visits to egg-mass and drift-fence sites.

Species	# of individuals	# of choruses	# of egg-masses
Salamanders			
Eastern newt	813[1]		
N. two-lined salamander	5		
Spring salamander	2		1
Spotted salamander	1		
Frogs and toads			
Green frog	46	6	
Spring peeper	35[2]	18	
American toad	29	3	1
Wood frog	10		
Pickerel frog	4		
Gray treefrog	2		

[1]Total includes references to "many" which were seen in the ponds while counting egg-masses. For this species on this table "many"were interpreted as 50 individuals. I suspect this is a conservative estimate.

[2]One reference to "many metamorphs" was interpreted as 20 individuals.

Other methods and accidentals

Night-time visits were made on June 8 and June 13, 1994 in an effort to locate calling Gray treefrogs. Five species of frog were heard calling: Spring peepers, Green frogs, Pickerel frogs, American toads, and Gray treefrogs. Only two Gray treefrogs were heard. Two other amphibians species were seen: Wood frog and Northern two-lined salamander.

A single site check on July 18 did not locate any additional species. The combined results from these two methods and all accidental finds from both 1994 and 1995 are shown in Table 7.

A Spring salamander egg mass

In 1994 a Spring salamander egg mass was found within one of the transects on Branch Pond Brook during the stream survey. Since egg masses of this species are rarely found and have not been described in the literature I will describe it here. On July 18, 1994 a mass of 73 eggs was found attached to the underside of a partially-submerged flat rock in the middle of the brook. The rock was 40 cm x 50 cm x 8 cm. Each egg was individually attached to the rock. The entire group covered an area of 13 x 15 cm. Three eggs were measured and found to be 14 x 14 mm, 14 x 12 mm and 13 x 14 mm. The rest were approximately the same size and shape. Those which were slightly oval were distended along the same axis as the lengths of the embryos inside them. Embryos were creamy-yellow, approximately 14 cm long, and yolk sacs were visible. Some, but not all, of them moved when the eggs were touched. An adult was found under the same rock with the egg mass. It stayed within the depression created by the rock. Most adults quickly fled to other cover when disturbed. The site was revisited 8 days later on July 26, 1994. Only 25 of the original 73 eggs remained. The two eggs measured were 18 x 13 mm and 16 x 13 mm. Some of the embryos were tightly curled into a 6 mm ball while others remained straight. An adult was again under the rock with them but this time the adult fled quickly when the rock was disturbed.

Diseased Eastern newts

Specimens of diseased Eastern newts were originally discovered in 1993 at Upper Abbey Pond in the Green Mountain National Forest in Addison County, Vermont. They were collected in June and sent to Dr. D. Earl Green D.V.M. at the Animal Health Diagnostic Laboratory in College Park, Maryland. Seven specimens that showed external evidence of the disease were sent along with 4 specimens from the site with no apparent symptoms. In addition a control group of 3 newts from a pond approximately 15 miles away in the Lake Champlain Valley were sent as a control group. A copy of his final pathology report is included in its entirety in Appendix C. A paper will be published on this disease in the near future. In brief, on June 28, 1994, five adults were found dead at this pond. Four of them showed the characteristic growths of this disease. On July 14, 1994, 7 adults were found dead at this site. Three of them showed the characteristic signs of this disease. On June 28 and 29, adult newts were both netted and trapped from the pond. Of 72 netted, 12 (17%) showed signs of the

Monitoring results from the 1994 and 1995 field seasons

Drift-fences

The combined results from the two upper drift-fences can be used both as baseline data for the first full year of monitoring and as a basis for comparison with other sites where the same protocol has been used (Table 8).

The three most frequently caught salamanders in descending order were Eastern newt (52%), Spotted salamander (36%), and Redback salamander (8%).

The three most frequently caught frogs (and toads) were Wood frog (41%), Green frog (34%), and American toad (22%, Table 8).

The most frequently caught amphibians in descending order were Eastern newt (29%), Spotted salamander (20%), and Wood frog (18%). The least frequently caught amphibians in ascending order were Spring peeper and Northern two-lined salamander (2% each), and Redback salamander (5%).

At least 67% of all American toads and 63% of all Spotted salamanders caught were young of the year. None of the Northern two-lined or Redback salamanders and very few Wood frogs (4%) were young of the year (Table 8).

Egg-mass counts

The most useful figure that can be generated from these counts for monitoring purposes are the maximum counts of egg masses for each of the two species monitored (Table 9). The first two years of monitoring show a large amount of variation in the numbers of egg masses of both species between years and between sites. At the Benson Pond site, the number of egg masses of both species dropped. At North Alder Dam the number of Spotted salamander egg masses increased dramatically (200%) while the numbers of Wood frog egg masses decreased dramatically (99%). At the pond near drift fence #2 the numbers of Spotted salamander and Wood frog egg masses both increased dramatically. The pH values at all of the sites varied little from 1994 to 1995.

Stream surveys

I have collected two years of stream survey data (Table 10). Although it is too early to look for any meaningful trends, the number of Spring salamanders dropped from 10 in 1994 to 6 in 1995 while the numbers of Northern two-lined salamanders found dropped from 11 to 1. The pH in both years was higher than that measured in 1993 [3.8 ± 0.5 (N = 8)], but still very acidic.

disease. Of 69 trapped, 9 (13%) showed signs of the disease. One of these was dead in the trap. On July 14, 1994 of 66 netted, six (9%) showed the characteristic growths. Of 66 trapped, 6 (9%) also showed signs of the disease. By October 25, 1994 however, of 183 newts caught at Upper Abbey Pond only 4 (2%) showed signs of the disease.

Although Dr. Green's report states that the swellings are probably the result of a fungus (*Aureobasidium pullulans*), he later informed me that this organism was probably a contaminant. He now believes that the infecting organism is most likely Ichthyophonus or an Ichthyophonus-like fungus. The external symptoms of this disease had been described once in newts from Sleepy Creek Lake in West Virginia by a Dr. Herman, but the cause of the disease was not correctly identified. This fungus was not found in any of the control group of newts from the Lake Champlain Valley, but was located in two of the newts from Upper Abbey Pond which appeared symptom-free in the field. Dr. Green's report suggests that these two newts were recovering from the fungal infection.

A small group of four visibly diseased newts was taken into my lab along with four healthy control newts from the Lake Champlain Valley-site. Three of the four diseased newts died in the lab. All four of the control group survived. Although the small numbers sampled can not generate a statistically significant result, the result does suggest, as do Dr. Green's findings, that while some newts do die as a result of this disease, others can survive it. This disease may be spread by leeches.

I have now located newts with these symptoms in Nebraska Notch on Mt. Mansfield in the north-central Green Mountains, Silver Lake in the central Green Mountains, and in North Alder Dam here in the LBW Region. So far, I have only found newts with these symptoms at elevations above 1,200 ft.

Other species found during the inventory from 1993 through 1995

While in the field during the course of this inventory, many species other than amphibians were seen and identified. Some of these species were recorded in my notes. I have included a list of those species in Appendix D. It is not meant to be inclusive. Moose tracks and sign were often seen while working in the region. A Common loon was seen on Bourn Pond on May 12, 1993 and an Osprey was fishing on Branch Pond on May 11, 1993. A Blue-gray gnatcatcher was seen at Benson Pond during spring migration on April 26, 1994 and Rusty blackbirds were seen on June 14, 1994 in a boggy area between Branch and Bourn Ponds and on June 9, 1995 at North Alder Dam. The Common garter snake was the only species of reptile seen in the region.

Pitcher plants were found east of Mud Pond and near Branch Pond. Cotton grass was found in The Burning. Early azalea was in bloom near Branch pond on June 16, 1993.

Table 8. Monitoring results from the upper two drift-fences in the Lye Brook Wilderness Region during 1995. Three trappings per month in April, May, June, July, September, and October are included (18 trappings).

Species name	# of all ages	# of young of the year	% young of the year[1]	date of first meta-morph[2]	largest adult (total length)	# per trapping[3]	% of group	% of total catch
Salamanders								
Eastern newt	228	38[4]	17%	July 2	98	12.7	52%	29%
Spotted salamander	156	63	40%	Sept. 8[2]	206	8.7	36%	20%
Redback salamander	36	0	0%	--	90	2.0	8%	5%
Northern two-lined	15	0	0%	--	95	0.8	3%	2%
Group totals	435	101	23%			24.2	100%	56%
Frogs and Toads								
Wood frog	147	6	4%	Sept. 10[2]	70	8.2	41%	18%
Green frog	122	39	32%	July 2	81	6.8	34%	15%
American toad	78	67	86%	May 25	86	4.3	22%	10%
Spring peeper	14	2	14%	June 25	35	0.8	4%	2%
Group totals	361	114	32%			20.0	100%	45%
Amphibian totals	796	215	27%			44.2		100%

[1]For each species individuals under a given total length were considered young of the year. The chosen length was based on the timing of their appearance, gaps in their size continuum and records in the literature. The cutoff sizes used were *A. maculatum* (70 mm). *E. bislineata* (60 mm), *N. viridescens* (45 mm), *P. cinereus* (32 mm), *B. americanus* (30 mm), *P. crucifer* (20 mm), *R. clamitans* (41 mm), *R. palustris* (30 mm), and *R. sylvatica* (25 mm). The maximum size of any year's young is not fixed. However, I have chosen to use these sizes for comparisons.

[2]No trapping took place in August.

[3]Number per trapping are rounded to the nearest 0.1. All other figures are rounded to the nearest whole number.

[4]Three individuals below the 45 mm cut-off length were caught very early in the spring. This suggests that they either overwintered at a very small size or overwintered as larvae and metamorphosed in the spring. They are not included in the young of the year category.

Discussion

Discussion of the inventory results

The overall diversity found at this site fits well with a pattern that has emerged as a result of work in Addison, Rutland, Chittenden, and Bennington Counties (Andrews 1988a, b, 1990, 1992, 1994, 1995a, b; Trombulak 1994).

The species list generated (Table 1) is almost identical to that of the two other central Green Mountain sites where I have data sets (Mt. Mansfield and the AP / BM Region). The proportions of each species differ, but the relative percentages are dependant on the mix of methods used for the inventory. A more direct comparison of drift-fence results will be available after the 1995 field season results from all three sites have been compiled.

The Vermont amphibian species which were not found at this site (Table 11) are either very rare, localized in other regions of the state, or found in habitat types which were not found in this region. Compared to sites outside of the Green Mountains, but still in western Vermont, this site has a lower diversity of amphibian species. Whether this is a result of the decreased buffering capacity of the soils and bedrock, habitat types, elevation, or other direct or indirect effects of a change in microclimate is not yet clear.

Missing frogs

The Western chorus frog has only been located along the northern end of Lake Champlain and even there it has not been located in this decade. The Northern leopard frog appears to be missing from large areas of southern Vermont and never has been found at high elevations in Vermont. It seems to prefer large permanent water bodies with extensive vegetation at low elevations. 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 in northeast and north central Vermont. It has not been reported from this far south in Vermont, although the habitat and local climate appear to be suitable.

Missing salamanders

The absence of Four-toed salamanders, Jefferson salamanders and Blue-spotted salamanders from the three Green Mountain sites I have surveyed suggests that they are entirely limited in distribution to foot hills and floodplains. The Blue-spotted salamander seems to prefer wooded lowland floodplains. The Jefferson salamander seems to prefer less acidic soils and waters in low- to mid-elevation oak-hickory woodlands. The Four-toed salamander has been found in association with the Blue-spotted and the Jefferson salamander but like them not at high elevations. I had thought that if I was to locate them at all in the Green Mountains, it might be on the south and west flank of the mountains in an area of oak woodlands. 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 but I still did not locate any of these

Table 9. Maximum counts of egg masses from monitoring locations in the Lye Brook Wilderness region in 1994 and 1995. At the site near Benson Pond the entire pond is surveyed. At North Alder Dam a four-meter strip around all of the pond except the swampy north end is surveyed. At the Pond Near Drift Fence #2 a four-meter strip around the entire pond is surveyed.

Site	Spotted salamander	Wood frog	Mean pH[2]
Near Benson Pond			
1994 count dates: 4/26, 5/10, 5/25	10	67[1]	7.3 (N = 1)
1995 count dates: 4/24[2], 5/12	3	19	6.8 (N = 1)
North Alder Dam			
1994 count dates: 5/11, 5/25, 6/8	97	225	5.0 ± 0.3 SD (N = 2)
1995 count dates: 4/24[2], 5/12, 6/9	292	3	5.1 ± 0.4 SD (N = 2)
Pond Near Drift Fence #2			
1994 count dates: 5/11, 5/25, 6/9	6	3	5.7 ± 0.3 SD (N = 2)
1995 count dates: 4/24[2], 5/12, 6/9	70	152	5.6 ± 0.4 SD (N = 2)

[1]Hatched by May 10

[2]All readings taken on April 24, 1995 were believed to be erroneus and are not included in the mean. Each reading used in the average is itself composed of three measurements taken from different areas of the ponds. All pH means have been rounded to the nearest 0.1.

Table. 10. The 1994 and 1995 combined results of three 50 m stream transects in Branch Pond Brook in the Lye Brook Wilderness Region. Only adult *Gyrinophilus porphyriticus* (Spring salamander) and *Eurycea bislineata* (Two-lined salamander are included in the table. All other species and larvae are excluded.

Year	Spring salamander	Two-lined salamander	pH[1]	Water temp. in °C[1]	Max. water depth[2] in cm
1994					
(7/18/94)	10	11	4.9 ± 0.2 (N = 3)	17.4	20
1995					
(7/24/95)	6	1	4.4 ± 0.5 (N = 5)	17.4	26

[1]Temperature and pH were taken two meters downstream from the downstream end of the first transect. Temperature was taken only once in 1994 and is the average of three measurements in 1995.

[2]Reference point is the deepest point between the two large rocks which constrict the channel approximately two meters downstream from the beginning of the first transect.

Table 11. Vermont amphibian species that were not found in the Lye Brook Wilderness Region. With the exception of historical records of the Mink frog (northern Vermont), none of these species have been reported from any mid- to high-elevation site in the Green Mountains.

Species	Common names
Salamanders	
Ambystoma jeffersonianum	Jefferson salamander
Ambystoma laterale	Blue-spotted salamander
Hemidactylium scutatum	Four-toed salamander
Necturus maculosus	Mudpuppy
Frogs	
Pseudacris triseriata	Western chorus frog
Rana pipiens	Leopard frog
Rana septentrionalis	Mink frog

Table 12. A comparison of the relative abundances of amphibians found in the Lye Brook Wilderness Region and the Abbey Pond / Beaver Meadow Region. Data used are from the drift fences, site checks, and active searches during the 1993 inventories of the two regions. The results have been altered in an effort to adjust for differing amounts of effort devoted to each of the three methods. The active search results from the Lye Brook Wilderness Region have been multiplied by 2. Site check results by 1.7 and drift fence-nights x 1.23. This data set was generated only for comparison purposes and should not be interpreted as the actual abundance of the species at each site.

Species	Lye Brook Wilderness Region		Abbey Pond / Beaver Meadows Region	
Salamanders				
Eastern newt	436	49%	583	61%
N. two-lined salamander	202	23%	70	7%
Redback salamander	152	17%	140	15%
Spring salamander	59	7%	2	<1%
Spotted salamander	20	2%	59	6%
Dusky salamander	19	2%	102	11%
Total	888	100%	956	~100%
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 treefrog	0	0%	1	<1%
Bullfrog	0	0%	0	0%
Total	211	~100%	217	~100%

species within the LBW Region. I did locate one individual of the Blue-spotted salamander group in the Batten Kill Valley less than 1 km west of the wilderness area.

The Mountain dusky salamander (*Desmognathus ochrophaeus*) has been reported from one site in central Vermont. The individual was an immature specimen that remains the only report of this species in Vermont. It is a species which can tolerate generally drier conditions than its close relative the Dusky salamander. Due to the scarcity of records for this species I have not included it in Table 11. However, there are many records from central New York State and it is a species which may (again?) be found in Vermont. Habitat which appears appropriate for the Mountain dusky salamander does occur within the region.

Mudpuppies would be expected primarily in Lake Champlain, the Connecticut River and their major tributaries, hence not at this site.

Frogs limited in abundance

Two frog species found within the wilderness area appear to be much more abundant within the Batten Kill floodplain: Bullfrog and Gray treefrog. Only one Bullfrog was found within the wilderness area. It was calling from Benson Pond near the access to Lye Brook Falls. I have not located Bullfrogs above 1200 ft. at any of my Green Mountain Study sites. In 1993 I located a single Gray treefrog inside the wilderness area. Despite efforts designed specifically to locate this species only three more were located during 1994 and 1995. I strongly suspect that there are small populations of this species within the wilderness area that I was unable to locate due to their arboreal habits and limited calling period.

The pickerel frog on the other hand appears to be more abundant in the uplands than in the broad river valleys, but even in the uplands it is one of the rarest frogs at any of my Green Mountain study sites. It was not caught in any of the drift fences in 1993 or 1994 and it was caught in only the Falls Access drift-fence in 1995. Outside of this corner of the survey area I located a very few of them using other methods near Stratton Pond, Bourn Pond, and Winhall Brook.

Salamanders limited in abundance

The Dusky salamander is not a common salamander anywhere in Vermont. It seems to prefer cool, well-shaded, permanent seepage areas or stream edges with an substrate that contains a lot of organic matter. Although I have occasionally found streams or seepage areas where this species is quite abundant, its distribution within a study region is often spotty. I found a very few scattered pockets of this species in this region. Most of them were found at low elevations near the base of Lye Brook (8 out of 11 individuals), one was found near Stratton Pond, and two along Winhall Brook.

Comparisons between this region and the AP / BM Region.

The most responsible comparison that can be made from the 1993 inventory data between the LBW Region and the AP / BM Region 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 in the LBW

Region was half that spent in the AP / BM Region, 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. The results of balancing the effort are shown in Table 12.

At both of the sites the high percentages of Green frog and Eastern newt are noteworthy. Research at other sites in the northeast would lead one to expect that the salamander found in greatest abundance would be the Redback salamander rather than the Eastern newt (Burton and Likens 1975, Wyman pers. comm.). I can think of four possible factors that may be the cause of the results at these sites.

1. The Redback salamander has been shown to be limited by soils with a pH value < 4.0 (Wyman and Hawksley-Lescault 1987) whereas the Eastern newt has been shown to be quite tolerant of a variety of substrate pH levels (Wyman and Jancola 1992). The mean soil pH from five sites in the LBW Region was generally acidic [4.7 ± 0.9 (N=5)].

2. The Redback salamander has been shown to be most abundant in areas of more mature hardwoods (>70 yrs.) (Petranka et al 1993) and most of this area has been regularly logged, some of it relatively recently.

3. The amount and distribution of permanent and semipermanent standing water in this area, although relatively acidic, provides good breeding sites for Eastern newts. In contrast Redback salamanders breed in or under fallen trees and among tree roots. Many of the large or rotten hardwood trees and branches that might have fallen and provided breeding sites for this species have been removed.

4. The Redback salamander has been shown to prefer the litter of broad-leafed forests over coniferous forests (Heatwole 1962). Large segments of this region are covered with dense spruce-fir forests.

Wood frogs are the species of frog that I would expect to be most abundant in the northern hardwood forests of the state. In this region and in the AP / BM Region the apparently higher abundance of Green frog is probably the result of abundant breeding sites with permanent water. The tadpoles of green frogs overwinter in ponds, lakes, and beaver dams. Without permanent water they can not survive. The wood frog tadpole on the other hand is found in temporary pools and metamorphoses by the end of summer. Consequently, the abundance of permanent water in this area is probably one of the main reasons for the higher percentage of Green frogs. Another possibility could be the existence of fish in the larger breeding sites. Predation on Wood frog larvae from fish, either natural or introduced, is presumed to be a large part of the reason that they usually breed in temporary ponds where fish can not survive. Green frogs, on the other hand, are frequently found in lakes, ponds, and streams with fish populations. This suggests that Wood frogs are less tolerant of the presence of fish than Green frogs. Introduction of fish to these ponds may have helped to increase the relative abundance of Green frogs relative to Wood frogs.

Although the American toad is the second most frequently found frog in this comparison (Table 12), I do not believe that it is actually the second most abundant in the region. American toads are more active during the day and in hot weather than both Wood frogs and Spring peepers. Spring peepers are most effectively located during calling surveys. I believe that the site checks and active searches would be biased in favor of American toads relative to Wood frogs and all three methods would be biased in favor of American toads relative to Spring peepers. I believe that the results at the drift fences in 1994 (Table 5), which show the American toad caught at one seventh the rate of Wood frogs, are a less biased comparison. The data do suggest that the American toad is relatively more abundant in the LBW Region than in the AP / BM Region.

Equally surprising in this comparison were the low numbers of the Spotted salamander and the Dusky salamander relative to the AP / BM Region. As expected the drift-fence results from 1994 and 1995 (Tables 5 & 8) show the Spotted salamander as the second most frequently caught salamander. In the case of the Dusky, on the other hand, I have had only limited success in locating breeding sites in the LBW Region.

The area surveyed in the AP / BM Region contains less of the appropriate habitat type for the Northern two-lined salamander than the LBW Region. In the LBW Region the Northern two-lined salamander makes up 23% of the salamanders found. It is second in abundance only to the Eastern newt. While in the AP / BM Region, it makes up only 7% and ranks fourth in abundance using these methods. Once one moves off the central plateau of the LBW Region, there are many fast well oxygenated brooks and streams. These streams were included in the area surveyed in this region. This was not the case in the AP / BM Region. The area surveyed in the AP / BM Region contains only one short section of this habitat type. These streams are the favored habitat of this salamander. The hypothesis that the large numbers of the Northern two-lined salamanders in the LBW Region are a result of the larger percentage of this habitat type in the area surveyed is further supported by the greater relative abundance of the Spring salamander in the LBW Region. In the AP / BM Region it is the least common salamander at only 0.2% while in the LBW Region it comprises 7% and is 4th in abundance. This large stream predator is found in the same habitat type as the Northern two-lined salamander.

Comparisons between two large regions, although useful, are less reliable in showing small proportional differences than comparisons between the same sites over time.

Discussion of the monitoring results

It is too early to look for any meaningful trends in any of the monitoring data. I believe that at least three years of monitoring data need to be collected before I can claim to have even a snapshot in time for future comparisons. Year to year variation is to be expected for some species as a result of natural factors such as the amount and distribution of precipitation and overwintering conditions. Ten years of monitoring data would begin to reveal any long-term trends of these populations.

The Eastern newt and the Spotted salamander made up 88% of the salamanders caught at the two drift fences (Table 8). It is possible that the

Redback salamander is under-represented in this sample. Both the Eastern newt and the Spotted salamander breed in water. The young disperse from the breeding sites after metamorphosis from their larval stages. In contrast, the Redback salamander breeds on land. The migration of metamorphs of both the Spotted salamander and Eastern newt away from the breeding site combined with the migration of adults of the Spotted salamander to and from the breeding site may skew the results of these two salamander species relative to that of the Redbacks which are not known to migrate to or from breeding sites. If the Redback salamander moves across the surface less often, it would be less likely to be caught in a drift fence. At one site in Addison County (Andrews 1995b), I saw evidence of fall movement of the Redback salamander. This may or may not be taking place here. If it is, it would help to balance the skewing of the relative abundance figures. This potential bias is not a concern for monitoring purposes since I am primarily interested in year to year comparisons within species rather than comparisons between species in a given year.

Based on the large number of metamorphs caught (Table 8), the Spotted salamander seems to have had a successful breeding year at these sites, despite the early summer drought. Perhaps the increase in the number of egg masses of this species over last year (Table 9) helped compensate for those eggs and larvae which dried up.

Young of the year of the Northern two-lined salamander are not showing up in this sample. Perhaps, unlike the adults, the young remain near their breeding sites (springs and brooks).

The absence of Redback salamanders under 32 mm is a surprise. This suggests that this species did not have a successful breeding year in the LBW Region. In the 1994 results from the AP / BM Region (Andrews 1995c), 10 percent of this species were under 32 mm. Although none of the Redback salamanders caught in the LBW Region this year were under 32 mm, slightly larger salamanders were caught. This could be intrepreted in a couple ways: the young of the year might have been growing faster and achieving a larger size sooner, or there was limited breeding success this year and the slightly larger individuals were last years cohort which grew slowly. Close examination of the data from a series of years will help clarify results such as these.

Based on the number of young caught (Table 8), both the American toad and the Green frog appeared to have had a successful breeding year, while the Wood frog seemed to produce relatively few young. The number of egg masses of the Wood frog counted in 1995 compared to 1994 (Table 9) did not show a consistent trend. Wood frog egg masses decreased near one drift fence and increased near the other. One might expect that the early drought would have limited larval metamorphosis of this species which is an early spring breeder. However, the Spotted salamander is also an early spring breeder and they successfully produced many young.

As a result of its climbing abilities, I believe we catch a small percentage of the number of Spring peepers in the vicinity of the fence. Therefore, I hesitate to make any judgements on its breeding success based on this data.

The relative success of a breeding year for any species at this site will become clearer as the number of years of data increases and comparisons can be made between years.

I suspect that the slight drop in the number of Spring salamanders (10-6) found in the stream surveys between 1994 and 1995 (Table 10) is a result of normal sampling variation. However, the drop in the number of Northern two-lined salamanders from 11 to 1 bears watching.

Although the data from the Falls Access drift fence was not collected according to the monitoring protocol (no May data, Table 6), the appearance of 11 Pickerel frogs is remarkable considering none were caught in the previous year at any of the three drift fences (Table 5). All individuals were less than 37 mm in total length and all were caught in September. Apparently this species had a successful breeding season at the Falls Access site.

Context

Very little data had been collected on Vermont reptiles and amphibians until the late 1980's. What little had been collected had not been compiled and presented in a document. Earlier this year the first compilation of reptile and amphibian records from Vermont was published (Andrews 1995a). The data collected in this inventory and in inventories of the Abbey Pond / Beaver Meadow Region (Andrews 1995c), Mt. Mansfield (Trombulak 1994), Addison County (Andrews 1990, 1995b) and parts of Franklin (Andrews 1992) and Rutland Counties (Andrews 1988a, 1988b) were all very important components of that report. Additional records of reptiles and amphibians still need to be gathered from many parts of the state to establish the present distribution of these species.

Global amphibian decline has recently become a subject of scientific concern (Blaustein and Wake 1990, Bishop and Pettit 1992, Vial and Saylor 1993). Coordinated monitoring programs have been called for in order to identify the current status and projected trends for this important group throughout their range. In addition to providing the initial amphibian inventory of the LBW region and establishing a monitoring program to track their populations over time, this effort is part of a larger monitoring network in Vermont. Three long-term monitoring regions have been established within the Green Mountains of Vermont (LBW Region, Mt. Mansfield, and the AP / BM Region). Data from all three regions will allow us to see if any amphibian species are declining in the Green Mountains of Vermont. In addition, it will allow us to see if population variations are local or state-wide.

Future plans

If funding continues, I hope to continue monitoring amphibian populations at the three Green Mountain sites for at least the next three years and hopefully the next eight years. In addition, funds are being sought to inventory reptiles and amphibians in additional areas of the state and gather records from other interested and knowledgable Vermonters. If funded, a state-wide education effort will also be implemented to raise awareness of these species and to encourage as many people as possible to contribute records and play an active role in reptile and amphibian conservation.

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References

Andrews, J.S. 1988a. Field investigation of northwestern Rutland County for Ambystoma opacum (marbled salamander). Technical report 4, Nongame and Endangered Species Program, Vermont Fish & Wildlife Department, Waterbury, Vermont. 11 pp.

Andrews, J.S. 1988b. A survey of selected sites in northwestern Rutland County for Eumeces fasciatus (Five-lined skink). Unpublished Report for the Nongame and Endangered Species Program, Vermont Fish & Wildlife Department, Waterbury Vermont. 13 pp.

Andrews, J.S. 1990. Areas of biological significance in Weybridge, VT. A report prepared for the Weybridge Town Planning Committee.

Andrews, J.S. 1992. A survey of selected sites in Franklin County, VT for *Apalone spiniferus*, *Hemidactylium scutatum* and *Pseudacris triseriata*. An unpublished report for the Lake Champlain Management Conference, through the VT Nongame and Natural Heritage Program.

Andrews, J.S. 1994. 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. *In* S.H. Wilmot and T.D. Scherbatskoy (Eds.),Vermont Monitoring Cooperative: annual report for 1993. VMC Ann. Rep. No. 3, pp. 164-182. Vermont Department of Forests, Parks and Recreation, 103 St. Main St., Waterbury, Vermont 05671.

Andrews, J.S. 1995a. A preliminary atlas of the reptiles and amphibians of Vermont. A report for the Vermont reptile and amphibian scientific advisory group. Middlebury College Reprographics, Middlebury Vermont. 64 pp.

Andrews, J.S. 1995b. Inventory and monitoring of amphibians in the Lake Champlain Drainage of Addison County, Vermont. Masters Thesis, Middlebury College, Middlebury, Vermont.

Andrews, J.S. 1995c. Inventory and monitoring of reptiles and amphibians in the Abbey Pond / Beaver Meadow Region of the Green Mountain National Forest, Addison County, Vermont. An unpublished report for the Green Mountain National Forest, Rutland, Vermont. 37 pp.

Bishop, C.A., and K.E. Pettit. 1992. Declines in Canadian amphibian populations: Designing a national monitoring strategy. Occasional Paper # 76, Canadian Wildlife Service, Ottawa, Ontario, Canada. 120 pp.

Blaustein, A.R., and D.B. Wake. 1990. Declining amphibian populations: A global phenomenon? Trends in Ecology and Evolution 5:203-204.

Burton, T.M., and G.E. Likens. 1975. Salamander populations and biomass in the Hubbard Brook Experimental Forest, New Hampshire. Copeia 1975:541-546.

Freda, J. 1986. The influence of acidic pond water on amphibians: a review. Water, Air, and Soil Pollution 30:439-450.

Heatwole, H. 1962. Environmental factors influencing local distribution and activity of the salamander, *Plethodon cinereus*. Ecology 43:460-472.

Klemens, M.K. 1993. Amphibians and reptiles of Connecticut and adjacent regions. State Geological and Natural History Survey of Connecticut, Bulletin No. 112. 318 pp.

Petranka, J. W., M.E. Eldridge, and K. E. Haley. 1993. Effects of Timber Harvesting on Southern Appalachian Salamanders. Conservation Biology Vol. 7, No. 2, 363-369

Trombulak, S. C. 1994. Amphibian monitoring on Mt. Mansfield *In* S.H. Wilmot and T.D. Scherbatskoy (Eds.),Vermont Monitoring Cooperative: annual report for 1993. VMC Ann. Rep. No. 3, pp. 110-127. Vermont Department of Forests, Parks and Recreation, 103 St. Main St., Waterbury, Vermont 05671.

Wyman, R.L. and D.S Hawksley-Lescault. 1987. Soil Acidity Affects Distribution, Behavior, and Physiology of the Salamander *Plethodon cinereus*. Ecology 68(6):1819-1827.

Wyman, R.L. and J. Jancola. 1992. Degree and Scale of Terrestrial Acidification and Amphibian Community structure. Journal of Herpetology, Vol. 26 No. 4, pp.392-401

Appendix A

Protocols

Guidelines for the Use of the Drift-fences

When

I would like to get the traps open three times per month for the months of April, May, June, July, September and October. In many months you won't get more than three nights of good activity, so you can not afford to pass up the right conditions very often. Having a back-up person who can open the traps when you can't is essential.

Amphibians are most active at night during and immediately after heavy rains. In the early spring it is possible to get activity associated with a wet snow, particularly if the spring is a little later than normal. Even if it stops raining well before dark, if the surface of the ground is still wet, and the soil and vegetation are saturated, activity could take place. Ideal conditions are a solid steady rain that starts during the day and continues well into the night. In the summer, thundershowers that occur during the evening, during the night, or late enough during the day so that the ground and vegetation are still wet can be good. Frequently you have to gamble that good weather conditions will develop after you open the traps. With the help of the weather radio you often need to make an educated guess on whether or not good conditions are likely to occur over night. Generally I don't open the traps if the ground is still dry and the chance of rain is under 70%. You will occasionally open the traps on dry nights by mistake. It is to be expected. Turn in the data sheets for these nights, but try to get an extra trapping in as well.

On occasion I have gone for a whole month without having good trapping conditions. The best you can do in that situation is open the traps in less than ideal conditions. If things have been really dry for a while and it looks like it may continue that way, open the traps after a lighter rain than you normally would. Also if, for example, you trapped successfully only two times in April, get in an extra trapping in early May. Sometimes there is nothing that you can do about it. It just doesn't rain. Remember that the weather at the trap site may be different from the weather where you are located. Often the higher elevation sites get rain or at least moisture that passes over the valleys.

When necessary, spread your trap-nights out. I am not suggesting that you skip a perfect night, but, if in April (for example), you had three successful trappings in the first week, add an extra trapping later in the month. We don't want to entirely miss the relatively short breeding periods of some species.

I have been impressed with the ability of some species to migrate and breed when there are still patches of snow on the ground and ice on the ponds. These early migrations are particularly important to catch. Some of our species have evolved a strategy of breeding in temporary pools that may dry up over the summer. In order for them to produce young, they need to get their eggs in the pond as early as possible. The first rains of spring will bring out spotted salamanders, wood frogs, and a few other early spring breeders that we may not be fortunate enough to trap later in the year. In the Lake Champlain Valley this activity sometimes starts as early as late March. At lower elevations that are exposed, it usually begins by the second week of April. At very high or shaded sites breeding activity may not begin until early May. As soon as some of the ice has melted around the edges of ponds or around the bases of trees in the swamps, breeding could begin. If large areas of ground are free from snow, and moisture can reach the wintering amphibians in the soil, some of them will move. Some of the sites will be hard to get to in the spring. Get there as early as you safely can.

How

When you open the traps make sure the bottom of the snake traps (screening) are placed flush with the fence, covered, and weighted down. Plug all other avenues of travel with leaves or soil debris to direct the amphibians into the traps. Spread a few leaves in the entrance to the traps as well.

Remove any branches that have fallen on the fence, as well as vegetation that has grown next to it. We don't want any bridges which might allow amphibians to get over the fence.

Open the traps before dark or very soon after and check them the next day.

It is safer, much more efficient, and more fun, to open and check traps with a partner. If you can't go with a partner, at least let someone know when and where you are checking or opening traps. Many fences are remote and accidents can happen.

When checking the pit-traps check under the funnel rims carefully. In some traps this requires a pencil or sharp stick to clear the area that your fingers are too large to reach. The bottom of the trap needs to be very carefully checked by sight and by feel. Small salamanders such as redbacks can easily swim around your fingers as you feel in the water. Use a cup to bail as much water as possible. In any remaining water move your fingers around in circles while touching the bottom and corner of the can in one direction (say clockwise) than quickly change to the other direction (counter-clockwise). Feel carefully for any momentary contact with anything in the trap. Remove all leaves and debris that your fingers come into contact with. Look for salamanders that may be half way up the sides of the can as well.

In the snake traps very carefully check the corners around the funnels at both ends. Small salamanders curled in these corners are easy to miss. Remove all debris, spiders, slugs, etc. that may accumulate in the traps.

Cover all traps securely, snapping the covers into place tightly. Put a rock on a lid if you think that it might not be secure. Hang the snake traps in the trees by the clips with the port open. We don't want to catch and kill creatures by accident while we are not using the fences.

Data

Take down data carefully while you are checking the pit traps. Do not wait until after you have checked a few. Do not risk forgetting or confusing some of the data.

Carefully identify all reptiles and amphibians caught in the traps. If you have any doubt at all about the identity of a species, put it in a plastic container with wet paper towels and take it out so that we can look at it. Store them in a cool dark place. Label the container with a wax pencil so that you will be sure to remember where you found it.

Any species that is not listed on the species list as either common or occasional at that site should be put in a plastic container as well. We need to verify any new or unusual species ourselves.

Identify species by the first letter of their genus name (capitalized) and their full specific epithet (not capitalized) for example; *A. maculatum*. Familiarize yourself with the measuring protocol (see the separate information sheet). Keep a running tally of the numbers of each size group of each species. When you are finished at the site, total up each size group, write the total at the end of the line, and circle it.

Fill out all appropriate blanks on the data sheets; remember, some don't apply to your situation (water temp., person time, specific location, and habitat type). Take the air temperature in the shade. Leave the thermometer in place for at least five minutes. Describe the weather conditions over the last 24 hours with particular emphasis on the timing and amount of rain; for example; (a heavy rain started yesterday around noon and continued all night). If you have some idea of how much rain fell, by all means put it down, but this is not critical.

Create a section near the end of your data sheet titled Accidentals. In this section list all amphibians and reptiles that you found while checking the drift fence that were not in the traps themselves. Individuals that were found in the mouths of traps, along the fence, or that were seen or heard on the way to or from the fences should be listed here along with any accompanying details.

Also create a section at the end of your data sheet titled Other Species. In this section list (or describe) species, other than reptiles or amphibians, that were caught in the traps. With a little practice you should be able to identify the small mammals in the traps (see the separate mammal identification sheet). We will help you learn to identify these. They usually fall into the basic categories of voles, mice, jumping mice, short-tailed shrews, and other shrews. Any unknown or unusual small mammals should be sealed in a plastic bag and frozen until we can look at them. At Mt. Mansfield fences all small mammals should be frozen and labeled with the location of the drift fence they originated from.

At the end of each month make photocopies of your data sheets and send me the originals.

Protocol for Sampling and Measuring Amphibians Captured in the Drift-fences

By keeping track of the sizes of amphibians caught we can begin to see a picture of survivorship, reproductive success, and perhaps health of the species as well as obtain data about the size at metamorphosis, maximum size and average adult sizes. However we don't want to have to measure all the amphibians caught, for example on days when 50 *N. viridescens* metamorphs are found in the traps. At the same time we need a standard method of deciding which ones to measure, so that apparent changes from year to year are not the result of different sampling or measuring methods.

So, **measure the first three individuals of each size class of each species at each drift fence.** For example if you get a trap full of *N. viridescens* metamorphs (tiny individuals that have just left the water this year for the first time), measure the first three of those. In a different can, you find a red eft that is much larger and is probably from last years crop of young. Measure that one and the next two of that size range that you find. If you then find an individual that is visibly larger than the efts you already measured, then that is a new size class and you should measure the first three of those as well. What you may be seeing is metamorphs, efts that left the water one year ago, others that left the water two years ago, and some others that are adults. In the case of adult toads and frogs you may also find that some look considerably larger than others. Instead of being a function of age this may be a function of sex. I suspect that most of the time in the late summer and fall you will catch many young of the year and relatively few adults. In the spring you will probably find that very few of the young have survived to be caught. Clearly this method requires some judgement on your part on whether or not an individual belongs to a separate size class. Short of measuring all of the individuals, there is no way around this that I can see. If you have the time and want to measure all of the amphibians, go right ahead. Write on your data sheet whether you measured all individuals or the first three of each size class. If you measure less than all of them, use this system.

All salamanders that you measure should be measured in two ways. You should measure their total length (from the tip of their nose to the tip of their tail) and their snout-vent length (from the tip of their nose to the beginning of their vent (cloaca). In frogs these two measurements are usually the same, unless the frog retains some of its tail immediately after changing from a tadpole. You need to measure only from the tip of their nose to the end of their body and write it in the snout vent box on the data sheet. Measure both lengths with any snakes that you find as well. With turtles measure the length of the shell on the bottom (plastron). Check your field guide on the green end papers for diagrams of these measurements. We differ only in measuring to the beginning of the vent, instead of to the end as shown in the book.

Even though you are only measuring a certain sample of those individuals you catch, you should still group all unmeasured amphibians and reptiles with the others of the same size class, so that I can see for example that there were twenty of a certain size class, three of which you measured. Also continue to write in the notes section whether they were metamorphs, juveniles and adults. Refer to the book if you aren't sure whether or not an individual is adult size.

Appendix B

Field Efforts and 1993 Results by Method

Table B1. A summary of field efforts in the Lye Brook Wilderness Region during the 1993 inventory.

Month	Active Searches	Canoe Searches	Drift-fence nights	Night-time Visits	Night-time Road Searches	Site Checks	Accidental Discoveries	Total 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 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 B2. Salamanders located in the Lye Brook Wilderness Region during the 1993 inventory.

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 Caudate Species	100%	33%	67%	17%	33%	100%	83%	100%	

Table B3. Frogs located in the Lye Brook Wilderness Region during the 1993 inventory.

Species	Active Searches	Canoe Searches	Drift-fence Nights	Night-time Visits	Night-time Road Searches	Site Checks	Accidental Discoveries	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**	**23.0%**
Hyla versicolor **Gray Tree Frog**				1?				**1?**	**0.5%**
Pseudacris crucifer **Spring Peeper**	7	1		6 3 choruses	2 10 choruses	7	1 1 chorus	**24** **14 choruses**	**12.0%**
Rana catesbeiana **Bullfrog**				1				**1**	**0.5%**
Rana clamitans **Green Frog**	18	6		20 2 choruses	2	40	10	**96** **2 choruses**	**48.0%**
Rana palustris **Pickerel Frog**	3					4	1	**8**	**4.0%**
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**	**12.0%**

# 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 Frog Species	71%	43%	29%	86%	57%	71%	71%	**100%**	--

Table B4a. Combined totals of all amphibians found in the Lye Brook Wilderness Region during the 1993 inventory.

# 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%**

Table B4b. Reptiles located in the Lye Brook Wilderness Region during the 1993 inventory.

***Thamnophis sirtalis* Common Garter Snake**	3					5	3	**11**

Appendix C

Dr. Green's Pathology Report

MARYLAND DEPARTMENT OF AGRICULTURE
Animal Health Laboratory
8077 Greenmead Drive
College Park, Maryland 20740
301-935-6074

FINAL
PATHOLOGY REPORT

Date: 16 January 1995
Submission Date: 7 & 28 June 1994

Accession No. CP4-4083 & CP4-4502
94P251 94P287

Veterinarian: None listed.

Owner: Jim Andrews
Department of Biology
Middlebury College
Middlebury, VT 05753

Species: Amphibian, Caudata, Notophthalmus viridescens (red-spotted newts)
Age: >7 yrs   Sex: 5-F, 6-M   Weights & Lengths (see Table A)
Specimen: Live animals   No. Submitted: 14
Morbidity: Unknown   Mortality: Unknown   Group size: Unknown
Locations: Two ponds: Upper Abbey Pond, Ripton, VT
& Andrews Home Pond, Bridport, VT
Collector: Jim Andrews
Dates of Euthanasias: 7-9 June 1994
28-9 June 1994
Dates of Necropsies: 7-9 June 1994
28-9 June 1994

Significant Findings and Remarks:

HISTORY: For at least the last two breeding seasons (1993 & 1994) red-spotted newts in Upper Abbey Pond have been observed with swellings (lumps) in the muscles of the pelvis. Morbidity and mortality rates were not known.

NECROPSY FINDINGS: See Tables A & B (page 2).

PARASITE EXAMINATIONS: See Table B (examinations of stained blood smears are in progress).

FLUORESCENT ANTIBODY TESTS (F.A.T.):

1. Chlamydia psittaci ("psittacosis"): Negative in 3 of 3 newts.
2. Leptospirosis: Negative in 3 of 3 newts.

BACTERIA & FUNGUS CULTURE RESULTS: See Table C (on page 3).
CYTOLOGIC EXAMINATIONS & WHITE BLOOD CELL COUNTS: See Table D (on page 3).
HISTOLOGIC EXAMINATIONS: See also Tables E & F on page 8.

1. Skeletal muscles: Mycotic granulomatous myositis, subacute to chronic, multifocal to disseminated, minimal to severe, in 9 of 14 newts. Etiology probably Aureobasidium pullulans fungus infection.
2. Small intestines: Protozoal enteritis, multifocal to disseminated, mild, in 4 of 14 newts. Etiology suggestive of coccidiosis (Eimeria, Isospora, or similar apicomplexan protozoa).
3. Small intestines: Protozoiasis, luminal, disseminated, mild to moderate, in 4 of 14 newts. Etiology: luminal protozoan about the size and shape of Hexamita or diplomonads.
4. Small intestines: Verminous enteritis, focal or multifocal, very mild, in 2 of 14 newts. Etiology: small nematodes and flukes.
5. Stomach: Protozoal gastritis, diffuse, mild to moderate, in 1 of 14 newts. Etiology suggestive of Cryptosporidium-like infection.
6. Liver: Hepatitis, eosinophilic, reactive & sinusoidal, diffuse, mild to moderate, in 3 of 14 newts. Etiology not detected but probably reactive to the fungal infection in the muscles.

COMMENTS: Fungi were isolated in pure cultures from the muscles of 3 newts submitted on 28 June 1994. Two of these fungal isolates were submitted to the National Veterinary Services Laboratory in Ames, Iowa, and both were identified as Aureobasidium pullulans. An exhaustive literature search has yet to be done on this fungus, but at present, I can find no reports of this fungus causing infections in animals or man. Neither can I find any histologic descriptions of fungi resembling Aureobasidium in animals, except for the single report by Herman (1984) in which the organism in newts from West Virginia was described as an Ichthyophonus-like infection. Histologic features of the fungus in Herman's report and your Vermont newts are identical, but are not typical of Ichthyophonus infection. I have contacted Dr Herman by telephone, and he has not done any further work on the disease, and is not aware of any other studies or publications. He does however, think the infection has recurred in newts from his locality (Sleepy Creek Lake, West Virginia) yearly for at least 20 years. I have examined newts from at least 4 ponds in Virginia in the last 5 years and have never seen this condition. So, although the disease cannot be considered "new", the one description in the literature has some errors, incorrect assumptions, is incomplete, and the organism was not isolated in cultures. Hence, this fungal disease is definitely worthy of publication.

This fungal infection has many very unusual features and associations. You submitted 14 newts from 2 ponds, but the infection was detected in only newts from Upper Abbey Pond. At necropsy, gross lesions were observed in 7 of 14 newts (Tables A & B). However, histologic examinations showed that 9 newts had mycotic (fungal) infections of the muscles (Table E). As detected at necropsy, the muscles of the posterior body, pelvic region, hindlimbs, and anterior tail were most heavily affected. Much fewer numbers of fungi were found in the muscles of the tail tip, anterior body, forelimbs, and neck. In two newts, fungal cysts were detected within the skin (epidermis). The fungi were not detected in any internal organs (or tissues) of the body. Ichthyophonus fungi infect a wide variety of internal organs (heart, liver, intestines, etc) so this feature is a major clue that the fungus in the newts was not Ichthyophonus. The cause for the selective (topistic) vulnerability of muscles is unknown, but it is possible that this region of the body was the site of invasion by the fungus. For reasons which are explained below, it is suggested (speculated) that this fungus may be spread by wounds or bites of leeches or some other predator. A key piece of information that might link this infection to leeches would be if leeches prefer to attach to newts in the pelvic region.

It appears based on histologic examinations, that some newts have an intense inflammatory reaction to the fungi in the muscles. However, this inflammatory reaction (granulomatous inflammation) may be slow to develop, because some newts had no inflammatory cells around the infected muscle cells, while some newts had intense inflammation around nearly all fungi. And some newts had both. The two newts in which the fungus infection was not suspected at necropsy had extensive inflammation around the fungi with collapse of the fungi and loss of their internal contents. It is logical to assume these two newts were in the healing, and, perhaps, recovery stages of this infection. Those newts with heavily infected muscle cells but little or no evidence of inflammatory reaction may be those animals which would have succumbed to the infection.

The morphology of the fungi in the muscle cells was most unusual and may be unique. This infection should be easily recognized histologically, and readily distinguished from other fungal infections. One problem which has not been resolved is the proper name or terminology for the fungal elements in the muscle cells. This problem may be resolved when a literature search is completed. Names such as spores, endospores, chlamydospores, sphaerules, spherical forms, cysts, pseudocysts, sporangia, and sporangiophores were considered. Although we probably may name the fungal elements in histologic sections whatever we choose, the terms spores, cysts or simply fungal elements are probably best. The shape of the fungal elements in the muscle cells was fusiform or cigar-like. Basically, the fungi seemed to conform to the shape of the muscle cells. In cross sections, however, the fungi were distinctly round. The size of the fungi was measured in unstained fresh crush smears of the infected muscles, and in histologic sections; measurements of the fungi are shown in Table F. The fungi never showed hyphae, budding, daughter spores, or any significant internal structures; absence of such features is important for distinguishing this fungus from other fungal infections. All fungi appeared to have moderately thick walls, and in one newt the fungi appeared to have very thick mucinous capsules. Color of the fungi was variable: unstained fresh smears showed the fungi to be slightly to mildly brown while in stained histologic sections the fungi lost the brown color and took up various colors from the stains. Characteristics of the fungi in special stains are listed in Table G.

The inflammatory reaction to the fungi in the muscles was highly variable. In some newts there was little inflammatory cell reaction despite the presence of massive numbers of fungi. Other newts had intra-muscular fungi with no inflammatory cell reaction, while nearby areas had intense granulomatous inflammation. A few newts had inflammatory reaction around all fungi. In some regions of the pelvic and lower body muscles over 90% of muscle cells were infected by fungi. It is merely assumed that those newts with massive numbers of fungi and little or no inflammation had infections which would have been fatal. Those newts in which all fungi had inflammation probably would have recovered. The prognosis for those newts which had fungi with and without inflammation is uncertain.

The presence of the fungal infection appeared strongly correlated with the presence of trypanosomiasis (Table E). Out of 9 newts with trypanosome infections, 8 (89%) had fungal infections; of the 5 newts without trypanosome infections, 4 (80%) did not have fungal infections. The one newt which had fungal infection without trypansomes, actually may have had trypanosome infection but it was simply not detected. This strong correlation between trypanosomiasis and this fungal infection implies that the leeches may be the proximate cause of the fungal infection. In newts, trypanosomiasis is transitted by leeches. It is possible the fungus enters the newts at the bite wound(s) of leeches. It cannot be determined whether this fungus infection is an opportunistic infection of the leech's bite wound, or whether the fungus is present in the leeches and is transmitted in a method similar to the trypanosomes. It would be very interesting to examine newts from Sleepy Creek Lake (West Virginia) [Herman, 1984] to determine if they have a similar correlation of trypanosomiasis and fungal infections. Many newts which have been examined from ponds in Virginia have had trypanosomiasis but no fungal infection, so the presence of trypanosomiasis or leeches is not the only factor in the transmission of the fungus infection.

The newts from the two ponds in Vermont had a variety of intestinal helminthic parasites (cestodes, trematodes, and nematodes) and at least three species of protozoan parasites. Further identification of some helminthic parasites is being attempted at the Zoological Society of London. A sample of the helminths was submitted in early December; the amount of time necessary for identification of these parasites is unknown, but results will be transmitted to you as soon as they are received. Two of the protozoan parasites were present entirely in the lumen of the intestines and on the surface of the the intestinal mucosal cells; these protozoa actually may have been part of the normal intestinal fauna. One luminal protozoan was probably a flagellate and the other a ciliate. No specific disease or illness can be attributed to the luminal parasites. However, the third protozoan had invaded the cells of the intestinal mucosa; the parasite resembled the disease of animals called coccidiosis. Coccidia are apicomplexan protozoa, all of which are considered parasites in the strictest sense. Eimeria and Isospora are the most common coccidia of mammals and birds. Three species of Eimeria have been described from newts in North American: E. longaspora, E. megaresidua and E. grobbeni; only the first two species have been documented in red-spotted newts. It was not possible to identify the coccidia of these newts to the genus or species level. All coccidian infections in these newts were considered mild, so it is unlikely they were causing illness. Finally, one newt had unusual tiny structures on the surface of the mucosal cells of the stomach; these structures may have been parasites of the genus Cryptosporidium. These organisms are so small the only certain method of identification is by electron microscopy.

Two potential disease-producing bacteria were isolated from the intestines of 2 newts: Yersinia sp. and Aeromonas hydrophila. Histologic examinations of both newts failed to detect any lesions which could be attributed to infection by these bacteria. Therefore, these two bacteria were probably inocuous in these newts, were transient in the intestines, or, were part of the normal intestinal and/or environmental flora.

SUMMARY & CONCLUSIONS: Nine of eleven newts from Upper Abbey Pond had fungus infections limited to the skeletal muscles. The fungus was cultured from 3 newts and was identified at a reference laboratory as Aureobasidium pullulans, a species which, to my knowledge, has never been described as causing infections in amphibians. However, this fungal infection in newts has been previously described (albeit poorly) and the fungus was mis-identified as an Ichthyophonus fungal infection. Therefore, a publication re-describing this infection and the fungus are warranted.

These newts had at least 4 protozoan parasites, as well as nematode, cestode, and trematode parasites. The blood protozoan was Trypanosoma diemyctyli and one intestinal protozoan may have been either Eimeria longaspora or E. megaresidum. Two protozoa were intraluminal organisms and were probably innocuous; these luminal protozoa could not be identified but probably were a flagellate and a ciliate. Some of the helminthic worms presently are being identified at the Zoological Society of London. None of these parasites were considered serious or life-threatening infections. However, there was a striking correlation between the occurrence of trypanosome infections and the fungus infections, suggesting the two organisms may have had the same vector (ie, leeches). Two potentially pathogenic bacteria (Yersinia and Aeromonas hydrophila) were isolated from the intestines of two newts; histologically, neither newt showed lesions which could be attributed to infection by these bacteria, therefore, disease cannot be attributed to these two bacteria.

FINAL PRIMARY DIAGNOSES:

1) Skeletal muscles: Mycotic myositis, in 9 of 14 newts; etiology: Aureobasidium pullulans fungus infection.
2) Blood: Internal parasite: Trypanosoma diemyctyli protozoa in 8 of 14 newts.

FINAL SECONDARY & INCIDENTAL DIAGNOSES:

3) Intestines: Yersinia sp. bacterial infection (culture diagnosis only).
4) Intestines: Internal parasite: Coccidiosis in 4 of 14 newts.
5) Stomach & intestines: Internal parasite: Flukes in 5 of 14 newts.
6) Intestines: Internal parasite: Nematode worms in 4 of 14 newts.
7) Duodenum: Internal parasite: Tapeworm in 3 of 14 newts.
8) Urinary bladder: Internal parasite: Nematode worm in 1 of 14 newts.

D. EARL GREEN, D.V.M.
Diplomate, A.C.V.P.

CC: J Andrews
SR: 56 (1,4)\deg
ST: All organs of 14 newts

TABLE A: Signalments, Morphometry, & Gross Necropsy Findings in 14 Newts

Newt ID No.	Date of Necropsy	Pond Site	Sex	Weight	SVL	Tail Length	Necropsy Lesions: Muscle Fungi	Spleno-megaly	Black Liver
251A	7 June	AHP	M	2.3	ND	ND	0	0	0
251B	7 June	AHP	F	1.45	ND	ND	0	0	0
251C	7 June	AHP	F	2.08	ND	ND	0	+	0
251D	7 June	UAbP	NR	2.62	ND	ND	+++	0	0
251E	8 June	UAbP	M	2.75	47	53	+++	++	++
251F	8 June	UAbP	NR	2.12	44	46	++	0	+++
251G	9 June	UAbP	M	2.48	46	48	++	+++	+++
251H	8 June	UAbP	NR	2.37	46	48	0	0	0
251I	9 June	UAbP	F	2.31	49	55	0	++	+++
251J	9 June	UAbP	F	1.72	41	43	0	0	0
251K	9 June	UAbP	M	1.82	43	46	0	+	+
287A	28 June	UAbP	M	2.5	46	49	+++	+	++
287B	29 June	UAbP	M	2.1	44	46	++++	0	+++
287C	29 June	UAbP	M	2.0	44	44	++++	0	+++

NR- Not recorded; the sex of all newts will be confirmed histologically from the histologic slides at a later date.
ND- Not done SVL - Snout-vent length (in millimeters)
Weights are in grams. F - Female M - Male
+ - minimal ++ - mild +++ - moderate ++++ - severe
AHP - Andrew's home pond
UAbP - Upper Abbey pond

TABLE B: Parasites in 14 Newts

Newt ID No.	Blood: Trypanosoma diemyctyli	Muscle: Fungus Spores	Stomach & Intestine: Duodenal Tapeworm	Stomach Flukes	Intestine Flukes	Jejunal Nematodes	Bladder: Nema-tode
251A	0	0	0	0	0	0	0
251B	0	0	0	0	0	0	0
251C	0	0	0	0	0	0	0
251D	0	+++	0	0	0	0	0
251E	++	+++	0	0	0	4	0
251F	+	++	0	0	0	1	0
251G	+++	++	0	0	0	0	1
251H	+++	0	0	0	1	0	0
251I	+++	0	0	2	0	0	0
251J	0	0	0	0	5	1	0
251K	+	0	1	0	2	1	0
287A	++	+++	1	0	0	0	0
287B	0	++++	1	0	0	0	0
287C	++	++++	0	0	0	0	0

Numbers represent the number of helminthic parasites found.
+ - minimal ++ - mild +++ - moderate ++++ - severe

TABLE C: Bacteria & Fungus Culture Results

Newt ID No.	Exam Date	Site	Rump Skin & Muscle	Liver	Intest/Colon
251A	7Jun	AHP	ND	No growth	No growth
251B	7Jun	AHP	ND	No growth	No growth
251C	7Jun	AHP	ND	*S.liquefaciens	Hafnia alvei
251D	7Jun	UAbP	ND	No growth	No growth
251E	7Jun	UAbP	ND	No growth	Hafnia alvei
251F	8Jun	UAbP	ND	No growth	Hafnia alvei
251G	9Jun	UAbP	ND	No growth	Hafnia alvei
251H	8Jun	UAbP	ND	No growth	Hafnia alvei
251I	8Jun	UAbP	ND	No growth	Yersinia sp. Escherichia coli **Ps. putida
251J	8Jun	UAbP	ND	No growth	No growth
251K	9Jun	UAbP	ND	No growth	No growth
287A	28Jun	UAbP	****A.p.	No growth	***Aero. hydrophila
287B	29Jun	UAbP	****A.p.	ND	Hafnia alvei
287C	29Jun	UAbP	****	No growth	ND

* - S. is the bacterial genus Serratia
** - Ps. is the bacterial genus Pseudomonas
*** - Aero. is the bacterial genus Aeromonas
**** - A.p. is the fungus Aureobasidium pullulans

TABLE D: White Blood Cell Counts in 14 Red-spotted Newts

Newt ID No.	Site	Trypanosomes Wet*	Trypanosomes Dry*	Smear Type	Differential WBC Counts: Lymphocytes	Foamy Lymph's	Monocytes	"PMNs"	Eosinophils	Basophils
251A	AHP	0	0	Heart	21	0	3	52	6	18
251B	AHP	0	0	Chest	32	6	14	46	0	2
251C	UAbP	0	0	Clot	12	4	12	40	8	24
**251D	UAbP	0	1	Tail	24	20	0	48	4	4
**251E	UAbP	++	5	Tail	24	14	6	44	4	4
**251F	UAbP	+	0	Tail	40	10	8	36	0	6
**251G	UAbP	+++	0	Tail	16	10	2	50	4	18
251H	UAbP	+++	1	Tail	20	36	10	30	0	4
251I	UAbP	+++	0	Tail	20	18	6	44(+2)	8	2
251J	UAbP	0	0	Tail	36	4	12	36	6	6
251K	UAbP	+	0	Tail	20	8	18	46	6	2
**287A	UAbP	++	2	Tail	4	12	20	58	0	2
**287B	UAbP	0	0	Heart	28	0	14	48	4	6
**287C	UAbP	++	6	Tail	10	12	2	76	0	0

* - Wet refers to fresh whole blood examined as a wet mount and unstained; trypanosomes were easily detected by their movement. Dry refers to air dried, stained blood smears; the number refers to the actual number of trypanosomes observed during counts of the white blood cells.
** - These 7 newts had grossly evident fungal infections in their pelvic muscles.
PMNs - Polymorphonuclear cells, also referred to as neutrophils.
WBC - White blood cells (leucocytes); numbers in the columns are percentages.
( ) - Number in parenthesis refers to band (immature) neutrophils.

TABLE E: HISTOLOGIC (and CYTOLOGIC) FINDINGS

		CYTOLOGIC FINDINGS			HISTOLOGIC FINDINGS: MUSCLE FUNGI BY LOCATION									
		Trypanosomes			Neck		Body		Cloaca /Rump		Tail		Leg	
Newt ID No.	Site	Wet*	Dry*	Smear Type	C	G	C	G	C	G	C	G	C	G
251A	AHP	0	0	Heart	0	0	0	0	0	0	0	0	0	0
251B	AHP	0	0	Chest	0	0	0	0	0	0	0	0	–	–
251C	UAbP	0	0	Clot	0	0	0	0	0	0	0	0	0	0
**251D	UAbP	0	1	Tail	0	0	+	+	++	+	++	+	+	+
**251E	UAbP	++	5	Tail	0	0	–	–	++	++	++	+	0	0
**251F	UAbP	+	0	Tail	0	0	+	++	+	++	+	0	+	++
**251G	UAbP	+++	0	Tail	0	+	0	++	0	+	0	+	0	0
251H	UAbP	+++	1	Tail	0	0	+	0	0	0	0	++	0	0
251I	UAbP	+++	0	Tail	0	++	0	+	0	+	0	+	0	0
251J	UAbP	0	0	Tail	0	0	0	0	0	0	0	0	0	0
251K	UAbP	+	0	Tail	0	0	0	0	0	0	0	0	0	0
**287A	UAbP	++	2	Tail	0	0	++	++	++	++	+	+	0	0
**287B	UAbP	0	0	Heart	+	0	++	0	++	+	++	+	+	+
**287C	UAbP	++	6	Tail	0	0	++	++	++	++	+	+	+	+

C = Cysts lacking inflammatory cell reaction
G = Granulomatous inflammation around fungal elements
* & ** = See Table D.

TABLE F: SIZES OF FUNGAL ELEMENTS IN MUSCLES.

Newt No.	FRESH		HISTOLOGIC SECTIONS	
	DIAMETER	LENGTH	CROSS SECTION	LONGITUDINAL SECTION
94P251D	70 (74.2) [50-113]	155.5 (175) [95-360]	74.5 (74.9) [36-135]	236.5 (231.7) [144-302]
94P251E	ND	ND	93 (91.1) [43-149]	212 (216.7) [135-351]
94P287A	ND	ND	101.5 (98.4) [59-135]	ND
94P287B	ND	ND	103.5 (104.4) [54-144]	241 (245) [158-315]
94P287C	ND	ND	99 (97.1) [63-135]	ND

( ) = Mean
[ ] = Range
All measurements in microns

TABLE G: COMPARATIVE MORPHOLOGY & SPECIAL STAINING FEATURES OF AUREOBASIDIUM IN RED-SPOTTED NEWTS AND OTHER AMPHIBIAN INFECTIONS.

AGENT	Location in Host	Size*	Shape	Internal Structures	Natural Color	HISTOLOGIC STAINS: Hematoxylin & Eosin (H&E)	P.A.S.	Giemsa
Aureobasidium pullulans	Skeletal muscle	35-150 x 135-360	Spindle	None	Lt brwn	Lt red or blue	++	Blue
Basidiobolus	Ventral skin	NR	Sphere	None	NR	NR	+	NR
Mucor amphibiorum	MO, liver, bladder	5 to 36	Sphere	Daughter spherules	NR	Blue	++	NR
Ichthyophonus spp.	Hrt, Liv, Kid, MO	4 to 23	Sphere	Multi-nucleate	NR	NR	+	
Chromomycosis	Skin, MO	3 to 17	Hyphae & yeast	Sparingly septate	Brn to black	Brn to black		Brn to black
Saprolegniasis	Skin, muscle	2 to 4	Hyphae	Sparingly septate	Clear	Clear to lt blue	+	Blue
Dermocystidium spp.	Skin	>250	Sphere, U-shape	Spores	NR	NR	NR	
Dermosporidium spp.	Skin	>250	Sphere	Spores	NR	NR	NR	
Prototheca spp.	NR	2 to 20	Sphere	4 endo-spores	Clear	Clear	+	NR
Pleistophora danilewskyi	Muscle	NR	Spindle	Spores	Clear	Blue	NR	NR

Brn= brown
MO = many organs
NR = not reported
Lt = light
PAS= Periodic acid Schiff's reaction
* = all measurements in microns

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Appendix D

Other Species

Table D1. Other species that were noted in the region. This is not meant to be a comprehensive list. Only those species that were recorded in my field notes for any reason are included. Unusual species are in bold type.

Mammals

Moose
White-tailed deer
Black bear
Masked shrew
Short-tailed shrew
Beaver
Eastern chipmunk
Redback vole
Woodland jumping mice
Peromyscus sp.

Birds

Common loon
Great blue heron
Mallard
American black duck
Wood duck
Broad-winged hawk
Osprey
Spotted sandpiper
Mourning dove
Chimney swift
Belted kingfisher
Pileated woodpecker
Downy woodpecker
Least flycatcher
Tree swallow
Black-capped chickadee
White-breasted nuthatch
Winter wren
Swainson's thrush
Blue-gray gnatcatcher
Golden-crowned kinglet
Solitary vireo
Magnolia warbler
Black-throated blue warbler
Yellow-rumped warbler
Blackburnian warbler
Black-throated green warbler
Blackpoll warbler
Ovenbird
Northern waterthrush
Common yellowthroat
American redstart

Birds continued

Red-winged blackbird
Rusty blackbird
White-throated sparrow

Reptiles

Common garter snake

Fish

Bullhead

Invertebrates

Damselflies
Dragonflies
Crickets
Daddy-long legs
Water beetles
Mosquitoes
Black flies
Deer flies
Ground beetles
Grasshoppers
Springtail
Slugs
Crayfish

Plants

Cotton grass
Pitcher plant
Early azalea
Buckbean
Wild sarsaparilla
Water arum

POPULATION DENSITY AND DEMOGRAPHIC STUDIES OF SUBALPINE SPRUCE-FIR AVIAN COMMUNITIES IN THE NORTHEASTERN UNITED STATES.

Progress Report 1995

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Abstract: Research on Bicknell's Thrush was expanded to encompass the entire subalpine breeding bird community in 1995 . Several field protocols (e.g., point counts, MAPS and BBIRD) were combined on study sites across the Northeast. Eleven point count series were conducted on 10 peaks, and 6 new sites were selected and marked for censuses planned to begin in 1996. Point count data indicated that relative abundance of breeding birds tended to be higher on large peaks with extensive spruce-fir habitat than on smaller, more isolated peaks. Mist-netting on 5 MAPS plots produced 607 total captures in 2,626 combined net hours (0.23 captures/net hour), and this protocol will likely be scaled down in 1996. Nest monitoring on 4 BBIRD plots yielded a total of 53 nests. Of the 49 nests whose outcome was known, 23 (47%) were successful in fledging at least one young. The most accessible and intensively monitored plot, Ranch Brook, accounted for 30 (57%) of the nests located. Plans in 1996 include assigning individual teams to single BBIRD plots and concentrating nest monitoring efforts on 3 species (Bicknell's Thrush, Swainson's Thrush and Blackpoll Warbler).

Introduction

Few studies have examined the population trends, dynamics, or productivity of migrant birds breeding in naturally fragmented habitats, such as mountaintops. Species restricted to high elevation habitat "islands" may be subject to greater risks of local or widespread extinctions due to their smaller population sizes, patchy distributions, and lower rates of population interchange. Because montane forests are limited in extent, occur as isolated patches of varying size (< 1 to several thousand hectares) and distance from one another, and support unique breeding bird assemblages, they provide vital habitat regionally. Loss or modification of these forests may adversely affect both breeding and migrant populations that depend on them. Detailed baseline data are critically needed to assess the conservation status of the high elevation avian community.

During 1995, VINS expanded its research on Bicknell's Thrush to encompass the entire subalpine breeding bird community. Several methods of study were combined in an effort to launch a comprehensive and integrated regional monitoring program. The project's overall goal was to collect bird population and habitat data along an north-south gradient spanning five discrete mountainous areas in the Northeast.

Methods

Six to 8 peaks in each of five northeastern U.S. mountain ranges (Catskills, Adirondacks, Greens/Taconics, Whites, and Maine mountains) were targeted as long-term population monitoring sites. Two sites (MANS and CAME) have been monitored since 1991. Nine additional sites were surveyed for the first time in 1995 (see *Population density and demographic studies of Bicknell's Thrush on Mt. Mansfield, Vermont and other northeastern United States peaks* in this volume for site descriptions and key to study plot four letter codes). Six new sites were established and will be censused beginning in 1996. Others are planned for future years.

The sampling protocol consisted of point counts (see Welsh 1995) at each site, following an existing scheme established in 1991 on MANS and CAME. A minimum of 5 points were located on each peak, depending on the extent of suitable habitat. Points were spaced at least 200 m apart and situated to optimize trail and terrain features. Points were marked with permanent metal tree tags and blue survey flagging. Points will be permanently referenced using a Global Positioning System (GPS) receiver in the future. Censuses were 10-min counts (recorded in first 3 min, second 2 min, last 5 min intervals) conducted twice during the height of breeding activities (early-mid June and late June to early July), beginning shortly after sunrise. Each individual bird seen or heard was plotted relative to its position inside or outside a 50m circle. This enabled density calculations for those birds encountered within 50 m of each point, as well as relative abundance estimates based on the larger sample of all birds counted at each point. These data will provide the basis for estimates of population change over time.

To more meaningfully assess densities, relative abundances and population changes of breeding species, and to enable comparisons among sites, detailed habitat data were collected on MANS in 1994 and on RABR, BELV, EQUI, and PLAT in 1995. Sampling protocol followed Martin and Conway (1994). Vegetation sampling will be conducted at 3-year intervals to monitor habitat change.

To complement long-term point counts, five study sites were selected for establishment of Monitoring Avian Productivity and Survival (MAPS) stations in 1995. One was situated on MANS, the site of a pilot MAPS station in 1994 and the location of focused demographic studies on Bicknell's

Thrush since 1992. This station was upgraded to conform fully with MAPS protocol. Four additional stations were established on the RABR, BELV, EQUI, and PLAT plots.

Beginning in early June, a team of two trained banders operated ten 12m, 36mm mist nets for 6 hours per day (beginning at local sunrise), for one day per 10-day period through 28 August. Hours of operation and placement of nets remained constant at each MAPS station throughout the year. All birds captured were identified, banded, aged, and sexed. Additional data recorded included date and time of capture, net site, characters used to determine age and sex, extent of skull pneumatization, breeding condition of adults, wing chord, weight, fat content, extent of juvenal plumage, extent of body and flight feather molt, and extent of primary feather wear. Numbers of nets and total net hours each day were recorded, as were numbers of newly banded and recaptured individuals of each species in each 10-day period. Data were recorded on standardized forms and submitted to the Institute for Bird Populations (coordinators of MAPS) for detailed analysis.

Four Breeding Bird Research and Monitoring Database (BBIRD) plots were established on the BELV, RABR, EQUI, and PLAT plots, in conjunction with the above MAPS stations. Plots were permanently marked in a 25 m grid system with tape measure, meter hip-chain, and compass. Nest searching and monitoring protocol followed the methods outlined in Martin and Conway (1994). Vegetation was measured at each active nest and at non-use sites associated with active nests, following the same method used at census points (Martin and Conway 1994).

Results and Discussion

Point Counts. A total of 35 species was recorded at the 11 point count sites (Table 1). However, only 12 species were encountered at 6 or more sites, and only 5 species were detected at all 11 sites (Table 1), illustrating the low diversity of regularly-breeding species in subalpine forests. Large peaks with extensive spruce-fir habitat (e.g., Mt. Mansfield, Hunger Mtn., Plateau Mtn., Whiteface Mtn.) tended to support higher overall relative abundances than did smaller, more isolated peaks (e.g., Burke Mtn., Haystack Mtn.). The low numbers recorded on Camel's Hump, Vermont's third highest peak, are difficult to explain. This could be related to vegetation changes caused by extensive red spruce decline documented during the 1970s and 1980s (Vogelmann 1982). Several years of additional bird population and habitat data collection at all sites will be necessary to interpret differences among sites and changes within sites.

MAPS Stations. Results of constant-effort mist-netting varied markedly among sites (Table 2). Birds captured per net hour ranged from 0.14 on RABR, 0.17 on EQUI, 0.18 on BELV, 0.29 on PLAT, to 0.36 on MANS. Data were submitted to the Institute for Bird Populations, and we await results of their detailed analysis. The combination of travel time (driving and hiking) between sites, forced rescheduling due to rain-outs or high winds, competing project demands, and generally small sample sizes cause us to question the efficacy of the MAPS protocol in subalpine forests. We plan to discontinue MAPS banding in 1996 on BELV, PLAT and EQUI. We will continue on MANS, RABR and implement one new station also on Mt. Mansfield, Vermont.

BBIRD Plots. Despite many hours of active searching, we located only 53 nests on the 4 BBIRD plots (Table 3). Of the 49 nests whose outcome was known, 23 (47%) were successful in fledging at least one young. RABR, the most accessible and intensively monitored plot, accounted for 30 (57%) of the nests located. Between-site travel times (driving and hiking) and the competing demands of other study protocols limited the success of the BBIRD technique on BELV, PLAT, and EQUI. We believe that assignment of teams to a single plot and concentration on a few selected species (e.g., Bicknell's Thrush, Swainson's Thrush, Blackpoll Warbler) will greatly enhance the effectiveness of BBIRD monitoring in 1996.

Future Plans

We will continue point counts at the previously censused sites, recruit observers for six new sites established in 1995, and establish several new point count sites. In 1996 we will consolidate demographic and nest monitoring studies on 4 long-term Mt. Mansfield plots (MANS, RABR, NDPO, and a new plot to be established on the summit ridgeline south of the "Forehead"). Spot mapping and point counts of all breeding species will be conducted on these plots. Intensive research efforts (e.g., color-banding, nest monitoring) will be focused on 3 species (Bicknell's Thrush, Swainson's Thrush, Blackpoll Warbler), although productivity and habitat data will be collected on all nests found. Constant-effort banding (MAPS) will be continued on MANS and RABR sites, with a MAPS station possibly to be established on the new "Forehead" plot.

Acknowledgments

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Table 1. Point count results by site (5 stations per site except WHIT and PLAT, which have 10) in 1995. Data represent maximum relative abundance indices from unlimited distance counts, determined by selecting the highest counts from the two censuses (early and late) completed at each station.

Species	BELV	BURK	CAME	EQUI	HAYS	HUNG	KEAR	MANS	PLAT	RABR	WHIT	Total
White-throated Sparrow	16	6	9	22	16	25	18	24	20	40	45	241
Myrtle Warbler	18	12	13	13	10	16	19	16	38	10	19	184
Blackpoll Warbler	6	6	8	12	12	8	0	14	35	18	25	144
Winter Wren	14	4	13	8	8	10	6	10	30	16	22	141
Dark-eyed Junco	6	12	6	8	12	16	26	10	20	16	9	141
Swainson's Thrush	8	0	8	14	4	14	8	5	20	10	26	117
Pine Siskin	0	0	1	0	0	30	0	22	0	12	25	90
Magnolia Warbler	0	0	6	8	12	8	4	0	22	4	9	73
Yellow-bellied Flycatcher	4	4	11	0	0	4	0	1	21	8	11	64
Hermit Thrush	18	4	0	8	8	0	6	0	14	2	0	60
Bicknell's Thrush	2	1	1	1	0	0	0	16	12	7	17	57
Red-breasted Nuthatch	8	1	2	3	2	8	1	3	9	7	5	49
Nashville Warbler	10	4	0	0	0	10	12	0	0	0	6	42
White-winged Crossbill	0	0	0	0	0	0	0	8	0	8	15	31
Purple Finch	2	2	0	8	0	1	0	0	10	4	2	29
Ruby-crowned Kinglet	2	0	2	0	0	4	0	2	0	6	12	28
Golden-crowned Kinglet	0	0	3	2	0	5	3	0	6	0	1	20
Black-capped Chickadee	0	0	0	2	4	0	4	0	4	2	2	18
Brown Creeper	0	0	0	2	2	0	0	0	12	0	0	16
American Robin	1	3	0	0	2	0	0	4	0	0	0	10
Hairy Woodpecker	0	0	0	1	0	3	0	0	1	2	3	10
Mourning Dove	0	4	0	0	2	0	4	0	0	0	0	10
Blue Jay	0	2	0	0	0	0	2	0	2	1	0	7
Yellow-bellied Sapsucker	0	0	0	0	2	0	0	0	5	0	0	7
Red-eyed Vireo	0	0	0	2	0	0	0	0	4	0	0	6
Solitary Vireo	0	0	0	0	0	0	2	0	2	0	2	6
Canada Warbler	0	0	0	2	0	0	0	0	1	0	0	3
Blackburnian Warbler	0	0	2	0	0	0	0	0	0	0	0	2
Black-throated Blue Warbler	0	0	0	0	0	0	0	0	0	2	0	2
Black-throated Green Warbler	2	0	0	0	0	0	0	0	0	0	0	2
Cedar Waxwing	0	0	0	0	0	0	0	0	2	0	0	2
Common Yellowthroat	0	0	0	0	0	0	2	0	0	0	0	2
Ruffed Grouse	1	0	0	1	0	0	0	0	0	0	0	2
Northern Raven	0	0	0	0	0	1	0	0	0	0	0	1
White-breasted Nuthatch	0	0	0	0	0	0	0	0	1	0	0	1
Total Birds (40 species)	118	65	85	117	96	163	117	135	291	175	256	1618

Table 2. Summary results of MAPS banding stations, 1995.

	MANS	RABR	BELV	PLAT	EQUI	Total
New bandings	160	61	77	134	70	502
Unbanded	11	5	4	3	10	33
Recaptures	29	11	6	17	9	72
Total captures	200	77	87	154	89	607
Number of species	25	18	20	23	16	39

Table 3. Numbers of successful and failed nests on BBIRD plots, 1995.

Species	RABR		BELV		PLAT		EQUI		Total	
	S[a]	F[b]	S	F	S	F	S	F	S	F
Bicknell's Thrush	1	2							1	2
Blackpoll Warbler	6	4	1	0	0	1	1 unk[c]	2	7	7
White-throated Sparrow	3	3					0	1	3	4
Yellow-bellied Flycatcher	2	1							2	1
Red-breasted Nuthatch	1	0							1	0
Myrtle Warbler	1	0	0	1	0	1	1	1	2	3
Swainson's Thrush	2	2			0	2			2	4
Dark-eyed Junco	0	2			0	1	1	0	1	3
Brown Creeper					1	0	1	0	2	0
Blue Jay					1	0			1	0
Roughed Grouse					0	1			0	1
Magnolia Warbler					1	0	0	1	1	1
Red-breasted Nuthatch							1 unk			
Hermit Thrush							1 unk			
Purple Finch							1 unk			
Total	16	14	1	1	3	6	3	5	23	26

[a] Successful nest (at least one young fledged)

[b] Failed nest

[c] Unknown outcome

Literature Cited

Martin, T.E. and C.J. Conway. 1994. BBIRD field protocol. Unpubl. handbook, Montana Coop. Wildlife Research Unit, Missoula, MT.

Vogelmann, H.W. 1982. Catastrophe on Camel's Hump. Nat. Hist. 91: 8-14.

Welsh, D.A. 1995. An overview of the Ontario Forest Bird Monitoring Program in Canada. Pages 93-98 *In* Monitoring Bird Populations by Point Counts. C.J. Ralph, J.R. Sauer, S. Droege, Tech. Eds., Gen Tech. Rep. PSW-GTR-149. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Dept. of Agr. 187 pp.

POPULATION DENSITY AND DEMOGRAPHIC STUDIES OF BICKNELL'S THRUSH ON MT. MANSFIELD, VERMONT AND OTHER NORTHEASTERN UNITED STATES PEAKS

Progress Report 1995

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Abstract: Research on the population ecology of Bicknell's Thrush *(Catharus bicknelli)* was expanded on Mt. Mansfield and 11 other northeastern U.S. peaks in 1995. On Mt. Mansfield, spot mapping of territorial males on an 8.8 ha ridgeline study plot yielded a density estimate of 45-53 pairs/40 ha, while estimates of 20-21.5 and 4-9 pairs /40 ha were obtained from two plots at lower elevations. Efforts to capture and band thrushes on ten study plots resulted in a total of 147 birds (75 males, 34 females, 38 juveniles) being uniquely color-banded in 1992-95, 103 of these on Mt. Mansfield. Band returns of adults indicated high survivorship and site fidelity. None of the juveniles banded on Mt. Mansfield in 1992-94 were recaptured in a subsequent year. Of 11 active nests located in 1992-95, only 3 (27%) were successful in fledging any young. Most nests failed due to predation, apparently by red squirrels (*Tamiasciurus hudsonicus)*. Analysis of vegetation data at nest sites (n=13) and non-use (n=13) sites failed to detect expected differences in stem densities, but did reveal significantly higher ground and fern cover on non-use sites.

Introduction

The Bicknell's Thrush (*Catharus bicknelli),* recognized as a subspecies of the Gray-cheeked Thrush (*Catharus minimus*) since its discovery in 1881 on Slide Mountain in the Catskills of New York, has recently been given full species status (AOU 1995). Significant differences between the two taxa in morphology, vocalizations, biochemistry, and breeding and wintering distributions contributed to this designation (Ouellet 1993). With this classification Bicknell's Thrush has become recognized as one of the most at-risk passerine species in the eastern United States. Rosenberg and Wells (1995) ranked Bicknell's Thrush as number one on a conservation priority list of Neotropical migrant birds in the Northeast. The species has been proposed for "threatened" status in Canada (Nixon 1995).

The breeding range of Bicknell's Thrush in the United States is limited to subalpine spruce-fir forests of New England and New York (Atwood et al. in press). In Canada it is found in highland spruce-fir forests in Quebec, Nova Scotia and New Brunswick (Erskine 1992, Ouellet 1993, Gauthier and Aubry 1995). It has also been found in mixed second-growth forest following clear cutting or burning in Quebec (Ouellet 1993) and New Brunswick (Nixon pers. comm.). As the only breeding songbird endemic to high altitude and maritime spruce-fir forests of the northeastern United States and adjacent Canada, Bicknell's Thrush qualifies as a potentially valuable indicator of the health of subalpine avian populations and their associated forest habitat. Surveys aimed at clarifying the distribution and population status of Bicknell's Thrush in the Northeast were conducted from 1992-95 (Atwood et al. in press, Rimmer et al. in press) and are in progress in New Brunswick, Canada (D. Busby, pers. comm.).

Many important questions about the ecology and stability of Bicknell's Thrush breeding populations require intensive monitoring of discrete habitat units and studies of known-identity individuals. Baseline data on population densities, territory size, movements, productivity, site fidelity, survivorship, and habitat use are needed to evaluate the conservation status of the species across its fragmented high elevation breeding range. Studies conducted since 1992 on Vermont's Mt. Mansfield, the site of a large, dense breeding population, have established a solid foundation for future long and short-term research.

In 1995 research was expanded on Mt. Mansfield and on 11 additional peaks in the Northeast, using a variety of methods (Table 1). Primary research objectives in 1995 were: 1) to uniquely color-band all known breeding pairs of Bicknell's Thrushes on 10 study plots, for demographic investigations ; 2) to obtain estimates of population density on 3 Mt. Mansfield study plots by spot-mapping and tracking movements of known identity individuals; 3) to examine site fidelity, territorial turnover, survivorship, and population stability on 6 established plots by searching for previously color-banded thrushes; 4) to obtain productivity data by locating and monitoring nests on 7 study plots, and through combined mist-netting and observations of banded family groups; and 5) to establish point count stations on additional peaks and to complete censuses on as many of these sites as possible.

Methods

Spot mapping. Territory mapping was conducted from 1992-95 on the MANS plot and in 1995 on the RABR and NDPO plots (Table 1). For each bird seen or heard a compass bearing and distance estimate were recorded from marked vantage points (MANS) or following a 25m grid system marked with blue survey flagging and metal tree tags (RABR, NDPO). Data were plotted on a base map of each study area. Simultaneous registration of two or more vocalizing birds was used as the primary means of discriminating between adjacent territories (Robbins 1970). Sightings of color banded birds were recorded and mapped in an attempt to match each territory with a known identity bird.

Surveys were conducted on 12 dates in 1992 (11-18 June, 27-30 June), 8 dates in 1993 (8-10 June, 16,17,23,24,29 June), 14 dates in 1994 (5-9 June, 14-17 June, 20,22,23,29,30 June) and 16 dates in 1995 (1, 5-8, 12-14, 16, 19, 20, 22, 23, 27 June). We determined the density of Bicknell's Thrush territories in several ways. Maximum density values were obtained by including percentages of territories estimated to be located within the boundaries of the study plot. Minimum density values were calculated by excluding all "partial" territories from consideration. Data from the MANS plot were independently evaluated by an individual experienced in spot mapping but unfamiliar with the study plot. Finally, we calculated the number of territories on each study plot using the international spot mapping standards (Robbins 1970), where each territory that is at least 50% within the plot boundaries is counted as a full territory on the plot. We applied a simple linear regression to each territory calculation method to compare the trends shown by each.

Color Banding. On 10 study plots we used strategically placed mist nets in combination with tape recorded playbacks of Bicknell's Thrush vocalizations and a life-like wooden decoy to attempt to capture and color band all known Bicknell's Thrushes on the study areas. Up to 10 mist nets were used simultaneously to passively capture thrushes as a complement to the use of vocal and visual lures. This facilitated the capture of females, which are not readily lured into nets. Detailed mensural (e.g., wing chord, weight) and body condition (e.g., subcutaneous fat, molt, feather wear) data were recorded for all captured birds. Capture locations were marked on study plot base maps. On plots where spot mapping was conducted we attempted to identify the color banded adults on each known territory. Concerted efforts were made to locate color banded birds throughout the season.

Nest Monitoring. From early June through mid-July, 7 study plots were systematically searched to locate active and recently-used nests. Each nest location was marked on a study plot base map. The chronology and success of all active nests were monitored, and nestlings were banded. Nest monitoring was conducted according to guidelines established by the Breeding Biology Research and Monitoring Database Program (BBIRD) (Martin and Conway 1994). After fledging, nest site and microhabitat data were collected in accordance with BBIRD protocols.

Univariate comparisons were made between Bicknell's Thrush nest sites and non-use sites. Ocular estimate variables (i.e., ground cover parameters) were placed in 5 classes (Table 11) (Barbour et al. 1987). These indices were compared with a Wilcoxon rank-sum test. All other comparisons were made with two-sample *t*-tests. We were unable to compare successful nest sites and unsuccessful sites due to the small sample size (n=13 nests). At least 20 nests are needed to give a reliable estimate of nest success (Hensler and Nichols 1981). Nearly all nests were found after the onset of incubation, so nest success, mortality and initiation dates were calculated using the Mayfield method (Mayfield 1961, 1975) as modified by Johnson (1979) and Hensler and Nichols (1981). Initiation date is the day on which the first egg was laid. To calculate this date we assumed laying intervals of one day and incubation and nestling periods of 14 days each. The small sample size should be kept in perspective when reviewing these results.

Point Count Surveys. Point count surveys have been conducted since 1991 on MANS and Camel's Hump, Vermont (CAME) and were initiated on 9 other peaks in 1995. We used the Forest Bird Monitoring Program protocol of the Canadian Wildlife Service, Ontario Region (Welsh 1995). Five point count stations are located at each site ecept WHIT and PLAT which contain ten stations. Stations are separated by at least 250m. Counts begin as soon as possible after observers arrive at the station. All birds seen or heard during a 10 minute period are recorded. All data are mapped on sheets to minimize duplicate records. All counts are conducted from dawn to approximately 4 hours after sunrise on the same morning. Surveys are conducted only in weather that is unlikely to reduce count numbers (i.e., avoidance of strong winds, moderate or heavy rain, extreme cold). Each site is sampled twice during the breeding season: once in early to mid-June and once in late June to early July. Singing males, observed pairs, occupied nests, or observed family group are assumed to represent breeding pairs. All other individuals seen or heard calling are counted as single birds. The higher count for each species from the two survey dates is used as the annual station abundance estimate. Station values can be summed to obtain site values.

Beginning in 1994 habitat parameters were monitored at each site using the BBIRD protocol. These will be repeated at 3-year intervals, sooner in the event of obvious habitat changes at a given site (e.g., fire, wind throw, human induced changes). As of 1995, habitat monitoring has been completed on MANS, BELV, PLAT, and EQUI.

Constant Effort Mist Netting. Using the Monitoring Avian Productivity and Survivorship Program (MAPS) protocol (Desante and Burton 1994), an array of six 12m mist nets were used on MANS in 1994. In 1995 we increased the number of nets on this site to ten. On RABR, BELV, EQUI, and PLAT we established arrays of ten 12m mist nets in 1995. Mist nets were operated for six hours on one morning in each of nine different ten-day periods (May 31-Jun 9, Jun 10-19, Jun 20-29, Jun 30-Jul 9, Jul 10-19, Jul 20-29, Jul 30-Aug 8, Aug 9-18, Aug 19-28). During the breeding season MAPS mist net locations were not used for any other mist-netting, and no tapes or decoys were used at these sites.

Results

Density estimates. Spot mapping of vocalizing males on the MANS plot yielded density estimates for Bicknell's Thrush of 36-52 pairs/40 ha in 1992, 50-59 pairs/40 ha in 1993, 55-65 pairs/40 ha in 1994 and 45-53 pairs/40 ha in 1995 (Fig. 1). The territories of 8, 11, 12, and 10 pairs were located entirely within the borders of the study plot in 1992-95, respectively. The total number of territories on the plot was estimated at 11.5 in 1992, 13.0 in 1993, 14.25 in 1994 and 11.75 in 1995. Independent evaluation of our data by an individual experienced in spot mapping but unfamiliar with the plot yielded estimated totals of 11.75 territories in 1992, 13.25 territories in 1993, 12.5 territories in 1994, and 10.0 territories in 1995 (Fig. 2). Spot mapping on RABR and NDPO yielded considerably lower densities than on MANS (Table 2). Densities calculated from MANS point counts showed little agreement with density estimates obtained by spot mapping (Table 2).

Point count totals from 12 sites in 1995 suggest that size of contiguous habitat area may influence Bicknell's Thrush densities (Table 3). Of two point count sites (MANS and CAME; n = 10 point counts) that were censused for 5 years (1991-95), CAME consistently had fewer Bicknell's Thushes than MANS. However, both sites showed similar population trends (Fig 3).

Mist Netting. We have banded a total of 137 AHY (after hatching year) and 24 HY (hatch year) Bicknell's Thrush since 1992 on 10 different plots. On our two longest term (1992-95) banding sites (MANS and OCTA) we banded 39 birds and recaptured 9 previously banded birds in 1995, 33 banded and 10 recaptured birds in 1994, 26 banded and 4 recaptured birds in 1993, and 11 banded adults in 1992. Total return rate for AHY birds, based on percent of banded birds recaptured or resighted in subsequent years, was 45.2% for MANS and 23.1% for OCTA (Table 4). We have never recaptured a HY bird (n=15, 1992-94) in a subsequent breeding season. We banded 30 adults on five smaller, more isolated mountains in 1994 and 1995 (Table 5). Fifty percent of the 18 birds banded in 1994 were confirmed to return in 1995 (Table 5).

We captured 11 adult males, 9 adult females and 3 adults of unknown sex on MANS in 1995, 12 males, 5 females and 1 unknown sex bird in 1994, 14 males and 5 females in 1993, and 3 males and 3 females in 1992 (Table 6). One female banded as an AHY on MANS in 1992 was recaptured in 1995. To our knowledge this represents a longevity record for the species. The oldest known males are three 4-year old males on MANS and one on OCTA, all banded in 1993 and recaptured in 1995 (Table 6).

Constant effort mist netting in 1995 yielded 25.5 Bicknell's Thrushes per 1,000 net hrs on MANS, 13.0 on PLAT, 11.0 on RABR, 8.5 on BELV and 4.0 on EQUI. Constant effort mist netting conducted on MANS in 1994 resulted in 12.2 Bicknell's Thrushes per 1,000 net hrs. However, we used fewer nets in 1994, a pilot year.

Nest Monitoring. Despite many hours of observations and systematic searches we found only 14 active or recently active nests in 1992-95 (7 MANS, 3 OCTA, 3 RABR, 1 NDPO). Of these 14 nests, 3 were successful (fledging at least one), 4 were depredated, 2 failed due to nest abandonment, 2 failed due to unknown circumstances, and 4 were of unknown status because they were never occupied during observation (Table 8). It remains unclear why the two 1994 MANS nests were abandoned. Of the 11 active nests that we monitored, 3 fledged 5 young. Wallace (1939) reported that only 4 of 15 nests monitored during his study on Mt. Mansfield fledged young. One nest with eggs was abandoned and the remaining 10 were depredated.

Clutch sizes ranged from 3-4 eggs ($n = 7$ nests, $x = 3.4$, SD = 0.53) (Table 8). Wallace (1939) recorded the same clutch size range ($n = 13$ nests, $x = 3.46$, SD = 0.56). Initiation dates ranged from 10 June to 6 July ($n = 10$ nests, $x = 20$ June, SD = 8.8 days). The latest date represents a probable second attempt by a pair that failed during the egg laying period. Wallace (1939) reported clutch initiation dates from 9 June to 10 July ($n = 11$ nests, $x = 18$ June, SD = 8.9 days). His latest nest also represented a second attempt. It is unclear how he calculated these initiation dates.

Twelve of 14 nest trees were balsam fir (*Abies balsamea*). One nest was located in a red spruce (*Picea rubens*), and one was situated in the junction of a balsam fir leaning on a white birch (*Betula papyrifera* var. *cordifolia*). Wallace (1939) found 7 nests in balsam fir, 5 in red spruce and 1 in a white birch. Nest trees were small (1.8-3.39 m tall and 1 -7.9 cm DBH), and nests were located between 1 and 2.85 m above ground (Table 10). Wallace (1939) found nests to be 0.9 - 3.7 m above the ground (Table 10). Nests were supported by 1 to 4 small branches (0.3-1.5 cm diameter) and were placed abutting the trunk of a tree or very close to the trunk. Nests were most often on the eastern side of the nest tree ($n =$ 13, $x^2 = 13.51$, DF = 4, $P < 0.025$). The amount of vegetation obscuring the nest in each cardinal direction in a 25 cm radius circle centered at the nest was higher on the north side and from above (Table 10). Nests were invariably found in a live portion of the tree and in healthy trees, except in one case where nest tree's top quarter was gnarled and dead.

We compared vegetation surrounding nest sites ($n = 13$) with randomly selected non-use (no nest) sites ($n = 13$) (Table 11). Shrub stem densities were measured on 5-m radius plots (shrubs were defined as woody plants > 0.5 m high with a DBH <8 cm). Similarly, tree densities were examined on 11.3-m plots around the nests and in randomly chosen non-use sites. We found no differences in the density of stems in any size classes. Ocular estimates of ground cover yielded some patterns. Both total green cover (< 50cm tall) and fern cover were significantly higher on non-use sites than on nest sites (Table 11).

Discussion

Spot mapping data showed an increase of 4 territories located entirely within the MANS plot from 1992-94, followed by a decrease of 2 territories in 1995. We believe that our data, from which two independent observers calculated similar numbers of territories in each year, closely approximated actual Bicknell's Thrush densities on the study plot. On 11 July 1994 we observed a color banded bird counter calling five times with other birds. The location of this bird coincided closely with a territory plotted from mapping data. These observations appear to support the accuracy of our spot mapping data. We analyzed these data using several methods to explore possible errors in determining edge territories on the study plot boundaries. Each technique yielded similar densities and population trends (Fig. 2).

Some birds wandered over a large area. These individuals were typically identified only through mist net captures and were rarely observed singing or calling. Most documented nomadic behavior occurred early (territory establishment phase) and late (post-breeding dispersal) in the breeding season, suggesting that territorial boundaries "relax" or break down outside of breeding activities. It is possible that some individuals were non-breeders, or "floaters", and simply wandered over the area throughout the summer. In 1995 we documented repeated movements (through mist net captures and color band observations) of a second year (SY) male over a 5 ha area on MANS between 5 June and 29 September. We captured another SY male on the MANS plot in early June and documented its occupancy of a territory on the NDPO plot later in the month.

A comparison of Bicknell's Thrush density estimates from spot mapping and point count surveys on MANS yielded conflicting results (Table 2). Bicknell's Thrush vocalizations tend to be sporadic and concentrated in brief temporal windows at dawn and dusk (Rimmer et al. in press). We believe that density estimates obtained by point counts alone are unreliable. We suggest the use of recorded vocal playbacks to determine the density of thrushes on point counts. In the future we will follow our current 10-min counts with an additional 2 min of playbacks of Bicknell's Thrush calls and songs and 3 min of silent observation for a total of 15 min. We believe that this will yield improved estimates of both density and relative abundance.

Wallace (1939) reported that Bicknell's Thrush territories on Mt. Mansfield "may apparently cover an acre or more." Assuming densely packed territories of about 0.6 ha (1.5 ac) in size, Wallace's suggestion would yield density estimates of approximately 65 pairs/40 ha. This is similar to our maximum estimates from spot mapping data on MANS and may reflect unusually high densities on Mt. Mansfield, which we believe may support over 250 pairs.

Spot mapping of Bicknell's Thrush on RABR and NDPO in 1995 yielded much lower densities than on MANS. This may reflect differences in thrush habitat selection. Bicknell's Thrush appears to prefer stunted, dense spruce-fir growth punctuated by standing dead snags and small openings. This habitat type characterizes the MANS plot, while the lower elevation plots, particularly NDPO, contain more continuous-canopy forests of taller stature and mixed species composition. Alternatively, there may be interspecific competitive interactions between Bicknell's Thrushes and Swainson's Thrushes at lower elevations. We have not documented breeding by Swainson's Thrushes on the MANS plot during our studies. However, at lower elevations the species is found breeding in densities comparable to or higher than Bicknell's Thrush. In 1995 we recorded Swainson's Thrush densities of 33 pairs/40 Ha on RABR and 11 pairs/40 Ha on NDPO. We witnessed several instances of Swainson's Thrushes reacting aggressively to recorded playbacks of Bicknell's Thrush calls and songs.

A significant, but still preliminary, finding is that the return rates and site fidelity of adult Bicknell's Thrushes appear to be high. Our estimates are undoubtedly low because of the difficulty in recapturing birds and sighting color bands in the dense habitat. We have not documented the return of a banded HY (juvenile) bird in a successive year. Despite capturing 13 HY birds on Mt. Mansfield in 1994 we failed to document any returns in 1995. However, we did capture 7 unbanded SY birds (juveniles from 1994) on MANS, suggesting that recruitment from other breeding areas may be occurring.

Similar breeding densities in 1992-95, coupled with apparent high adult site fidelity and return rates, suggest that Mt. Mansfield's breeding population may be relatively stable. However, the demographics of this relatively large population may not reflect those on the many smaller, more isolated peaks occupied by this species. We will continue to compare Bicknell's Thrush demographics and population stability on peaks with both extensive and limited subalpine spruce-fir habitat as part of our overall research on the status of this species.

Obtaining productivity data from nest monitoring has proven to be difficult because of the rough terrain and dense vegetation on our study plots. Two nests abandoned on MANS in 1994 during incubation were believed to have been caused by either excessive foot traffic on nearby hiking trails (both nests located < 5m from trails), observer disturbance, or predation of the females. We do not believe that our limited visits to the nests caused their abandonment. During 1994 five Blackpoll Warbler (*Dendroica striata*)nests, 1 Myrtle Warbler (*Dendroica coronata*) nest and a Purple Finch (*Carpodacus purpureus*) nest were discovered on MANS and monitored in a similar manner, yet all 7 nests fledged young. We failed to recapture either female associated with the two abandoned 1994 nests in 1995. We did not document any nest abandonment in 1995.

Possible nest predators of adults or nests observed from 1992-1995 on Mt. Mansfield included: Blue Jay (*Cynocitta cristata*), Northern Raven (*Corvus corax*), *Accipiter* species, red squirrel (*Tamiasciurus hudsonicus*), eastern chipmunk (*Tamias striatus*; observed only on RABR), raccoon (*Procyon lotor*), and weasel (*Mustela* species). Wallace (1939) reported that red squirrels and a Blue Jay preyed on Bicknell's Thrush nests on Mt. Mansfield. We strongly suspect red squirrels to be the major nest predator. We began to map red squirrel territories in 1995 to obtain yearly population indices and found 10 squirrel territories on RABR and 5 territories on NDPO. We believe that extremely high cone production in 1994 may have resulted in unusually high numbers of red squirrels on Mt. Mansfield in 1995. Cone production in 1995 was relatively low. Future indices of red squirrel populations and their correlation with annual nest predation rates may reveal the influence of this species on Bicknell's Thrush productivity.

Despite our small sample size (n = 13) of nests, we conducted a preliminary analysis of vegetation at nest sites versus non-use sites to examine possible selection features by Bicknell's Thrush. We suspected a priori that nest site selection was based primarily on woody stem density, as nest sites seemed to be characterized by high densities of balsam fir trees. Our analysis of the data did not confirm this, however, possibly resulting in part from the small sample size. Five nests were located along human-created edges, which may have reduced the number of stems found in the circular plots. In the non-use sites we found significantly more total green cover (<50cm tall) and fern cover, reflecting the more open, glade-like appearance of non-use sites.

In 1995 we kept detailed records of net hours, number of tape recorded playbacks with and without decoys, and passive captures on all study sites (Table 7). The low number of captures per playback and the higher passive capture rate were surprising. We plan to greatly reduce the future use of playbacks for capturing Bicknell's Thrushes and to rely more heavily on passive mist netting. This will allow us to more easily apply capture-recapture models to our data.

The long-term habitat monitoring plots on Mt. Mansfield may enable an understanding of changes that occur in the habitat over time. Several studies have documented severe declines of red spruce throughout the Northeast since the early 1960's (e.g., Siccama et al. 1982, Foster and Reiners 1983, Battles et al. 1992, Miller-Weeks and Smoronk 1993), as well as heavy mortality of balsam fir (Miller-Weeks and Smoronk 1993). Most of the hypotheses proposed to account for this decline involve the effects of atmospheric deposition and include: 1) soil acidification/aluminum toxicity; 2) spruce needle damage and disease; 3) general stress from reduced photosynthetic activity and secondary metabolite production; 4) excess nitrogen deposition; 5) complex high-elevation disease from the combined effects of high ozone concentrations, acid deposition and nutrient deficiencies; and 6) organic air pollutants (Krahl-Urban et al. 1989). The possible impacts of this habitat degradation on populations of Bicknell's Thrush and other subalpine bird species are unknown. Detection and assessment of such impacts will require long-term monitoring of both vegetation and avifauna.

Future Plans

In 1996 we will initiate radio telemetry studies of Bicknell's Thrush on two Mt. Mansfield plots (MANS and NDPO). Spot mapping of Bicknell's Thrush territories will be completed on RABR, MANS, NDPO, EQUI, BELV, PLAT and a new plot to be established south of the "forehead" on Mt. Mansfield. Point count censusing protocol will include a tape recorded playback of songs and call of the Bicknell's Thrush for 2 min. followed by 3 min. of listening after the present protocol of a 10 min. count. This will result in better detection of this species on point counts. Constant effort mist netting and nest monitoring will be conducted on three Mt. Mansfield study plots (RABR, MANS, and new plot).

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Table 1. Locations and summary descriptions of Bicknell's Thrush study areas in the northeastern United States.

Location	USGS 7.5 Quad	Study Plot ID	Elevation (m)	Plot Size (Ha)	Impacts[a] on Study Plot	Study[b] Methods	Number of Study Years
Mt. Mansfield, VT	Mansfield	MANS	1,160 - 1,190	8.8	1,3,4	1,2,3,4,5,6	5
Mt. Mansfield, VT	Mansfield	RABR	914 - 1,070	20	3	1,2,3,4,5,6	1
Mt. Mansfield, VT	Mansfield	NDPO	885 - 1,070	20	2,3	2,3,4,5,6	1
Mt. Mansfield, VT	Mansfield	OCTA	1,070 - 1,130	6	1,2,3,4	3,4	4
Belvidere Mtn., VT	Hazens Notch	BELV	960 - 1,000	16.5	3	1,3,4,5,6	2
Mt. Equinox, VT	Manchester	EQUI	1,100 - 1,160	13.5	3,4	1,3,4,5,6	2
Plateau Mtn., NY	Hunter	PLAT	1,130 - 1,175	12.2	3	1,3,4,5,6	1
Burke, VT	Burke	BURK	915 - 985	na	1,2,3,4	1,4,6	2
Okemo Mtn., VT	Mt. Holly	OKEM	945 - 1,020	na	1,2,3,4	1,4,6	2
Haystack, VT	Wilmington	HAYS	930 - 1,040	na	3	1,4,6	2
Mt. Hunger, VT	Stow	HUNG	1,005 - 1,080	na	3	1,6	1
Shrewsbury Mtn., VT	Killington	SHREW	1,005 - 1,130	na	3	1,6	1
Camel's Hump, VT	Huntington	CAME	1,130 - 1,230	na	3	1,6	5
Mt. Kearsarge, NH	Warner	KEAR	825 - 895	na	3,4	1,6	2
Whiteface, Mtn., NY	Lake Placid	WHIT	1,250 - 1,330	na	1,3	1,6	1

[a] 1-road(s), 2-ski area, 3-foot trails, 4-communications equipment/buildings.

[b] 1-point counts, 2-spot mapping, 3-nest monitoring, 4-color banding, 5-constant effort mist netting, 6-habitat monitoring. Not all methods used during all years of study on each site.

Table 2. Bicknell's Thrush pairs/40 ha determined by spot mapping (high and low indices) and point counts (n=5 counts, radius=50m) on 3 study areas, Mt. Mansfield, Vermont.

Study Plot and Census Method	1991	1992	1993	1994	1995
MANS Spot mapping (Low)		36	50	55	45
MANS Spot mapping (High)		52	59	65	53
MANS Point Counts	51	81.5	36	25.5	25.5
RABR Spot mapping (low)					20
RABR Spot mapping (high)					21.5
NDPO Spot mapping (low)					4
NDPO Spot mapping (high)					9

Table 3. Density estimates of Bicknell's Thrush in 1995 as determined from 5 point counts (50m radius) at each site, except PLAT and WHIT which contained 10 counts.

Location	BITH/40 Ha
WHIT	76.4
MANS	61.1
PLAT	40.7
RABR	30.6
BURK	10.2
EQUI	10.2
BELV	10.2
CAME	10.2
KEAR	0
HUNG	0
HAYS	0

Table 4. Annual return rates of AHY and HY Bicknell's Thrush on Mt. Mansfield, Vermont, 1992-95. Return rate defined as the percentage of birds banded during a summer that returned in a later year. Data from two plots (MANS and OCTA).

Year	No. Captured AHY	No. Returning AHY	Return Rate (%)	No. Captured HY	No. Returning HY
MANS1992	6	4	66.7	2	0
MANS1993	19	9	47.4	2	0
MANS1994	17	7	41.2	11	0
MANS1995	26	na	na	8	na
Total	68	19	45.2	23	0
OCTA1992	3	0	0	0	0
OCTA1993	5	1	2	0	0
OCTA1994	5	2	4	0	0
OCTA1995	5	na	na	0	na
Total	18	3	23.1	0	0

Table 5. Annual and total Bicknell's Thrush AHY return rates on small, isolated peaks in Vermont, 1994 and 1995. Return rate defined as the percentage of birds banded during a summer that returned in a later year.

Study Plot	No. Captured AHY		No. Returning AHY	Return Rate (%)
	1994	1995		
BURK	2	3	1	50
EQUI	2	6	2	100
HAYS	2	2	1	50
BELV	5	6	3	60
OKEM	7	4	2	28.6
TOTAL	18	21	9	50

Table 6. Number of individual Bicknell's Thrush captured each year (by age [a] and sex).

Sex	Unknown			Male			Female		
Age	HY	SY	AHY	SY	AHY	ASY	SY	AHY	ASY
MANS 1992	2	0	0	1	2	0	1	2	0
MANS 1993	2	0	0	1	11	2	0	4	1
MANS 1994	11	0	1	0	4	7	0	2	3
MANS 1995	10	1	2	3	4	8	3	4	2
OCTA 1992	0	0	0	0	3	0	1	2	0
OCTA 1993	0	1	0	0	3	0	0	1	0
OCTA 1994	1	0	0	1	2	0	0	0	1
OCTA 1995	1	0	0	0	1	2	0	2	0
BELV 1994	0	0	0	0	3	0	0	2	0
BELV 1995	0	0	0	2	0	2	1	0	1
BURK 1994	0	0	0	0	2	0	0	0	0
BURK 1995	0	0	0	1	0	1	1	0	0
EQUI 1994	0	0	0	0	2	0	0	0	0
EQUI 1995	0	0	1	2	0	2	0	0	1
HAYS 1994	0	0	0	0	1	0	0	1	0
HAYS 1995	0	0	0	0	1	1	0	0	0
OKEM 1994	0	1	0	2	2	0	0	2	0
OKEM 1995	0	0	0	1	0	2	1	0	0
NDPO 1995	0	0	0	1	2	0	0	1	0
PLAT 1995	1	1	1	2	4	3	0	1	2
RABR 1995	3	1	0	3	1	5	0	0	2

[a] HY= juvenile, SY= second year, AHY= after hatch year, ASY= after second year.

Table 7. Number of mist net hours (one 12m net hr = 1 hr.), tape broadcasts with and without decoys and capture success of each method during 1995.

All Study Areas Combined	Month						Total
	5	6	7	8	9	10	
No. broadcasts with decoy	35.0	143.0	2				198.0
No. captures with broadcast/decoy	3.0	23.0	1.0				27.0
% capture success	8.6	16.1	5.0				13.6
No. broadcasts only	8.0	9	12.0		1.0		111.0
No. captures w/ broadcast only	3.0	8.0					11.0
% capture success	37.5	8.9					9.9
Total net hours	33.6	1501.9	1442.1	2558.3	1799.3	660.4	7995.6
No. of passive captures	2.0	61.0	35.0	3.0	11.0		112.0
No. passive captures / 100 hours	6.0	4.1	2.4	0.1	0.6		1.4

Table 8. Success rate and cause of failures of Bicknell's Thrush nests monitored during this study and by Wallace (1939) on Mt. Mansfield, Vermont. Nest stages that were completed by at least one egg or chick were considered successful. Four nests of unknown status that were not occupied during this study are not included. Wallace's data are presented in parentheses.

Nesting Stage	Success	Depredated	Abandoned	Failed / Cause Unknown	Success (%)
Egg Laying	9(13)	1(0)	0(0)	1(0)	82(100)
Incubation	6(8)	1(4)	2(1)	0(1)	67(62)
Nestling	3(4)	2(3)	0(0)	1(1)	50(63)
Final	3(4)	4(7)	2(1)	2(2)	27(31)

Table 9. Clutch sizes, number of eggs hatched, number of fledglings, and chronologies of active nests monitored on Mt. Mansfield, Vermont during this study and by Wallace (1939). W = Wallace (1939); nests in this study indicated by I.D. number, study plot, year. Julian dates given.

Nest	Egg Period			Nestling Period			% Success
Nest	No. Eggs	Initiation Date	Incubation Period	No. Hatch	No. Fledge	Nestling period	
W1	3	169	171-?	0	0	---	0
W2	4	161	163-177	1	0	---	0
W3(a)	3	174	176	0	0	---	0
W4	4	162	164-178	4	0	---	0
W5	4	167	169-182	3	3	± 12 days	75
W6	4	before 173	---	0	0	---	0
W7	3	164	±166-179	3	0	---	0
W8	4	164	±166-179	2	2	9 and 10 days	
W9	3	before 176	---	0	0	---	0
W10	4	176	---	0	0	---	0
W13	3	169	±171-184	3	0	---	0
W14	3	192	194-206	3	3	---	100
W15	3	175	±177-190	3	3	10 days	100
Mean	3.4	170.3	13.1 days	1.7	0.9	10.5 days	
± SD	0.5	8.9	0.64	1.6	1.3	0.4	
1MANS92	3	167	169-181	2	2	181-192	67
1MANS93	4	165	168-179	4	0	---	0
1MANS94	4	165	---	0	0	---	0
2MANS94	4	165	---	0	0	---	0
1MANS95	3	178	180-192	3	0	---	0
2MANS95	3	182	184-198	3	0	---	0
1OCTA95	NA	168	170-182	2	1	182-194	50
1RABR95	3	162	164-174	3	2	174-184	67
2RABR95	NA	178	---	0	0		0
3RABR95	NA	188	---	0	0		0
Mean	3.4	171.8	11.8 days	1.7	0.5	11 days	
± SD	0.5	8.8	1.5	1.6	0.7	1.41	

Table 10. Bicknell's Thrush nest placement and concealment (n = 13) on Mt. Mansfield, Vermont. Nest heights for this study and Wallace (1939) compared. Wallace did not record other pertinent measurements for comparison.

Parameter	Range	Mean	± SD
Nest height (m)	1 - 2.85	1.51	0.58
Nest height (Wallace 1939)	0.9 - 3.7	2.1	0.87
Nest plant height (m)	1.8 - 3.39	2.46	0.51
Nest plant DBH (cm)	1 - 7.9	4.0	1.9
Concealment:			
west side	0 - 100	71.4	25.4
east side	40-100	68.8	22.2
south side	10 - 100	65	32.9
north side	5 - 100	59.2	30.7
above	50 - 100	85.3	16.9
No. of nest support branches	1 - 5	2.5	1.0
Diameter. of nest support branches (cm)	0.3 - 1.5	0.8	0.4
Nest distance from main stem (cm)	0 - 25	2.0	7.0
Nest distance from outer foliage of plant (cm)	28 - 110	50.8	24.8

Table 11. Comparison of microhabitat variables ($x \pm SD$) at Bicknell's Thrush nest sites (n = 13) with random non-use sites ($n = 13$) on Mt. Mansfield, Vermont, 1992-95.

Parameter	Nest Site	Random Site	P
5m radius woody stem density < 2.5 cm diameter at 10 cm height:			
Dead	7.15 ± 6.66	4.77 ± 11.59	
Balsam Fir	59.62 ± 39.33	52.38 ± 35.94	
Red Spruce	0.15 ± 0.55	0.10 ± 0.30	
White Birch	15.10 ± 13.1	10.23 ± 9.45	
Mt. Ash	0.62 ± 1.12	0.08 ± 0.30	
Mt. Shadbush	0.92 ± 3.04	0	
Mt. Maple	0	0.20 ± 0.60	
Mt. Holly	12.54 ± 26.24	18.31 ± 22.96	
Pin Cherry	0	0.10 ± 0.30	
Meadowsweet	0	2.10 ± 7.50	
5m radius woody stem density >2.5 cm diameter at 10 cm height:			
Dead	6.31 ± 7.80	4.70 ± 6.32	
Balsam Fir	117.54 ± 204.33	43.80 ± 37.42	
Red Spruce	0.40 ± 0.80	0.23 ± 0.44	
White Birch	12.80 ± 10.01	11.10 ± 13.33	
Mt. Ash	0.69 ± 1.40	0.38 ± 1.0	
Mt. Shadbush	1.10 ± 3.90	0	
Mt. Holly	1.23 ± 4.15	0.62 ± 1.33	
Pin Cherry	0	0.20 ± 0.60	
11.3m radius tree density >8-23 cm DBH:			
Balsam Fir	21.40 ± 14.22	20.62 ± 13.0	
Red Spruce	0.69 ± 1.44	0.31 ± 0.48	
White Birch	0.46 ± 1.13	1.69 ± 2.56	
Mt. Ash	0.23 ± 0.60	0	
Dead (>12-23)	13.62 ± 8.90	12.62 ± 8.42	
11.3m radius tree density >23-38 cm DBH:			
Balsam Fir	1.23 ± 2.52	2.15 ± 3.02	
Red Spruce	0	0.08 ± 0.30	
White Birch	0.15 ± 0.55	0.31 ± 0.63	
Dead	1.15 ± 1.41	2.92 ± 2.02	
5m radius ground cover[a] (%):			
Total	4.9 ± 1.2	5.5 ± 0.5	0.052
Shrubs	2.5 ± 1.1	2.5 ± 1.1	
Forbs	2.2 ± 0.7	2.2 ± 0.9	
Ferns	1.6 ± 0.8	2.3 ± 1.5	0.047
Grass/sedge	1.08 ± 0.3	1.08 ± 0.3	
Leaf litter	2.9 ± 1.2	2.5 ± 1.1	
Downed Logs (>12cm dia)	1.5 ± 0.5	1.4 ± 0.5	
Bare ground	1.4 ± 0.7	1.2 ± 0.4	
Litter depth (cm)	4.0 ± 1.2	2.9 ± 1.6	

[a] Index of percent coverage: 1=0-4, 2=5-24, 3=25-49, 4=50-74, 5=75-94, 6=95-100. Index values were compared with a Wilcoxon rank-sum test; all other comparisons made with a two-sample *t*-test.

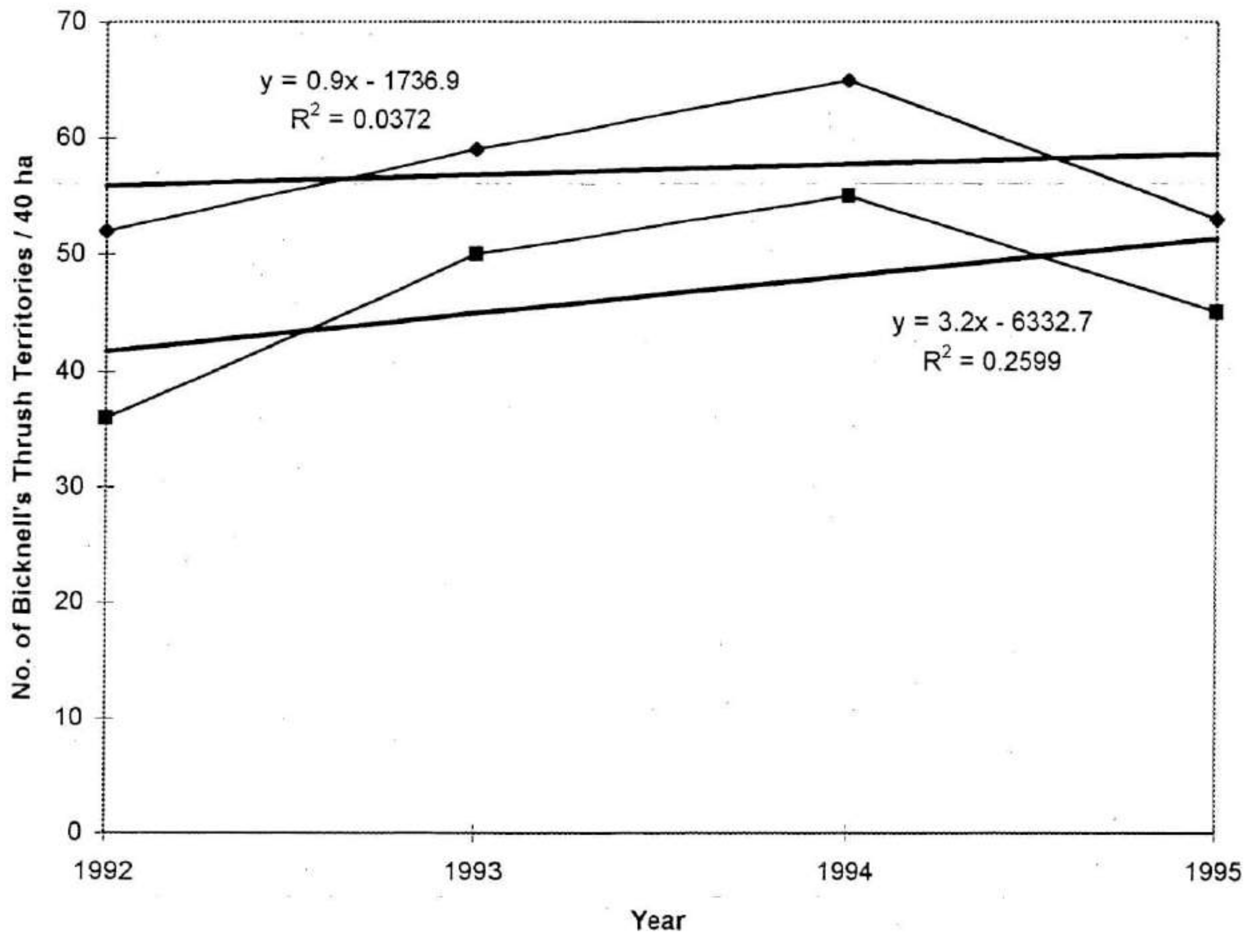

Figure 1. High and low density indices determined from spot mapping of Bicknell's Thrush on MANS study plot, Mt. Mansfield, VT.

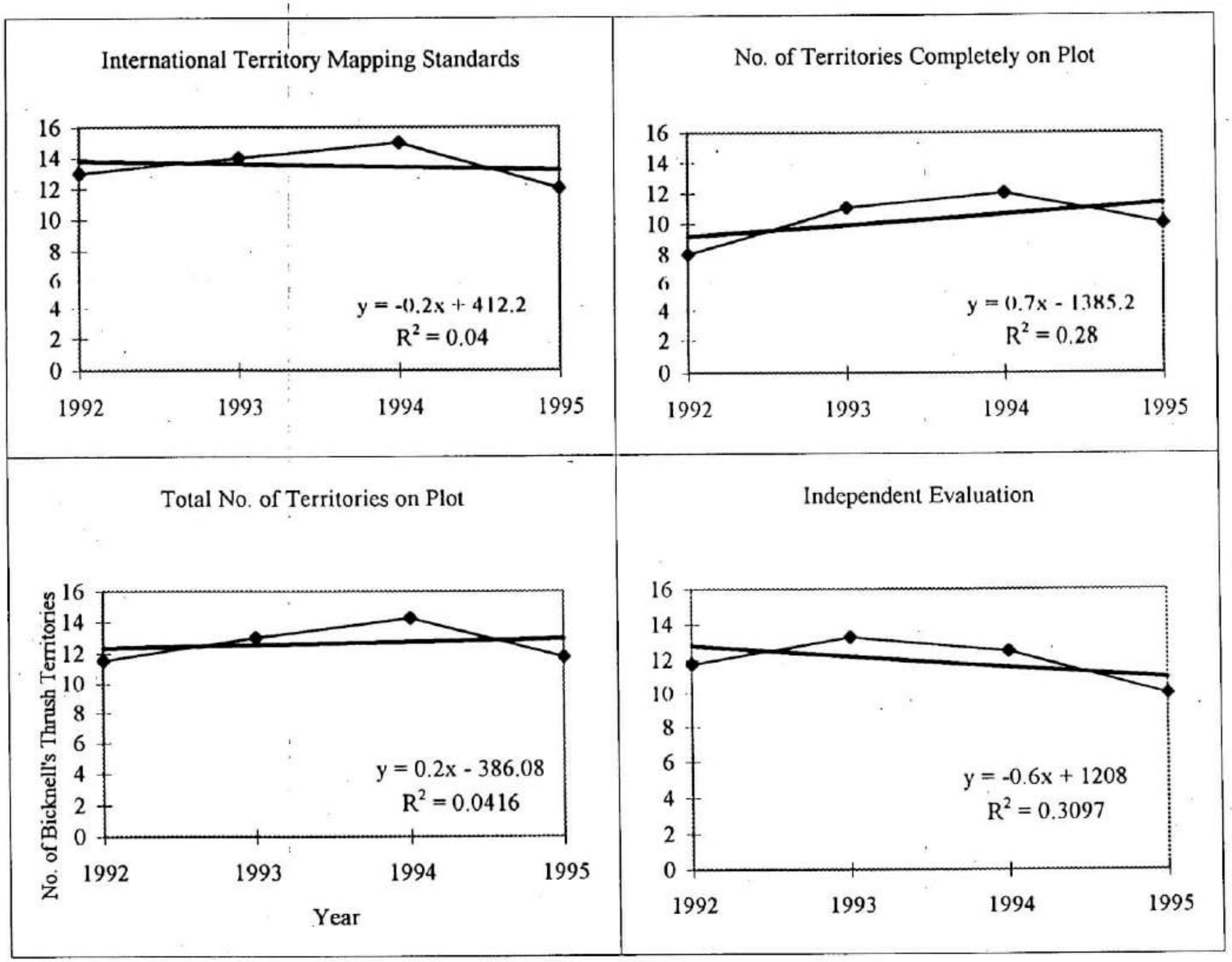

Figure 2. Density indices determined using four different analyses methods of spot mapping data from MANS study plot, Mt. Mansfield, VT.

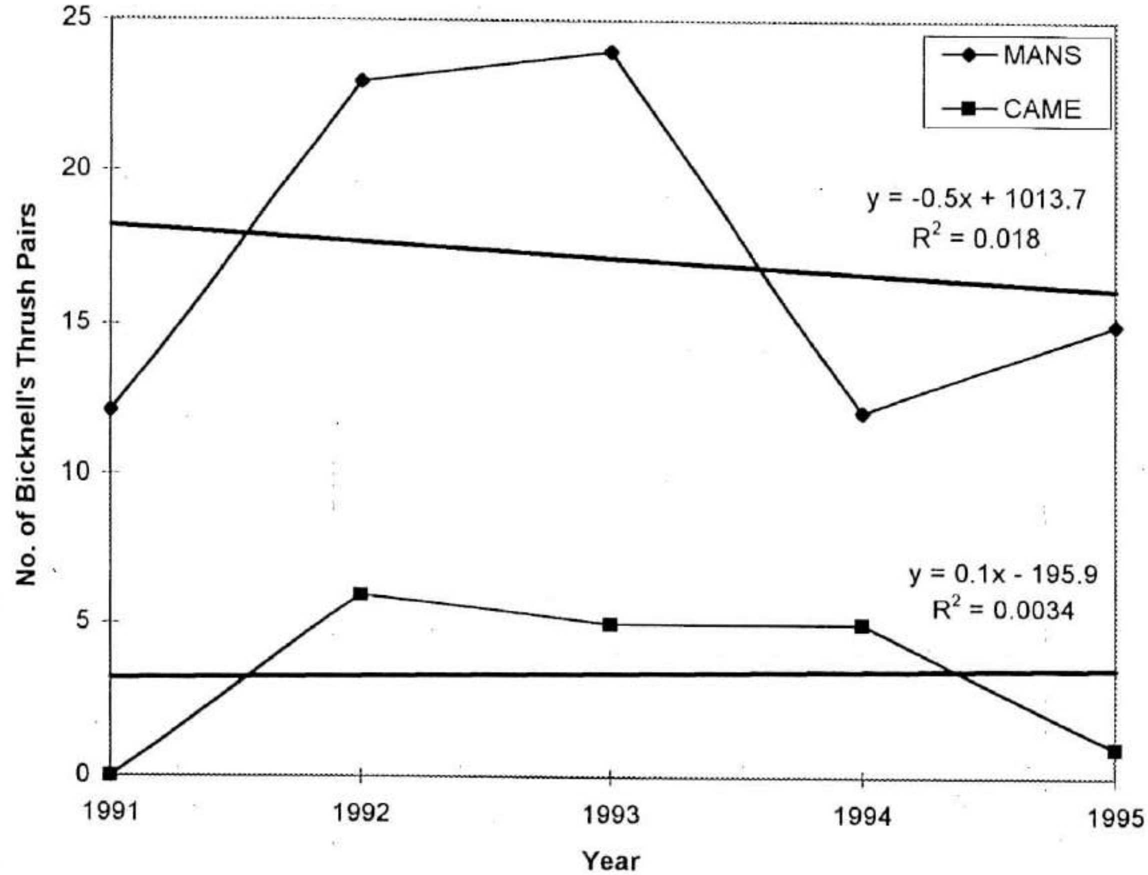

Figure 3. Number of Bicknell's Thrush pairs detected on unlimited distance point counts on Mt. Mansfield and Camel's Hump, Vermont (n = 5 counts at each site)

Literature Cited

American Ornithologists' Union. 1995. Fortieth supplement to the AOU checklist of North American birds. Auk 112:819-830.

Atwood, J.L., C.C. Rimmer, K.P. McFarland, S.H. Tsai, and L.R. Nagy. Distribution of Bicknell's Thrush in New England and New York. Wilson Bull. In Press

Barbour, M.G., J.H. Burk, and W.D. Pitts. 1987. Terrestrial Plant Ecology, 2nd ed. Benjamin/Cummings Publ. Co., Inc. Reading, MA. 633 pp.

Battles, J.J., A.J. Johnson, T.G. Siccama, A.J. Friedland, and E.K. Miller. 1992. Red Spruce death: effects on forest composition and structure on Whiteface Mountain, New York. Bull. Torrey Bot. Club 119:418-430.

Desante, D.F. and K.M. Burton. 1994. M.A.P.S. Manual. Unpubl. handbook. Institute for Bird Populations, Point Reyes Station, CA.

Erskine, A.J. 1992. Atlas of breeding birds of the Maritime Provinces. Nova Scotia: Nimbus Publishing Limited and the Department of Natural Resources. 270p.

Foster, J.R. and W.A. Reiners. 1983. Vegetation patterns in a virgin subalpine forest at Crawford Notch, White Mountains, New Hampshire. Bull. Torrey Bot. Club 110: 141-153.

Gauthier, J. and Y. Aubry, Eds. 1995. Les Oiseaux Nicheurs du Québec. Montréal, Canada.

Hensler, G.L. and J.D. Nichols. 1981. The Mayfield method of estimating nesting success: a model, estimators and simulation results. Wilson Bull. 93:42-53.

Johnson, D.H. 1979. Estimating nest success: the Mayfield method and an alternative. Auk 96: 651-661.

Krahl-Urban, B., H.E. Papke, K. Peters and C. Schimansky. 1989. Forest Decline. Assessment Group for Biology, Ecology, and Energy of the Julich Nuclear Research Center.

Martin, T.E. and C.J. Conway. 1994. BBIRD field protocol. Unpubl. handbook, Montana Coop. Wildlife Research Unit, Missoula, MT.

Mayfield, H. 1961. Nesting success calculated from exposure. Wilson Bull. 73:255-261.

Mayfield, H. 1975. Suggestions for calculating nest success. Wilson Bull. 87:456-466.

Miller-Weeks, M. M. and D Smoronk. 1993. Aerial assessment of red spruce and balsam fir condition in the Adirondack Region of New York, the Green Mountains of Vermont, the White Mountains of New Hampshire, and the mountains of western Maine, 1985-86. USDA Forest Service, Tech. Rep. NA-TP-16-93.

Nixon, E. Status report on Bicknell's Thrush (*Catharus minimus bicknelli*) in Canada. Unpubl. report, Canadian Wildlife Service.

Ouellet, H. 1993. Bicknell's Thrush: taxonomic status and distribution. Wilson Bull. 105: 545-572.

Rimmer, C.C., J. Atwood, K.P. McFarland, and L.R. Nagy. Population density, vocal behavior and recommended survey methods for Bicknell's Thrush. Wilson Bull. In Press.

Robbins, C.S. 1970. An international standard for a mapping method in bird census work recommended by the International Bird Census Committee. Audubon Field Notes 24: 722-726.

Rosenberg, K.V. and J.V. Wells. 1995. Importance of Geographic Areas to Neotropical Migrant Birds in the Northeast. Report submitted to U.S. Fish and Wildlife Service, Region-5, Hadley, MA.

Siccama, T.G., M. Bliss, and H.W. Vogelmann. 1982. Decline of red spruce in the Green Mountains of Vermont. Bull. Torrey Bot. Club 109: 163-168.

Wallace, G. J. 1939. Bicknell's Thrush, it's taxonomy, distribution, and life history. Proc. Boston Soc. Nat. Hist. 41: 211-402.

Small Mammals on Mt. Mansfield, Vermont

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Abstract: An inventory of small mammals on the west slope of Mt. Mansfield was begun during the spring of 1994 and concluded in 1995. During these two years, four techniques were used to determine what species were found across the elevational gradient: live trapping, pitfall trapping, walking transects, and road surveys. These techniques were biased towards detection of rodents and insectivores, and to a lesser extent rabbits, marsupials, medium-sized carnivores, and large herbivores. Bats and large carnivores were not sampled at all. Fifteen species of mammals were identified in this area, including 9 species of rodents, 2 insectivores, 2 lagomorphs, 1 carnivore (coyote), and 1 large herbivore (white-tailed deer). Inventory efforts in 1994 were restricted to elevations between 1,200 and 2,200 feet. Pitfall trapping was the most complete of all the techniques used to inventory the small mammal population (8 of 11 species of rodents and insectivores, only failing to note three diurnal or large-bodied rodents). Inventory efforts in 1995 involved live trapping at 3,800 feet and 4,200 feet, as well as pitfall traps between 1,200 and 3,200 feet. Species fell into one of two groups with respect to elevation: those restricted to below treeline and those that are found across the entire elevational range. No rare or unusual species were noted. Field work specifically focused on small mammals will be discontinued at this site, but future work will involve the identification of small mammals captured in pitfall traps at drift fences from 1991 to 1995, and in all subsequent years when the amphibian drift fences are in operation.

Introduction

During the late spring of 1994, I began an inventory of the small mammals on the west slope of Mt. Mansfield, an area within the study region of the Vermont Monitoring Cooperative. The purpose of this work was to identify the species of small mammals that live in this region and to establish a methodology that will allow for standardized replicate sampling in this area at intervals throughout the coming years. In 1994, inventory effort was restricted to the elevations between 1,200 and 2,200 feet in order to assess the effectiveness of a range of inventory techniques. No effort was made to establish a methodology to answer questions associated with the demography of resident populations. In 1995, the inventory effort was concentrated at 3,800 feet and on the summit ridgeline at 4,200 feet.

For the purposes of this study, the small mammal fauna is considered to be composed of the insectivores and rodents. Bats, all carnivores, and all large-bodied mammals were excluded from this inventory effort. However, an attempt was made to collect anecdotal information on rabbits and medium to large-sized herbivores and carnivores at the lowest elevations of the study region, primarily along roads.

Methods

Four techniques were used to inventory the small mammal species on Mt. Mansfield. The first was night-time live-trapping. In 1994, Sherman live traps (7.7 cm x 9.0 cm x 23.0 cm) were set on nine nights in two locations within the VMC monitoring area: 1,200 feet and 2,200 feet elevation. The 1,200 foot location is to the east of and adjacent to the lower 1,200 foot amphibian drift fence, and the 2,200 foot location is to the south of and adjacent to the 2200 foot amphibian drift fence (Figure 1). At each site, forty traps were set in a 4 x 10 trap pattern at 10 m intervals. Traps were set in the early evening hours, baited with rolled oats and peanut butter, and checked again the following morning. All animals captured were identified to species and sex and then released unharmed at the point of capture. Traps were set on 9 evenings at each site, resulting in 720 trap-nights from 2 June to 25 July.

In 1995, Sherman live traps were set on eight night in two locations: 3,800 feet along the Sunset Ridge Trail and at 4,200 feet along the summit ridgeline (Figure 1). At each site, 20 traps were set in an irregular pattern (dictated by the vegetation and terrain) within an area of between 1.0 and 1.5 hectares. Traps were set in the early evening hours, baited with rolled oats and peanut butter, and checked again the following morning. All animals captured were identified to species and sex and then released unharmed at the point of capture. Traps were set on eight evenings at each site, resulting in 320 trap-nights from 1 June to 29 July.

The second technique was pitfall traps at drift fences. These traps are associated with the amphibian drift fences, 2 fences at 1,200 feet and one at 2,200 feet. Pitfall traps were opened on evenings that seemed to be good for amphibian activity (e.g., warm and wet) and checked again the following morning. Animals that were in the pits the following morning, including small mammals, were identified and, if dead, frozen and returned to the laboratory. During 1994, the pitfall traps were open on 12 evenings between 18 May and 1 November, and in 1995 they were open on 18 evenings between 1 May and 1 November.

The third technique was morning transect walks. An observer slowly walked over a known route recording all small mammal activity either on the ground or in nearby trees. Two transects were used, one along the road heading east and south from the 2,200 foot trapping site (0.50 mile) and the other along the trail extending west from the 1,200 foot trapping site (0.25 mile). During 1994, each transect was walked nine times, once each week between 3 June and 26 July. This technique was not used in 1995.

The fourth technique was road surveys. A set route of 9.8 miles in the western part of the VMC monitoring area was driven during mid-day, and all mammals living or dead (roadkills) were recorded. The road survey route was driven nine times, once each week between 3 June and 26 July. This technique was not used in 1995.

Results and Discussion

Species richness. All techniques combined identified 11 species of insectivores and rodents (Table 1) of a possible 29 known from the state (Table 2). The deer mice (Peromyscus maniculatus) and white-footed mice (P. leucopus) were distinguished by the depth of their cheek pouches, a technique that is not completely reliable on living animals. Therefore, the identity of these two species in particular--as opposed to the genus--at each elevation should be viewed as probably but not certain. Further work using analysis of salivary amylase would be necessary to identify Peromyscus species with certainty.

With respect to elevational changes, the small mammal fauna is divided into two groups:

1. Those found primarily or exclusively below treeline. They include the jumping mice, Microtus voles, chipmunks, beaver, porcupines, and Sorex shrews. The absence of Sorex above treeline, however, may be a function of not doing any pitfall trapping, the most effective technique for inventorying that group, in those locations.

2. Those found over the entire elevational range. This group includes the Peromyscus mice, red-backed voles, and short-tailed shrews.

Four additional species, eastern cottontail, snowshoe hare, coyote, and white-tailed deer, were also observed (Table 1) from a total possible of 30 known from Vermont (Table 3). No effort was made, however, to systematically survey this group, and the absence of any species does not indicate anything of biological importance.

Analysis of techniques. Analysis of 1994 data indicate that pitfall traps at the drift fences are more effective at sampling small mammals in this area than are live traps. The pitfall traps caught eight identifiable species, whereas the Sherman traps only caught five at any one site, which were a complete subset of those found in the pitfall traps. Further, the Sherman traps caught fewer individuals of many species, especially jumping mice, voles, and masked shrews. Therefore, the results of the trapping conducted at the higher elevations in 1995 must be viewed with caution. Pitfall traps were specifically excluded above 3,200 feet because of the potential for permanent harm to the fragile vegetation there. If a more complete survey of small mammals above treeline is needed in the future, the relative costs and benefits of these traps should be reconsidered.

The transect walks were useful at locating a small number of diurnal and arboreal species, like squirrels, porcupines, and rabbits, that normally are not found in traps, but only accounted for three species not found in the pitfall traps. It is apparent that the road surveys are not a useful technique. Despite the susceptibility of many mammalian species to being killed by cars, it does not appear that traffic in the VMC study area is sufficiently high or fast enough to kill animals that cross the road with any regularity.

Future plans

Active work focusing on the small mammals will not be continued at this site. However, further information on this taxon will be gained by two techniques:

1. Identifying the small mammals killed in amphibian pitfall traps from 1991 to 1995. This represents hundreds of specimens that must be individually prepared for cleaning by the dermestid beetle colony at the Zadoch Thompson Memorial Museum at the University of Vermont, and is a slow process.

2. Continuing to trap small mammals as incidental captures at pitfall traps run primarily to monitor amphibian populations.

Although funding for the small mammal portion of this work is not being requested, additional reports will be submitted to the Vermont Monitoring Cooperative as data warrant.

Context

This study is unique. It is the only site in Vermont at which this full range of inventory techniques is being used to look for the presence of small mammals species over a large area. It is also the only site at which a long-term monitoring program for small mammals has been implemented. At one other site in the Champlain Basin and at one site in the Battenkill River watershed (Lye Brook Wilderness Area), small mammals are captured in pitfall traps incidental to amphibian trapping. At two sites in the Champlain Basin (Camel's Hump and the Bread Loaf Wilderness area), small mammals are regularly live trapped to assess their status, particularly with regard to changes in vegetation over time.

Figure 1. The location of drift fences and trapping plots on the west slope of Mt. Mansfield.

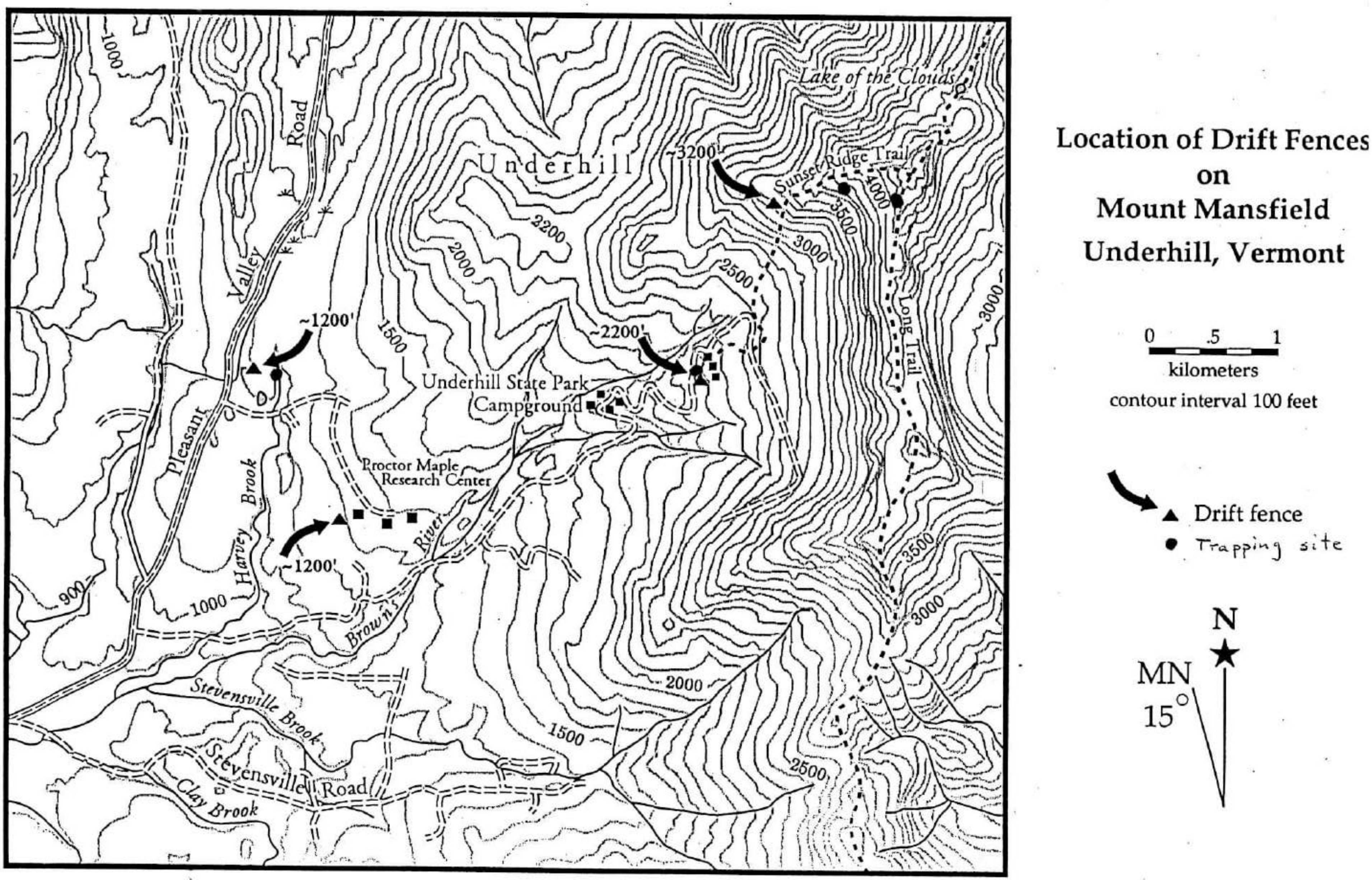


Table 1. Species observed in 1994-1995 by any technique (trapping or observation) at each elevation on the west slope of Mt. Mansfield, Vermont.

	1200 ft.	2200 ft	3200 ft	3800 ft	4200 ft
Rodents					
Peromyscus maniculatus	+	+		+	+
P. leucopus	+	+	+	+	+
Zapus hudsonicus	+				
Napaeozapus insignis	+	+			
Clethrionomys gapperi	+	+		+	
Microtus pennsylvanicus	+	+			
Unidentified vole	+	+			
Tamias striatus	+	+		+	
Castor canadensis	+				
Erithozon dorsatum	+	+			
Insectivores					
Sorex cinereus	+	+	+		
Blarina brevicauda	+	+		+	+
Unidentified mole	+				
Lagomorphs					
Sylvilagus floridanus		+	+	+	+
Lepus americanus					+
Carnivores					
Canis latrans		+			
Ungulates					
Odocoileus virginianus	+	+			+

Table 2. Checklist of insectivores and rodents in Vermont, and their status on the west slope of Mt. Mansfield in the Vermont Monitoring Cooperative study area. Information current to Summer 1995.

Latin name	Common name	S[a]	C[b]
Sorex cinereus	Masked shrew	K	A
Sorex palustris	Water shrew	S	--
Sorex fumeus	Smokey shrew	S	--
Sorex dispar	Long-tailed shrew	S	--
Microsorex thompsoni	Thompson's pygmy shrew	S	--
Blarina brevicauda	Short-tailed shrew	K	A
Parascalops breweri	Hairy-tailed mole	S	--
Condylura cristata	Star-nosed mole	S	--
Tamias striatus	Eastern chipmunk	K	A
Marmota monax	Woodchuck	S	--
Sciurus carolinensis	Gray squirrel	S	--
Tamiasciurus hudsonicus	Red squirrel	S	--
Glaucomys volans	Southern flying squirrel	S	--
Glaucomys sabrinus	Northern flying squirrel	S	--
Castor canadensis	Beaver	K	O
Peromyscus maniculatus	Deer mouse	K	A
Peromyscus leucopus	White-footed mouse	K	A
Clethrionomys gapperi	Gapper's red-backed mouse	K	A
Microtus pennsylvanicus	Meadow vole	K	A
Microtus chrotorrhinus	Rock vole	S	--
Microtus pinetorum	Pine vole	S	--
Synaptomys cooperi	Southern bog lemming	S	--
Ondatra zibethicus	Muskrat	U	--
Mus musculus (I)	House mouse	S	--
Rattus rattus (I)	Black rat	S	--
Rattus norvegicus (I)	Norway rat	S	--
Zapus hudsonicus	Meadow jumping mouse	K	A
Napaeozapus insignus	Woodland jumping mouse	K	A
Erithizon dorsatum	Porcupine	K	O

a: status, based on field work in the VMC study area, on the known geographic distribution of mammals in Vermont, and the natural history of the species:

U = unlikely

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

b: observed commonality at the VMC study area

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	=	rare, observed only once or twice

Total in Vermont =		29
At VMC site:	abundant	9
	locally common	0
	occasional	2
	rare	0

Table 3. Checklist of marsupials, chiropterans (bats), lagomorphs (rabbits and hares), carnivores, and artiodactyles (even-toed ungulates) in Vermont, and their status on the west slope of Mt. Mansfield in the Vermont Monitoring Cooperative study area. Information current to Summer 1995.

Latin name	Common name	S[a]
Didelphis virginiana	Virginia opossum	S
Myotis lucifugus	Little brown bat	S
Myotis septentrionalis	Northern long-eared bat	S
Myotis sodalis	Indiana bat	S
Myotis leibii	Eastern small-footed bat	S
Lasionycteris noctivagans	Silver-haired bat	S
Pipistrellus subflavus	Eastern pipistrelle	S
Eptesicus fuscus	Big brown bat	S
Lasiurus borealis	Eastern red bat	S
Lasiurus cinereus	Hoary bat	S
Sylvilagus floridanus (I)	Eastern cottontail	K
Sylvilagus transitionalis	New England cottontail	S
Lepus americanus	Snowshoe hare	K
Canis latrans	Coyote	K
Vulpes vulpes	Red fox	S
Urocyon cinereoargenteus	Gray fox	S
Ursus americanus	Black bear	S
Procyon lotor	Raccoon	S
Mustela erminea	Ermine	S
Mustela frenata	Long-tailed weasel	S
Mustela vison	Mink	S
Martes pennanti	Fisher	S
Martes americana	Marten	S
Mephitus mephitus	Stripped skunk	S
Lutra canadensis	River otter	U
Lynx rufus	Bobcat	S
Lynx canadensis	Lynx	U
Felis concolor (E?)	Mountain lion	U
Odocoileus virginianus	White-tailed deer	K
Alces alces	Moose	S

a: status, based on field work, known geographic distribution of mammals in Vermont, and the natural history of the species:

U = unlikely
K = known
S = suspected, based on published range maps
R = rare, observed only once or twice

Total in Vermont = 30
Known at VMC site = 4

Terrestrial Flora

Annual Assessment of Forest Health in the Lye Brook Wilderness Area 1995

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

Cooperators
Brent Teillon, Nate Fice, Allan Sands, Barbara Burns and Tim Morton, Department of Forests, Parks & Recreation.

Abstract

Annual assessments of forest health in the Lye Brook Wilderness Area are conducted to monitor trends in tree condition over time and to aid in the identification of causes, if declines occur. Monitoring efforts began in 1990 in spruce and fir forests at 2300', and have since been expanded to include monitoring at 1400' in northern hardwood forests. Data collection includes mensuration, crown health and tree damages. Plot design and measurement variables follow the procedures of the National Forest Health Monitoring program.

Over 92% of overstory trees at both elevations were considered healthy ($\leq$15% dieback) in 1995. Average dieback for all trees remains below 10% at both elevations, an indication of overall good tree health. However, all species, except red maple, showed increasing dieback from 1994 values. Foliage transparency and crown density likewise increased. Spring and early summer drought conditions most likely contributed to these signs of tree stress.

Black cherry at 1400' showed a significant increase in average dieback, nearly doubling that of 1994. High transparency ratings (29%) were also recorded, as were observations of curled leaves and foliage discoloration. The combination of these crown symptoms indicates both past and current stress responses are affected these trees. A longer time period is needed to determine a baseline condition for "normal" health.

No new mortality occurred for any of the overstory trees on previously established plots. Standing dead trees on newly established plots appears high for some species due to the relatively small sample size, and does not reflect annual mortality rates.

Introduction

Annual assessments of crown condition, mortality, and damage are conducted on permanent plots located at two elevations, 1400 and 2300 feet. The purpose of these plots is to document changes in tree health over time and to aid in the identification of causes for declines, if they occur.

Materials and Methods

Four long-term monitoring plots using the design and measurement variables of the National Forest Health Monitoring Program (NFHM) (Tallent-Halsell, N.G. 1994)are used to represent forest health in the Lye Brook Wilderness Area. Data collected to assess forest health includes mensuration, crown condition and tree damages. In 1990, one plot was established at 2300′ as part of the NFHM Program grid. One additional plot at the same elevation and 2 plots at 1400′ were established in 1994. An additional high elevation plot was added in 1995 to improve the hardwood sample size. These elevations were chosen for comparison with plots on Mt. Mansfield, the northern Vermont VForEM study site.

Results and Discussion

Over 92% of overstory trees at both elevations were considered healthy ($\leq$15% dieback) in 1995 (Table 1). Average dieback for all trees remains below 10% at both elevations, an indication of overall good tree health. However, all species, except red maple, showed increasing dieback from 1994 values. Foliage transparency and crown density likewise increased. Spring and early summer drought conditions most likely contributed to these signs of tree stress.

Black cherry at 1400′ showed a significant increase in average dieback, nearly doubling that of 1994 (Table 2). High transparency ratings (29%) were also recorded, as were observations of curled leaves and foliage discoloration. The combination of these crown symptoms indicates both past and current stress responses are affected these trees. A longer time period is needed to determine a baseline condition for "normal" health.

No new mortality occurred for any of the overstory trees on previously established plots (Table 1). Standing dead trees on newly established plots appears high for some species due to the relatively small sample size, and does not reflect annual mortality rates (Table 2).

References

Tallent-Halsell, N.G. (ed.). 1994. Forest Health Monitoring 1994 Field Methods Guide. EPA/620/R-94/027. U.S. Environmental Protection Agency, Washington, D.C.

Table 1. Crown condition measurements for overstory trees growing on monitoring plots at different elevations in the Lye Brook Wilderness Area for 1995.

Species	Elevation	Dieback (%)	Transparency (%)	Density (%)	Healthy (%)
Balsam Fir	2200	2.0	24.3	44.6	100
Black Cherry	1400	12.5	29.0	42.5	90
Paper Birch	1400	4.5	28.0	52.5	100
Red Maple	1400	5.7	19.8	52.5	95.4
	2200	5.9	24.9	48.8	100
Red Spruce	2200	2.9	21.7	53.8	100
All Species	1400	7.3	23.3	52.5	92.4
	2200	4.5	24.0	49.0	99

Healthy = trees with $\leq$ 15% dieback

Table 2. Tree condition measurements for all crown classes of trees growing on monitoring plots at different elevations in the Lye Brook Wilderness Area for 1995.

Species	Elevation	Dieback (%)	Transparency (%)	Density (%)	Healthy (%)	New Dead (%)
Balsam Fir	2200	2.1	25.5	42.8	100	0
Beech	1400	9.5	22.0	59.0	80	0
	2200	10.0	29.6	38.8	83.3	7.7*
Black Cherry	1400	12.3	28.6	41.8	90.9	0
Paper Birch	1400	4.5	28.0	52.5	100	0
Red Maple	1400	5.7	19.8	52.5	95.4	0
	2200	5.9	24.9	48.8	100	3.7*
Red Spruce	2200	2.6	22.4	49.9	100	0
Striped Maple	2200	8.0	21.5	50.0	80	9.1*
All Species	1400	6.8	23.0	54.0	94.2	3.8
	2200	3.4	19.1	46.3	100	0

* = Standing dead trees on newly established plot.

ANNUAL ASSESSMENT OF FOREST HEALTH ON MOUNT MANSFIELD 1995

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

Cooperators

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

Abstract

Forest health is monitored annually using two different methods. One plot-cluster of the North American Maple Project (NAMP) monitors trends in the condition of sugar maple at an elevation of 415 m (1360'). Site characterization, crown condition, and bole and crown damage are measured. In addition, 8 plots have been established following the design and measurement variables of the National Forest Health Monitoring Program. These are located on the west slope of the mountain along an elevation gradient, with pairs at 1400, 2200, 3000 and 3800 feet. Measurements taken on these plots are used to determine current tree health and to create a baseline for long-term monitoring.

Data on sugar maple condition has been collected since 1988 under the NAMP and shows a general improvement from 1988 to 1989, then a stable and generally healthy condition thereafter. In 1994, 95.8% of trees were considered healthy ($\leq$ 15% dieback), average dieback was 7.3%, transparency of foliage was 11.3%, and no new mortality was observed. Thinner foliage can be attributed to a spring and early summer drought conditions.

Tree health data from the other forest health plots showed slight increases in dieback, one indicator of tree condition, at the 1400, 2200 and 3000 foot elevations. Early season drought conditions may have been responsible. Dramatic improvements in tree condition at 3800 feet occurred, where balsam fir is the dominant species. However, balsam fir at the 3000 foot elevation has shown a steady increase in average dieback over the last 4 years. All other species showed small fluctuations in crown conditions. Few stress agents were active this year. There was an increase in mortality at the 3000 and 3800 foot elevations, where 1.3 and 4.0% mortality occurred in 1995. Mortality was preceded by poor crown vigor and damages to bole and crown.

Introduction

Annual assessments of crown condition, mortality, and damage are conducted on permanent plots located at four elevations. The purpose of these plots is to document changes in tree health over time and will aid in the identification of causes for declines, if they occur.

Two types of plots are used: one plot at low elevations is part of the North American Maple Project (NAMP) plot system, 8 additional plots use the design and measurement variables of the National Forest Health Monitoring Program (NFHM).

NAMP Plot Methods

Plot establishment, site characterization and annual tree evaluations follow standardized NAMP protocols (Millers et al, 1991). Annual evaluations of tree condition and foliage damage require two - three visits to the plot to determine extent of injury from early-, mid-, and late-season defoliators: one in mid-to-late June, July, and early September. Evaluators are trained and certified with other state and provincial field crews to maintain high Quality Control. Between-crew and between-state remeasurements are done on 12 % of the plot-clusters and with each field crew. Data entry is completed in-state, and statewide data is acquired following quality check by the NAMP data analyst at SUNY in Syracuse, NY. Metric units are used for data collection and analysis.

NAMP Plot Results and Discussion

Overstory sugar maple tree condition has improved since 1988 and maintained a generally healthy status since 1991. In 1995, average dieback and the percentage of trees considered healthy (< = 15% dieback) remained stable from the previous year. Transparency, a measure of current year stress, increased slightly. Early summer drought conditions may have been responsible, producing slightly thinner tree crowns. No other stress agents were active this year. No new mortality occurred in 1995.

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	8.2	14.3	0	91.5
1994	7.6	10.4	0	95.8
1995	7.3	11.3	0	95.8

Table 1. Tree health results for the NAMP plot at 415 m (1360 ft) at the Proctor Maple Research Center, Mount Mansfield, Vermont. Average crown dieback, average foliage transparency (the amount of light coming through the foliated portions of the crown), mortality, and percent of trees healthy are all used to assess the health of dominant and codominant sugar maple trees in this plot.

Forest Health Plot Methods

Eight permanent plots are used to monitor the health of forests on the west slope of Mount Mansfield, annually. Two plots at each of four elevations (1400, 2200, 3000 and 3800 feet) were established following the design and measurement variables of the NFHM program (Tallent-Halsell 1994). At each elevation, except 3800 ft, paired plots are located in each of the two watersheds: Browns River and Stevensville Brook. In the Stevensville Brook watershed, no canopy trees are present at the 3800 foot elevation, so the paired plots at this elevation are in the Browns River watershed. English units are used for data collection and analysis.

Forest Health Plot Results and Discussion

Trees monitored at 1400, 2200 and 3000 foot elevations had slightly greater dieback than in 1994. At all three elevations, fewer trees were considered healthy (< = 15% dieback) in 1995 (Tables 2a and 2b). At 3800 feet, there were dramatic improvements in tree health. Average dieback decreased to 17.1%, and the percentage of trees healthy increased to 64.7%. While lower elevations experienced below average precipitation conditions throughout the spring and early summer months, the high elevation forests had normal rainfall except for April and June, creating fairly normal growing conditions overall. These trees are still significantly less healthy than at all other elevations.

When compared to 3-year averages, trees on the 3000 foot plots had significantly higher dieback in 1995, while trees on the 3800 foot plots had significantly less dieback (Figures 1-3). Some of this improvement may be the result of removal of poor vigor trees from the sample due to mortality. Other crown health indicators, foliage transparency and crown density, were similar to past years.

Mortality increased on the 3000 and 3800 foot elevation plots, with 1.3 and 4.0% mortality, respectively. Mortality was preceded by years with poor crown vigor (high dieback and low density), and damages to boles and crowns. No mortality occurred on the 1400 and 2200 foot elevation plots.

Tree damages are injuries observed on any location of the tree that meet a minimum threshold. The most common type of damage found on survey plots is indicator of decay, which includes conks, fruiting bodies, decaying wood, etc. (Table 3).

Yellow birch at 2200 feet, paper birch at 300 feet, and balsam fir at 3800 feet had large percentages of trees affected by numerous types of damage. Over half of the overstory yellow birch trees had indicators of decay (58% of trees). Light defoliation by an early season shot hole defoliator occurred on 68% of the trees. Overstory paper birch were affected by indicators of decay (36% of trees), large open wounds (20% of trees) and dead terminals (4% of trees) Nearly half the overstory balsam fir trees had dead or broken terminals (43% of trees), probably due to adverse winter conditions. Other damages included indicators of decay (15% of trees) and broken branches on greater than 1/4 of the trees (10% of trees).

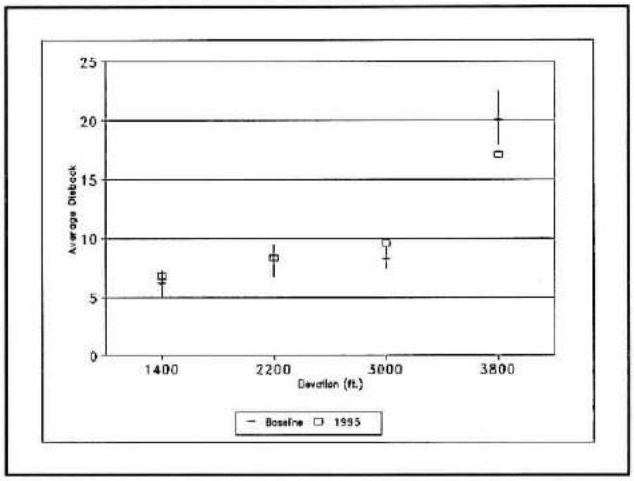
Table 2a. Average dieback for overstory trees of species growing on monitoring plots at different elevations on Mt. Mansfield from 1992 through 1995.

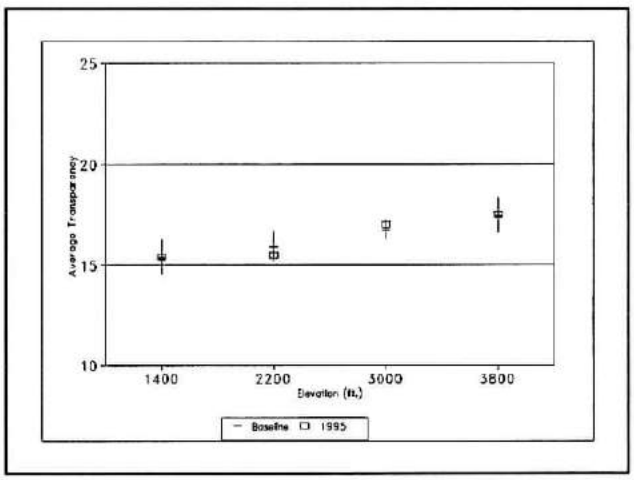
SPECIES	ELEVATION	1992 DIEBACK (%)	1993 DIEBACK (%)	1994 DIEBACK (%)	1995 DIEBACK (%)
BALSAM FIR	3000	5.6	6.8	8.2	9.8
	3800	18.8	20.5	20.3	16.9
SUGAR MAPLE	1400	4.2	5.6	5.6	5.0
YELLOW BIRCH	2200	6.6	7.1	5.4	6.6
PAPER BIRCH	3000	9.6	8.4	6.1	7.6
ALL SPECIES	1400	5.3	6.1	5.4	6.8
	2200	8.6	9.4	8.3	8.3
	3000	9.0	8.4	9.2	9.6
	3800	18.8	20.2	20.7	17.1

Table 2b. The percentage of overstory trees of different species growing at different elevations on Mt. Mansfield that are considered healthy ($\leq$ 15% dieback) over a 3 year period, 1992 through 1995.

SPECIES	ELEVATION	1992 HEALTHY (%)	1993 HEALTHY (%)	1994 HEALTHY (%)	1995 HEALTHY (%)
BALSAM FIR	3000	100	91.3	92	93
	3800	54.0	60.6	57	64.2
SUGAR MAPLE	1400	100	100	100	100
YELLOW BIRCH	2200	94.7	94.7	100	100
PAPER BIRCH	3000	88.5	83.3	97	92
ALL SPECIES	1400	97.0	100	100	97.6
	2200	90.6	90.6	97	95.1
	3000	89.8	88.5	92	91
	3800	54.0	60.6	57	64.7

Figures 1-3. Overstory tree health in 1995 compared to 3 year averages (baseline) for survey plots at 4 elevations on Mount Mansfield. Tree health indicators used are crown dieback, foliage transparency and crown density.





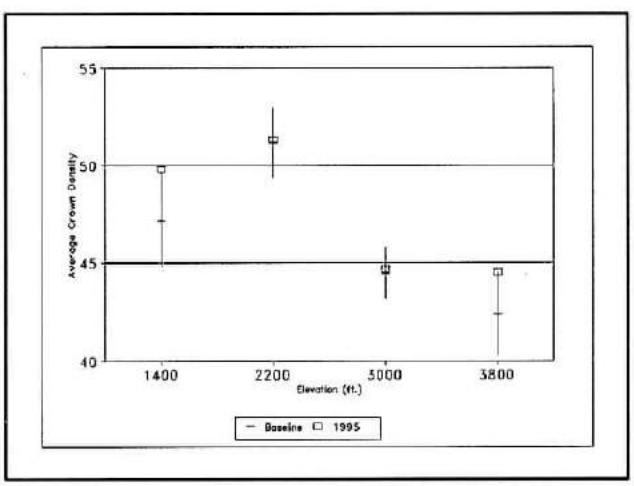


Table 3. Percent of trees affected by significant damages. Minimum thresholds for each type of damage are those considered significant for tree growth and vigor. Protocols follow those of the National Forest Health Monitoring Program.

Species (elevation)	Percent of trees and type of damage
Balsam Fir (3000 ft.)	2% with broken bole or roots, 2% with discolored foliage (30% of foliage), 2% with broken branches (40% of branches)
Balsam Fir (3800 ft.)	15% with indicator of decay, 43% with dead terminal, 10% with broken branches
Sugar Maple (1400 ft.)	12% with indicator of decay
Yellow Birch (2200 ft.)	58% with indicator of decay, 5% with open wound (size > 20% of circumference), 68% with light defoliation by unknown shot hole defoliator (<30% defoliation)
Paper Birch (3000 ft.)	36% with indicator of decay, 20% with open wound (size >20% of circumference), 4 % with dead terminal

References

Millers, I., D. Lachance, W. Burkman & D. Allen. 1991. North American Sugar Maple Decline Project: organization and field methods. Gen. Tech. Rep NE-154. Radnor, PA: U.S. Dept. of Agr., Forest Service, Northeastern Forest Experiment Sta. 26 p.

Tallent-Halsell, N.G. (ed.). 1994. Forest Health Monitoring 1994 Field Methods Guide. EPA/620/R-94/027. U. S. Environmental Protection Agency, Washington, D.C.

FOREST PEST MONITORING ON MOUNT MANSFIELD - 1995

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ABSTRACT

Monitoring pest population trends and tree damage is conducted annually on a statewide basis to understand 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 plants sensitive to ground level ozone.

Monitoring efforts on Mount Mansfield include conducting aerial surveys to detect areas of defoliation or decline, ground plot evaluations of tree damages, and monitoring of forest pest population trends. At the Lye Brook Wilderness Area (LBW) aerial surveys and ground plot evaluations are used to detect defoliation and declines.

The objective of this monitoring effort is to detect trends in the populations of major insect pests, and to document the occurrence of damage to the forests on Mount Mansfield and the LBW from detectable stress agents.

The major stress affecting forests in 1995 was drought conditions in the spring and early summer. At Mount Mansfield, below normal precipitation was recorded from February through June at the Proctor Maple Research Center. At the summit weather station, below normal precipitation occurred only during April and June, suggesting that high elevation forests were less stressed than lower elevation forests.

Population levels of all six major insect pests monitored on Mount Mansfield decreased to or maintained a low population level in 1995. Light defoliation to sugar maple trees from Bruce spanworm was visible but not serious.

On Mount Mansfield, areas of moderate and heavy dieback were mapped from aerial surveys. These correspond to areas defoliated in 1993 by pear thrips. A small area of moderate birch defoliation was also mapped in the Browns River watershed. This same area has been defoliated for the past 3 years.

Four areas of hardwood declines in the Lye Brook Wilderness Area were identified from aerial surveys.

Ground level ozone monitoring at the Underhill and Bennington stations recorded cumulative SUM06 exposures at 21.56 and 19.49 ppb-hr, respectively for 1995. Plants sensitive to ozone were evaluated in August for symptoms of ozone injury. Severity of injury at the Rupert site (southern Vermont) showed light injury. Not injury was found on plants at the Underhill site.

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 understand 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 plants sensitive to ground level ozone.

Monitoring efforts on Mount Mansfield include conducting aerial surveys to detect areas of defoliation or decline, ground plot evaluations of tree damages, and monitoring of forest pest population trends. At the Lye Brook Wilderness Area (LBW) aerial surveys and ground plot evaluations are used to detect defoliation and declines.

The objective of this monitoring effort is to detect trends in the populations of major insect pests, and to document the occurrence of damage to the forests on Mount Mansfield and the LBW from detectable stress agents.

Mount Mansfield Monitoring
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.

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 accordance with that of other statewide surveys for these pests (Teillon et al, 1995).

Each trap type is deployed during the adult moth flight period. FTC traps are active between June 26 and August 15. SHL traps are placed out between May 19 and July 29. FHL catches are made from August 31 to October 31. SBW traps are deployed between June 22 and August 12. Trap catches were returned to the Vermont Department of Forests, Parks & Recreation (FPR) Laboratory in Waterbury for identification and counting of target and non-target species.

PEAR THRIPS

Pear thrips 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 Proctor Maple Research Center [1360 ft. (415 m) elevation].

Soil samples are collected annually in the fall of 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.

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 from April 1 through June 13, with trap catch counts verified by VT FPR Laboratory staff.

GYPSY MOTH

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. 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.

Mount Mansfield and Lye Brook Wilderness Area METHODS

AERIAL SURVEY OF FOREST DAMAGE

Aerial surveys conducted by trained FPR staff during the summer months are used to detect areas of defoliation, discoloration, heavy dieback or mortality, and determine the cause of this injury, if possible. 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, 1995). Information is later digitized into a Geographic Information System.

OZONE BIOINDICATOR PLANTS

Plants sensitive to ground level ozone are monitored throughout the growing season as part of the National Forest Health Monitoring Program (NFHM)(Tallent-Halsell 1994). During the period of maximum exposure, August 7-23, 30 individuals of each sensitive species growing naturally in large openings are examined for symptoms of ozone injury. These include milkweed, black cherry and blackberry. Symptoms are verified by a regional expert in ozone injury identification as part of the NFHM. For Mount Mansfield, plant evaluations are conducted at the Proctor Maple Research Center in the open field where the state ozone monitor is located. The availability of large (>3 acres) opening containing plants sensitive to ozone have not been possible at LBW. A location in Rupert is used as a southern Vermont representative of injury on sensitive plants with maximum ozone exposure.

Mount Mansfield
RESULTS AND DISCUSSION

The major forest stress agent for 1995 was an early season drought. Precipitation was below normal from February through June at the Proctor Maple Research Center weather station (Figure 1a). The summit weather station showed below normal precipitation only for April and June (Figure 1b). So high elevation forests may not have suffered from moisture deficit to the same extent as lower elevations.

Results from insect monitoring showed no detectable populations of forest tent caterpillar or spring hemlock looper. Fall hemlock looper populations were lower than in 1994, and no detectable defoliation was observed. Spruce budworm populations on Mount Mansfield were the highest relative to other survey locations in the state, especially at the high elevation site. These population levels still remain low compared to building and outbreak levels, and no detectable defoliation was observed. Gypsy moth and pear thrips populations remain low, with only slight increases from last year. Overall, all these insect pest populations remained at low levels this year.

Light defoliation was recorded on survey plots at Proctor Maple Research Center (1400') from Bruce spanworm. Lower canopy branches were especially affected. This seemed to be a localized population, since other low elevation areas were unaffected.

Another insect that was active on high elevation spruce and fir trees was the white spotted sawyer beetle (*Monochamus scutellatus*). The noticeable symptom was apical flagging on trees with no apparent pattern. The adults feed on the underside of twigs causing a wound. The twig dies and the foliage from the wound to the tip turns red. Damage to trees was minimal. No previous outbreaks of this insect have been observed, so significant defoliation in the future is not expected.

Mount Mansfield and Lye Brook Wilderness Area
RESULTS AND DISCUSSION

Aerial survey results for Mount Mansfield outline areas of heavy dieback throughout the east slope of the mountain. An area of moderate dieback was mapped on the northwest slope of the Browns River watershed, adjacent to an area of moderate birch defoliation. Both these areas of dieback were mapped in 1993 as defoliated by pear thrips, but recovered in subsequent year. These recovering trees may have been less resistant to drought conditions experienced during the early summer this year.

Four areas of hardwood decline were identified within the Lye Brook Wilderness Area from aerial surveys. Two of these areas are in the far north, and the other two are on the southwest slopes of the wilderness area. On the northeast edge of the wilderness area, outside the boundaries, an area of birch leaf miner defoliation was recorded.

Monitoring of ground level ozone at the Underhill and Bennington stations showed cumulative SUM06 values of 21.56 and 19.49, respectively for 1995 (Figure 4). These ozone values are based on a 24 hour, April through September calculation. Symptoms of ozone injury to sensitive plants was present at the southern Vermont site in Rupert, where light injury was recorded. No injury was observed at the Underhill site. Early season drought conditions probably prevented the uptake of ozone, limiting plant injury.

ACKNOWLEDGEMENTS

Aerial survey data collection was conducted by dedicated Forest Resource Protection staff. GIS maps of aerial survey information was provided by Tom Luther of the USDA Forest Service, Northeastern Area State & Private Forestry in Durham, NH. Ozone data has been generously provided by the Vermont Air Pollution Control Division.

REFERENCES

Millers, I., D. Lachance, W. Burkman & D. Allen. 1991. North American Sugar Maple Decline Project: organization and field methods. Gen. Tech. Rep NE-154. Radnor, PA: U.S. Dept. of Agr., Forest Service, Northeastern Forest Experiment Sta. 26 p.

Parker, B. L., M. Skinner, S. H. Wilmot and D. Souto. 1990. Proceedings, Regional Meeting: "Pear Thrips Research and Management: Current Methods and Future Plans." South Burlington, VT, November 15-16. Vt. Agr. Exp. Sta. Bull. 697, Univ. Vt., Burlington. 151 pp.

Tallent-Halsell, N.G. (ed.). 1994. Forest Health Monitoring 1994 Field Methods Guide. EPA/620/R-94/027. U.S. Environmental Protection Agency, Washington, D.C.

Teillon, H.B., B.S. Burns and R.S. Kelley. 1995. Forest Insect and Disease Conditions in Vermont - 1995. Agency of Natural Resources, Dept. of Forests, Parks and Recreation, 103 So. Main St., Waterbury, VT 05671-0602. 103 pp.

Table 1. Survey results on six forest pests monitored on Mount Mansfield from 1991 to 1995. Results are in average population counted unless otherwise indicated. Blanks for 1991 indicate pests and elevations not included in the survey for that year.

Target Pest	Survey Type	Elevation	1991	1992	1993	1994	1995
Forest Tent Caterpillar	Pheromone traps	1400′ 2200′ 3800′	0	0 0 0	0 0 0	0 0 0	0 0 0
Spring Hemlock Looper	Pheromone traps	1400′ 2200′ 3800′		0 0 -	0 0 0	0 0 0	0 0 0
Fall Hemlock Looper	Pheromone traps	1400′ 2200′ 3800′		325 521 41	80 - 0	123 133 0	111 28 0
Spruce Budworm	Pheromone traps	1400′ 2200′ 3800′	19.7	29.0 5.0 2.3	16.0 6.3 1.7	53.0 16.0 18.7	11.7 5.0 25.7
Gypsy Moth	Burlap banded trees	1400′	3 e.m.	4 e.m.	1 e.m.	0 e.m.	2 e.m.
Pear Thrips	Adult sticky traps	1400′	8	313	1472	4	37

e.m. = egg mass

Table 2. Pear thrips soil populations and resulting damage to sugar maple foliage at 1400' on Mount Mansfield from 1989 through 1995. 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
1994	0	NONE	6.0	11.0	NONE	NONE
1995	.1	NONE	6.0	11.0	NONE	NONE

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 1a. Precipitation at the Proctor Maple Research Center.

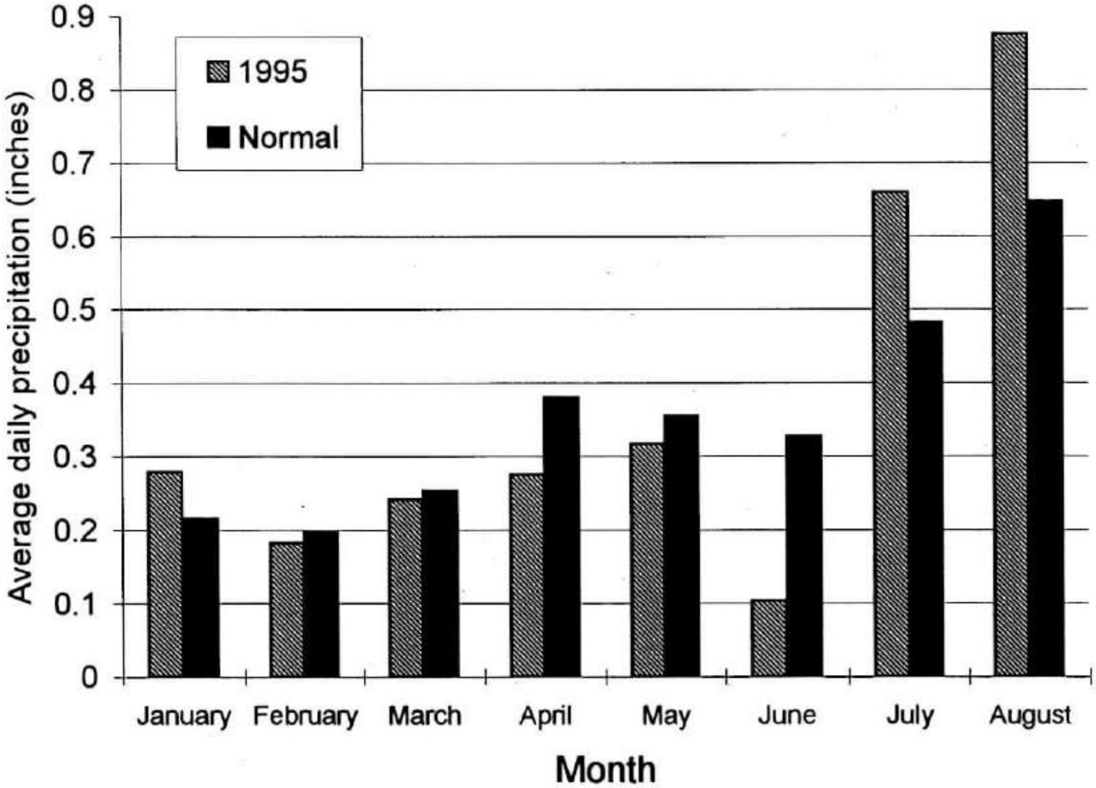


Figure 1b. Precipitation on the summit of Mt. Mansfield.

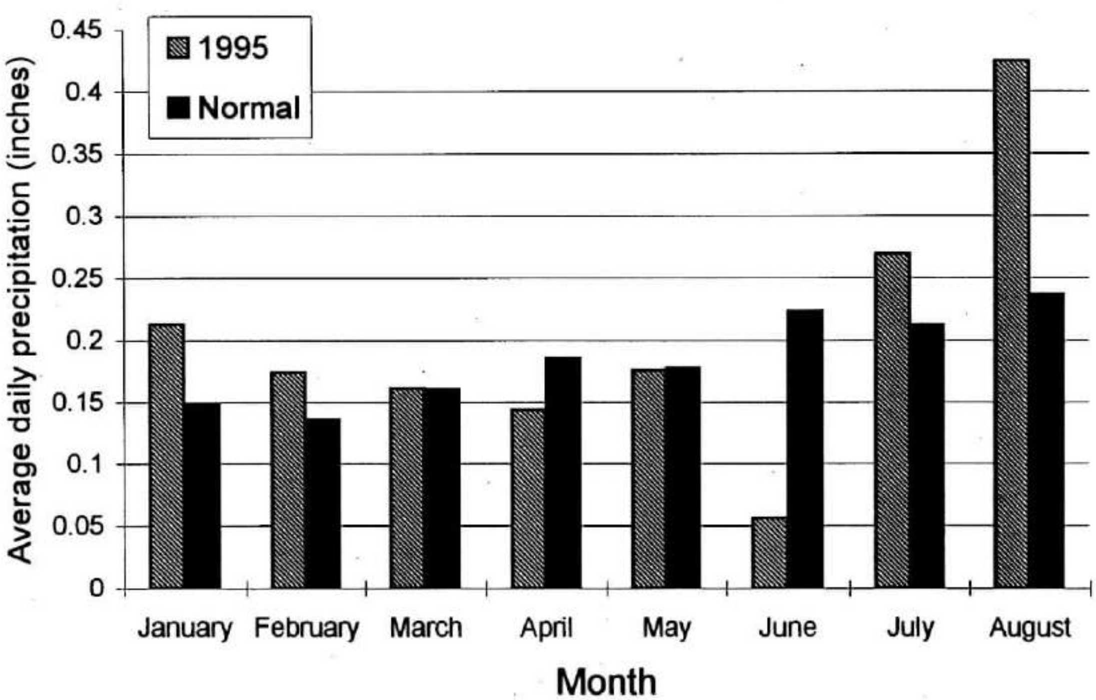


Figure 2. Forest damage mapped on Mt. Mansfield, 1995.

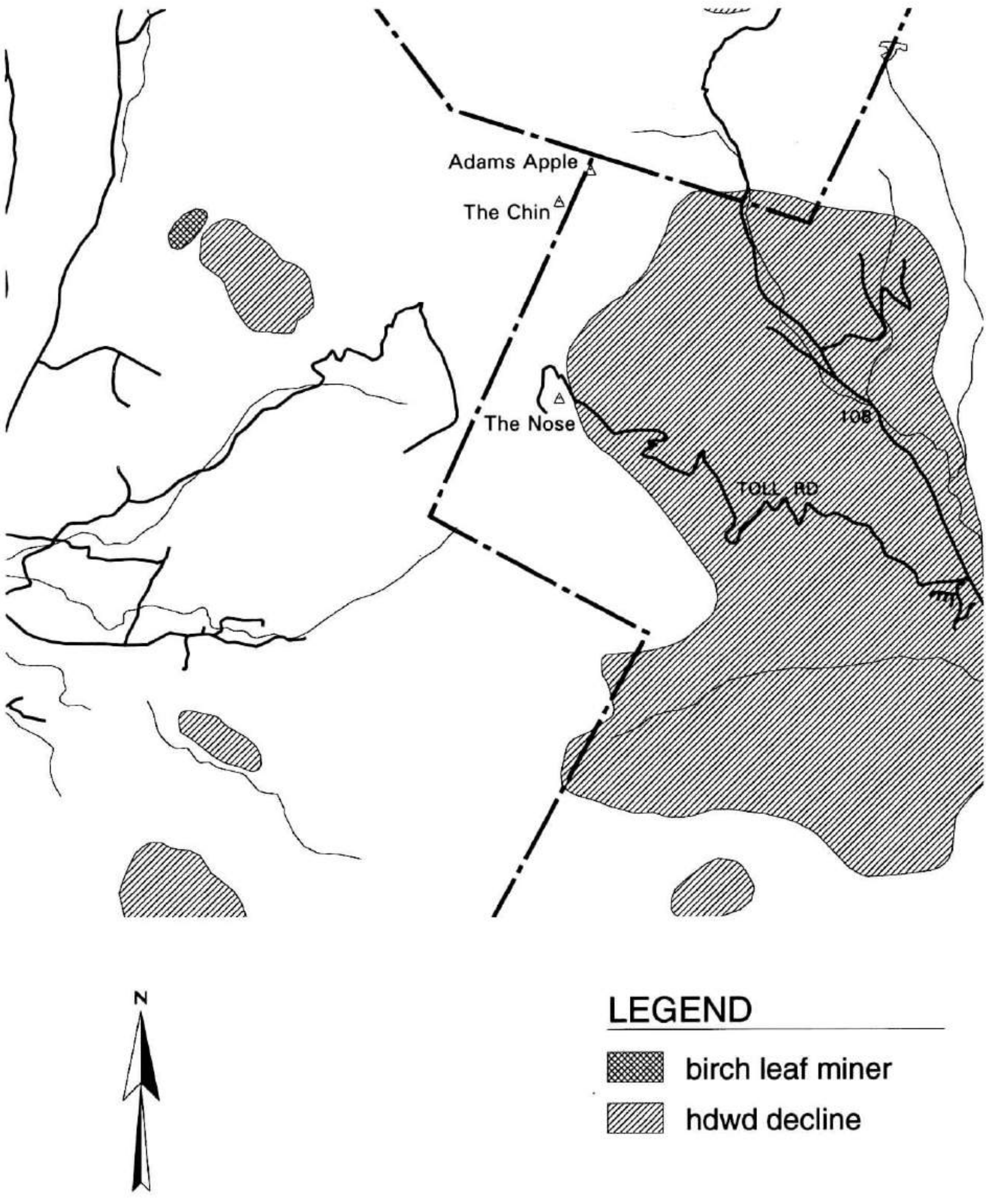


Figure 3. Forest damage mapped in Lye Brook Wilderness Area, 1995.

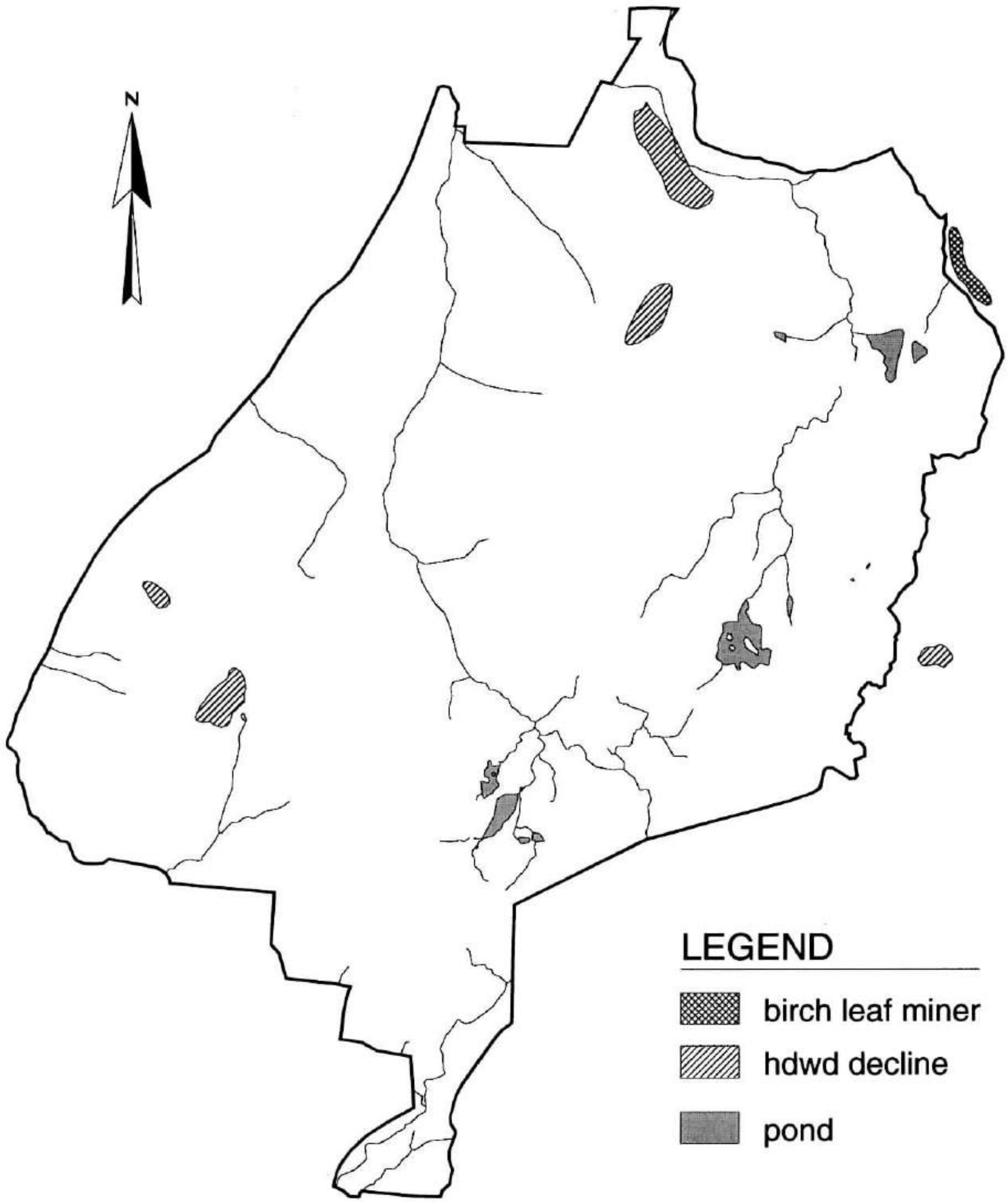
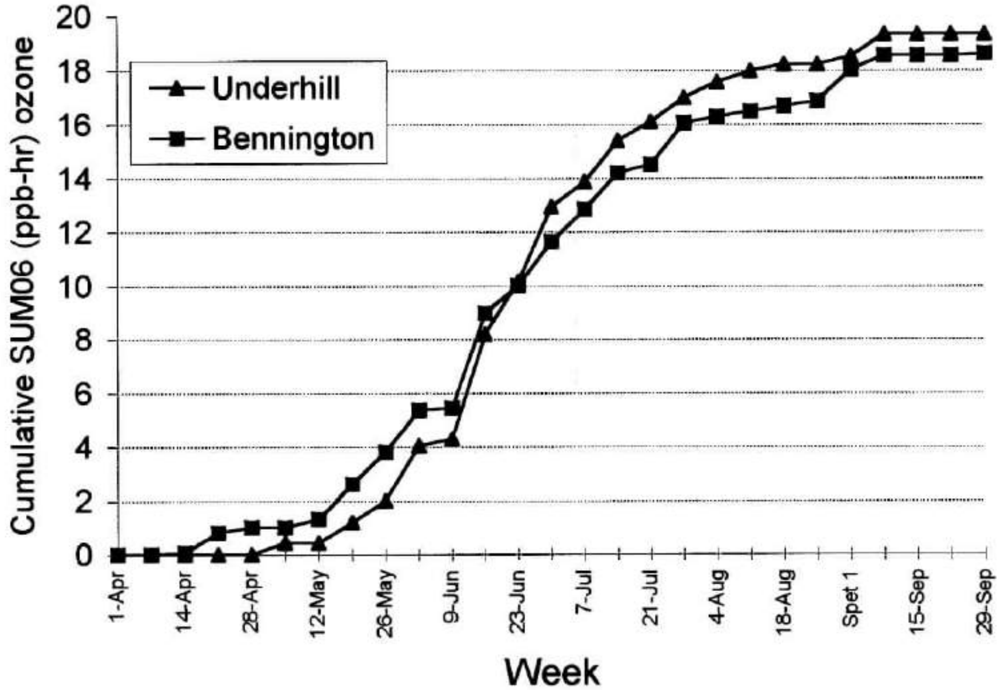


Figure 4. Cumulative weekly SUM06 ozone exposure for 1995.



Decline in sugar maple growth and regeneration near its elevation limit in the Green Mountains, VT

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Abstract

We hypothesized that sugar maples (*Acer saccharum* Marsh.) growing near upper elevation limits are particularly responsive to temporal changes in the growing environment, and that sugar maple may therefore be expanding its elevational range in response to perceived increases in global temperatures. Basal area increment (BAI), regeneration, and sapling top death were studied on five west-facing slopes in Vermont at the elevation limit and at elevations of 25m, 50m, and 100m below the limit. BAI per tree, averaged over five year intervals,declined steadily and significantly from 1973-77 (15cm^2/yr) to 1988-92 (8.5 cm^2/yr), but the most striking decline between successive growth intervals was the most recent (27% BAI reduction from 1983-87 to 1988-92). BAI was consistently and significantly lowest at the limit, but relative changes in BAI over time were most pronounced at 25m and 50m. Monitoring of temporal change in radial growth would therefore be most effective at this elevation. Regeneration was abundant at 100m (43,100 germinants/ha), but declined to zero as the limit was approached. Surprisingly, all saplings near the elevational limit regenerated by root sprouts and almost all (88%) saplings experienced multiple top deaths. The cause of these phenomena is unclear, but a combination of biotic and abiotic factors is suspect.

Sampling and Analyses of Balsam Fir Foliage and Soil-air; Mt. Mansfield, Vermont; June, 1995 (Sources and Sinks of Chloroform and its Precursors)
Michael Aucott

The purpose of the expedition was to investigate further the hypothesis that chloroacetic acids may be involved in forest decline. These compounds are formed in the atmosphere through the degradation of certain chlorinated solvents used in metal cleaning and dry cleaning, including methyl chloroform, perchloroethylene, and trichloroethylene. Researchers in Germany have found surprisingly high levels of chloroacetic acids in the foliage of forest trees, and they have reported that the concentrations of these substances in the foliage are correlated with needle loss.[1] Both monochloroacetic acid and trichloroacetic acid (TCA) have herbicidal properties; in fact, TCA was marketed as a herbicide at one time. . One study also found high levels of chloroform in soil gas compared background atmospheric levels.[2] The chloroform could possibly have come from chemical reactions in the soil, probably biologically mediated, which degraded trichloroacetic acid.

The expedition to Mt. Mansfield was an effort to observe first-hand the symptoms of high-altitude forest decline and to replicate the findings of chloroacetic acids in foliage of high-altitude conifers and of chloroform in the soil gas of these forests. I was assisted by Beorn Sunflower and Gabriel Aucott.

On the first day, June 9, 1995, we met with Sandy Wilmot, Monitoring Coordinator for the Vermont Monitoring Cooperative. It was determined that we would sample along the Halfway House Trail, which starts at about 2000 feet and goes up fairly steeply to the summit of Mt. Mansfield.

On the first day, we hiked this trail to get a general idea of the terrain and to identify areas and particular trees which looked like good sampling subjects. We determined that there were not enough red spruce to provide samples at a variety of altitudes, and decided to take samples from balsam fir, which is present from about 2000 feet to the tree line at about 3900 feet. We used a portable altimeter, whose response is geared to air pressure changes, to indicate our altitude. The meter readings seemed to correlate well with the altitude stated on our trail map and Geological Survey map, provided that the meter was calibrated first at a known altitude.

On the second day, we again hiked to the summit along the Halfway House Trail, and then began the sampling on our descent. Locations were picked at 3850 feet, 3620 feet, 3050 feet, 2590 feet, and 2050 feet. Most of the initial foliage sampling was done by removing tips of branches from selected balsam fir trees at a height of 20 to 30 feet using a tree-pruner on a three-piece extendable aluminum and fiberglass pole. Smaller pieces were clipped from the branches so obtained and placed in glass vials. At each spot, I also set up the pump to obtain samples of soil gas. Two samples were also taken of the ambient air on Mt. Mansfield. The pump, a battery-powered constant-volume type, was then hooked with a plastic tube to a tenax-filled tube type trap, which was in turn hooked to a stainless steel probe with small holes on the end. The probe was poked into the soil to about a 20 cm. depth. When the pump was turned on, in pulled soil gas from the interstitial spaces in the soil. The gas passed through the tenax-filled trap.

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[1] Frank, H., "Airborne Chlorocarbons, Photooxidants, and Forest Decline," Ambio, Vol. 20, 1991.

[2] Frank, H., Frank, W., and Thiel, D., "$C_1$and C_2-Halocarbons in Soil-air of Forests," Atmospheric Environment, Vol. 23, pp. 1333-1335, 1989.

Upon returning to camp, the foliage samples were placed in the refrigerator of the forest rangers at the campsite, Underhill Center. The next morning, they were placed in a ice chest.

The foliage samples were taken to the lab at Rutgers University, and portions of last year's growth were analyzed for dichloroacetic acid (DCA) and TCA on June 13. The tenax traps were analyzed for chloroform several days later. The analysis procedures involve extracting the chloroacetic acids from the needles and them converting them to ester derivatives which are volatile enough to be measured with a gas chromatograph.[3 4] The gas samples were desorbed by heat from the tenax tubes and also analyzed with a gas chromatograph.

The results indicate that there are modest levels of DCA and TCA in the balsam fir foliage, with no particular correlation with altitude. The levels are comparable to some of the lower values reported in the European studies. This may be typical of fir foliage early in the season; at least one study has shown fir trees to have lower levels of the chloroacetic acids than spruce or pine, and most studies in the literature show lowest levels in late winter and spring and highest levels in late summer and early fall. There is much variation in the chloroform data, but two samples appear to show significantly higher levels than ambient air.

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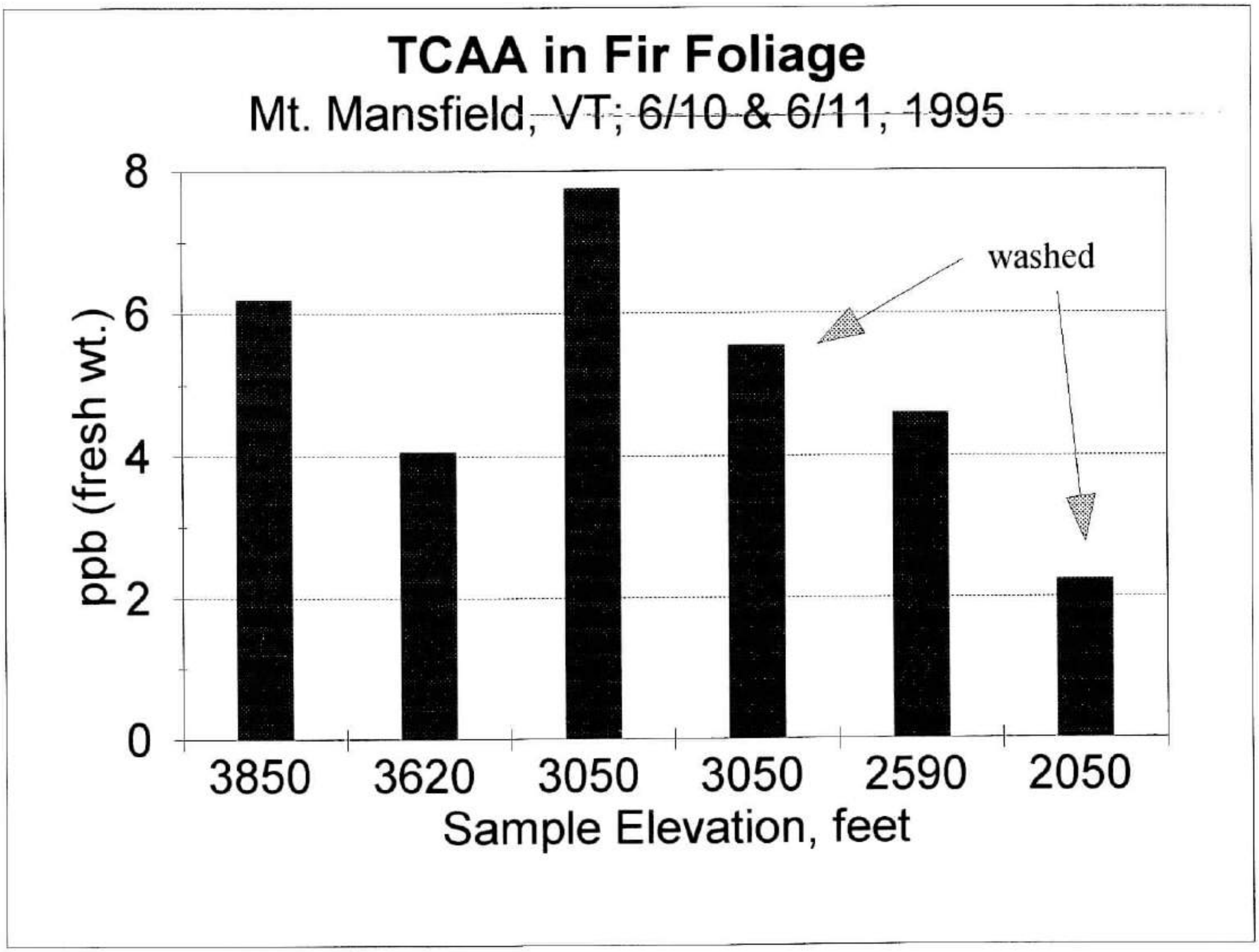
[3]Frank, H., H. Scholl, D. Renschen, B. Rether, A. Laouedj, Y., Nrorkorpi, "Haloacetic Acids, Phytotoxic Secondary Air Pollutants," Environ. Sci. & Pollut. Res., Vol 1, pp 4-14, 1994.

[4]Frank, H., D. Renschen, A. Klein, H. Scholl, " Trace Analysis of Airborne Haloacetates," J. High Resol. Chromatogr., Vol. 18, 1995.



TCAA = trichloroacetic acid

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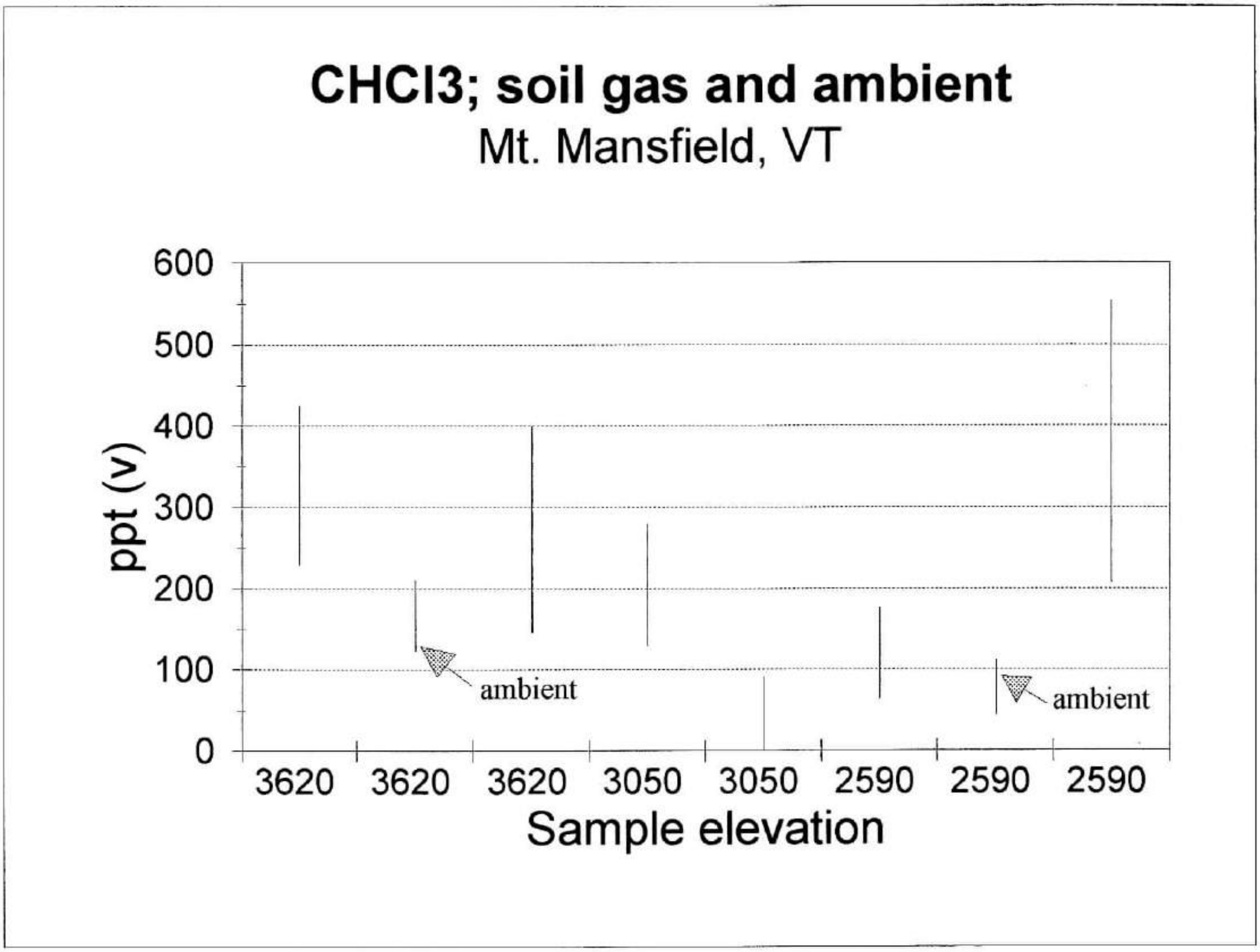

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each "elevation" value on x-axis represents one sample (i.e., 3 at 3620', 2 at 3050', 3 at 2590')

TREE PHENOLOGY MONITORING ON MOUNT MANSFIELD - 1995

Sandra Wilmot, Thomas Simmons and Michael Johnson
Vermont Department of Forests, Parks and Recreation

ABSTRACT

Monitoring of bud development, and fall color and leaf drop began in 1991 on sugar maple at 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. In 1995, red maple and white ash were added at the 1400 foot elevation to provide broader information on early and late season bud development. The purpose of this monitoring effort was to gather baseline information on these fundamental tree processes. 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 inter-relations between tree physiology and stress events.

Bud development and leaf expansion followed a similar pattern to that of 1994. For most species and elevations, development was slower and later, especially when compared to 1992 and 1993. At the lower elevation site where 5 species are evaluated, the progression of bud development among species shows sugar maple, red maple and yellow birch all reaching budbreak together, then beech, and finally ash. The progression toward full leaf expansion shows sugar maple first, followed by red maple and beech, then yellow birch, and finally ash.

In general, fall color at the 2200 foot elevation was slightly earlier than in the past 3 years, while at lower elevations (1400 feet), color development was similar to past years. This may be a symptoms of stress experienced in the spring and early summer due to drought conditions. Full color (50% of crown with color) occurred at similar dates for sugar maple, yellow birch and beech at both elevations.

Comparisons between species at the 1400 foot elevation site show that ash is the first of these species to reach full color and drop its leaves. Sugar maple is the last species to reach full color, and has significant leaf drop similar to red maple and yellow birch.

INTRODUCTION

Monitoring of bud development, and fall color and leaf drop began in 1991 on sugar maple at 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. In 1995, red maple and white ash were added at the 1400 foot elevation to provide broader information on early and late season bud development. The purpose of this monitoring effort is to begin gathering baseline information on these fundamental tree processes. 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 inter-relations 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, American beech, red maple and white ash are monitored at the 1400 foot elevation site at the Proctor Maple Research Center for a total of 25 trees and 25 saplings. Sugar maple, yellow birch and American beech are monitored at the 2200 foot elevation in the Underhill State Park for a total of 15 trees and 15 saplings at this site. Bud stages are recorded from the upper canopy, lower canopy and regeneration from dormancy through full leaf expansion (Table 1a & 1b). Descriptions of sugar maple bud stages (Skinner & Parker, 1994) have been modified for the other species to allow between-year comparisons of bud and leaf development. Flower bud stages are rated, but not all trees have flower buds each year and in the same years, so trend information is limited and will require many more years of data collection.

FALL COLOR AND LEAF DROP

Initial crown ratings are recorded on the same sample trees and saplings in late July to establish a baseline for trees with full foliage. From mid-August through October, trees and saplings are rated for color and leaf drop. Color is rated in 5% categories using the North American Maple Project definitions for discoloration (color other than green). Leaf drop was initially measured using crown dieback (defined here as the percent of branches without foliage) and foliage transparency ratings as per the National Forest Health Monitoring Program. Crown density was added in 1995 to more accurately capture leaf drop. A measure of the density of the tree with no foliage (leaf-off density) is taken late in the fall once all the leaves are gone, or in the spring before leaf out. Using both the full leaf-on and leaf-off density ratings, the percent leaf drop is calculated. In future years, density will replace dieback and transparency ratings in monitoring leaf drop.

Table 1a. Vegetative bud stages for sugar maple, yellow birch, American beech, red maple and white ash.

VEGETATIVE STAGE	SUGAR MAPLE	YELLOW BIRCH	BEECH	RED MAPLE	WHITE ASH
V0	bud dormancy	bud dormancy	bud dormancy	bud dormancy, 2-3 scale pairs	bud dormancy, 2 scale pairs
V1	initial bud swell	initial bud swell	bud lengthening	initial bud swell, 3-4 scale pairs	initial bud lengthening, 3 scale pairs
V2	bud elongation	buds fatter and slightly green	buds wide at base, exaggerated point at tip	bud swell and elongation, 4 scale pairs	bud elongation and swelling, 4 scale pairs, smooth
V3	buds in green tip stage		bud scales separating and bending back slightly	buds in green/yellow tip stage, 5 scale pairs	buds in green stage, 4 scale pairs with end scales wrinkled like leaf tip
V4	bud break, leaf tips expanded beyond the bud tip	bud break, leaf tip exposed, appears fuzzy	bud break, leaf tips exposed	budbreak, leaf tip exposed	budbreak, wrinkled leaf tip exposed
V5	extended bud break, leaves not yet spread apart	extended bud break	extended bud break	extended budbreak, leaves show beyond scales	extended budbreak
V6	initial leaf emergence, leaves breaking away from tip	initial leaf emergence, leaves breaking away from tip	initial leaf emergence, leaves breaking away from tip	initial leaf emergence, leaves breaking away from tip	initial leaf emergence, leaves breaking away from tip
V7	initial leaf expansion, leaves unfolding, broadening, elongating, wrinkled, individual leaves not yet fully expanded	initial leaf expansion, leaves unfolding, broadening, elongating, wrinkled, individual leaves not yet fully expanded	initial leaf expansion, leaves unfolding, broadening, elongating, wrinkled, individual leaves not yet fully expanded	initial leaf expansion, leaves unfolding, broadening, elongating, wrinkled, individual leaves not yet fully expanded	initial leaf expansion, leaflets spread apart on petiole and begin elongating, broadening and expanding, individual leaves not yet fully expanded
V8	full leaf expansion, flattened surface without wrinkles, may not be full size	full leaf expansion, flattened surface without wrinkles, may not be full size	full leaf expansion, flattened surface without wrinkles, may not be full size	full leaf expansion, flattened surface without wrinkles, may not be full size	full leaf expansion, flattened surface without wrinkles, may not be full size

Table 1b. Flowering bud stages for sugar maple, yellow birch, American beech, red maple and white ash.

Flower Stages	Sugar Maple-Male & Female	Yellow Birch-Male (catkin)	Yellow Birch-Female	Beech-Male	Beech-Female	Red Maple-Male	Red Maple-Female	White Ash-Male	White Ash-Female
F0		dormant				dormant rounded buds in clusters	dormant rounded buds in clusters		
F1	initial bud swell	initial bud swell		initial bud swell, buds wider at base than vegetative buds	initial bud swell, buds wider at base than vegetative buds	initial bud swell, 3 scale pairs, orange hairs at tip	initial bud swell, 3 scale pairs, orange hairs at tip	initial bud development, side buds open, 2 scale pairs	
F2	bud elongation, buds more rounded at tip than vegetative buds	bud elongation		bud elongation and continued swelling					
F3	green tip stage	full bud elongation		bud separation					
F4	bud break, flower tips show expanded beyond bud tip	bud break, stamens show below scales	bud break, flower tips show beyond bud scales	bud break, green flower shows		bud break, bud scales crack open	bud break, bud scales crack open	bud break, yellow or red stamens exposed	
F5	initial flower expansion, flower bundle expands beyond bud scales		initial flower expansion, flower stalk fully exposed, slender	initial flower expansion, flower bundle on stalk extends beyond bud scales		initial flower expansion, red stamens expand beyond scales	initial flower expansion, red stigma extends beyond scales	initial flower expansion, stamens extend beyond scales	
F6	full flower expansion and pollen dispersal	full flower expansion and pollen dispersal	full flower expansion, stigmas red, flower stalk swollen	full flower expansion, yellow stamens extended, pollen dispersed	full flower expansion, red stigmas extended (small flowers among leaves)	full flower, yellow stamens, pollen dispersed	full flower, flower hangs down on stalk, stigma red	full flower, pollen released	full flower, small flowers with red stigmas on yellow flower stalk
F7	flower senescence and drop	flowers brown and drop	stigmas brown or absent	flower senescence and drop		flower senescence, stamens brown, drop		flower senescence and drop	
F8	initial seed development		initial seed development		initial seed development		initial seed development		initial seed development

Leaf drop at each visit (%) =

((full leaf-on density - density at visit) /
(full leaf-on density - full leaf-off density)) X 100

RESULTS

SPRING PHENOLOGY

Bud development and leaf expansion followed a similar pattern to that of 1994. For most species and elevations, development was slower and later, especially when compared to 1992 and 1993.

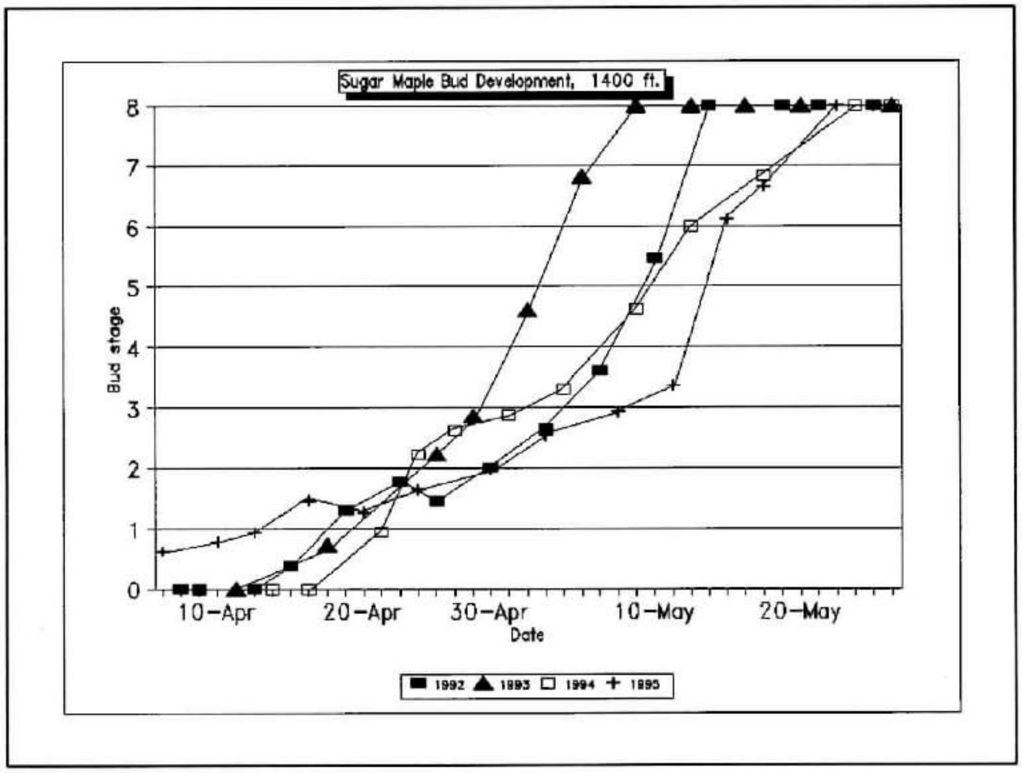
Sugar maple buds began swelling earlier than in past years. Development then slowed down, and budbreak was later than usual, 10 days later than in 1993 (Figure 1). Full leaf expansion was likewise later than other years, but similar to 1994 (late May). At the higher elevation site, early bud development was similar to other years, but slowed down at budbreak (late May) so that it was 2 weeks later than in 1993. The timing between budbreak and full leaf expansion was rapid and was completed in less than a week.

Beech buds at the 1400 foot elevation were slower in early stages of bud swell than in past years (Figure 2). Development mirrored 1994 from early budbreak through full leaf expansion, but was about 2 weeks later than in 1993. Average budbreak did not occur until May 19th, and full leaf expansion on June 2nd. At the 2200 foot elevation, average budbreak for beech trees was May 27th and full leaf expansion was June 4th. As with the lower elevation, development was slower and later than in most years, but very similar to development in 1994.

Yellow birch bud development began earlier than in the past three years, but proceeded at a pace similar to other years (Figure 3). Average budbreak occurred on May 12th and full leaf expansion on May 24th, slightly later than other years. Similar development occurred at the higher elevation site, with average budbreak on May 16th (as in 1994) and full leaf expansion on June 6th (similar to 1994). In general, development was slower than in 1993.

Comparisons between species at the 1400 foot elevation site reveals that red maple, sugar maple and yellow birch all reached budbreak together, on May 11 (Figure 4). Ash was the last species to reach budbreak, and this occurred on May 22. Full leaf expansion was reached first by sugar maple (May 15), followed by red maple and beech (May 22), yellow birch (May 25) and finally ash (June 4).

Figure 1. Sugar maple bud development at 1400 and 2200 feet on Mount Mansfield from 1992-1995.



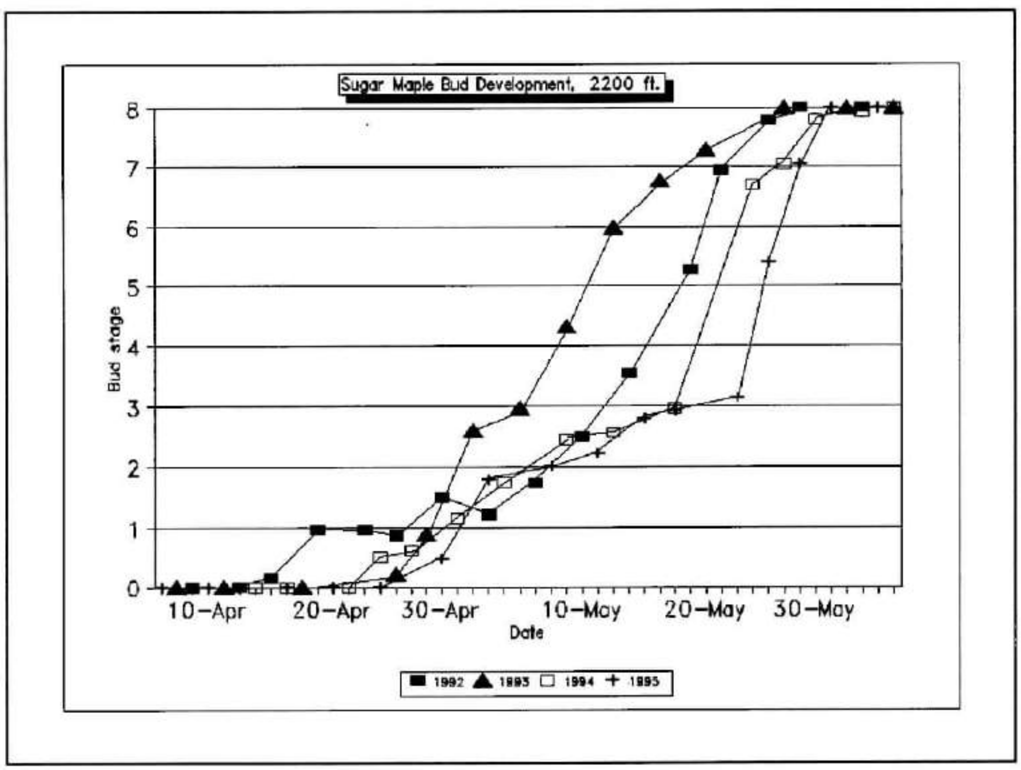
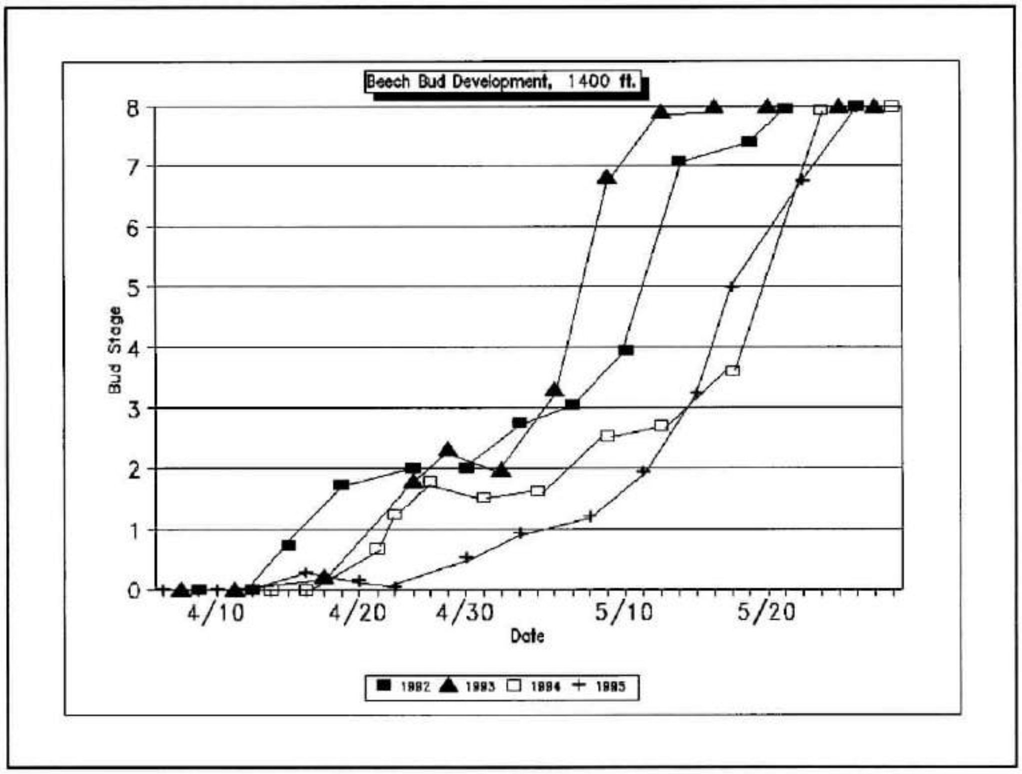


Figure 2. Beech bud development at 1400 and 2200 feet on Mount Mansfield from 1992-1995.



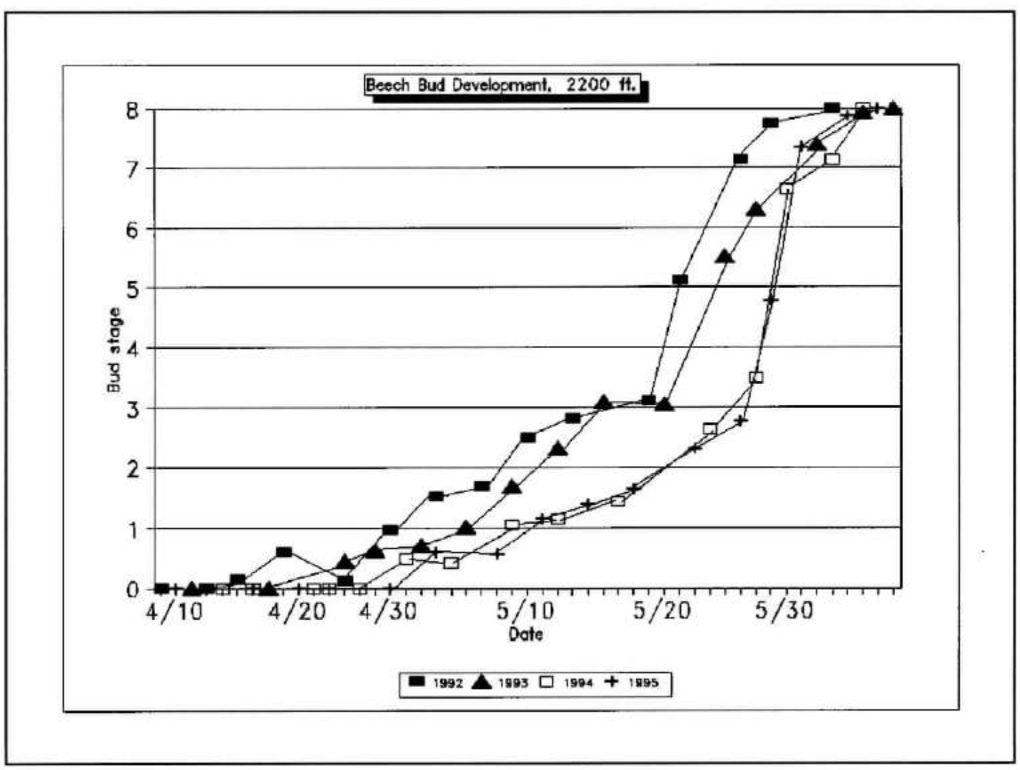
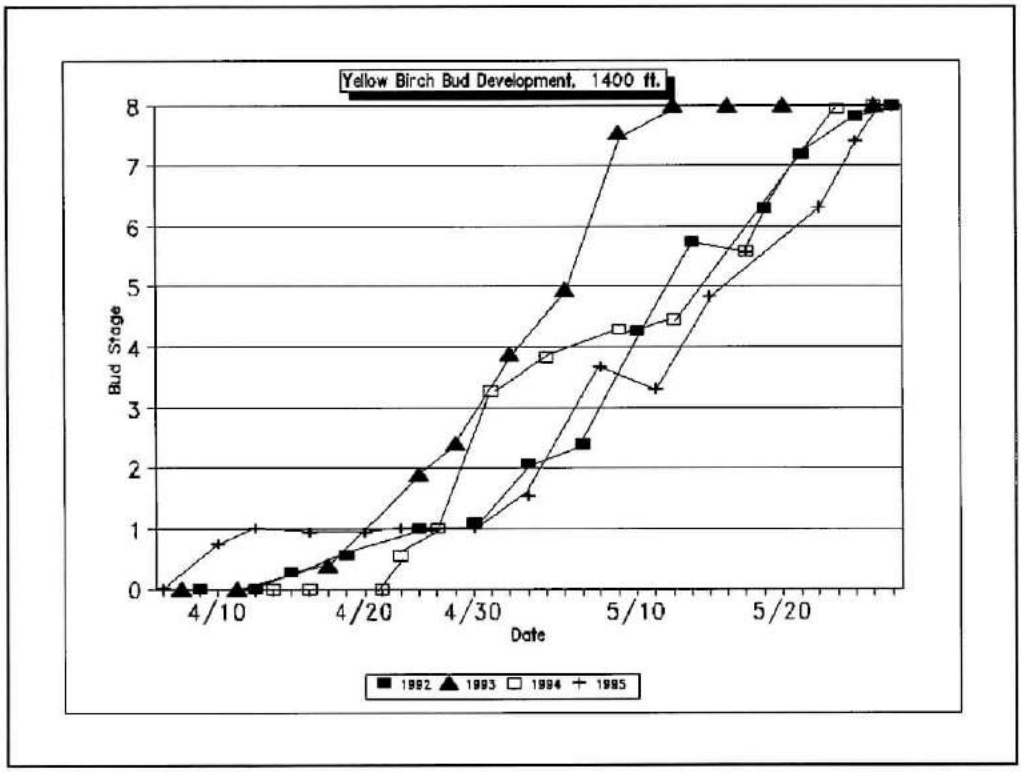


Figure 3. Yellow birch bud development at 1400 and 2200 feet on Mount Mansfield from 1992-1995.



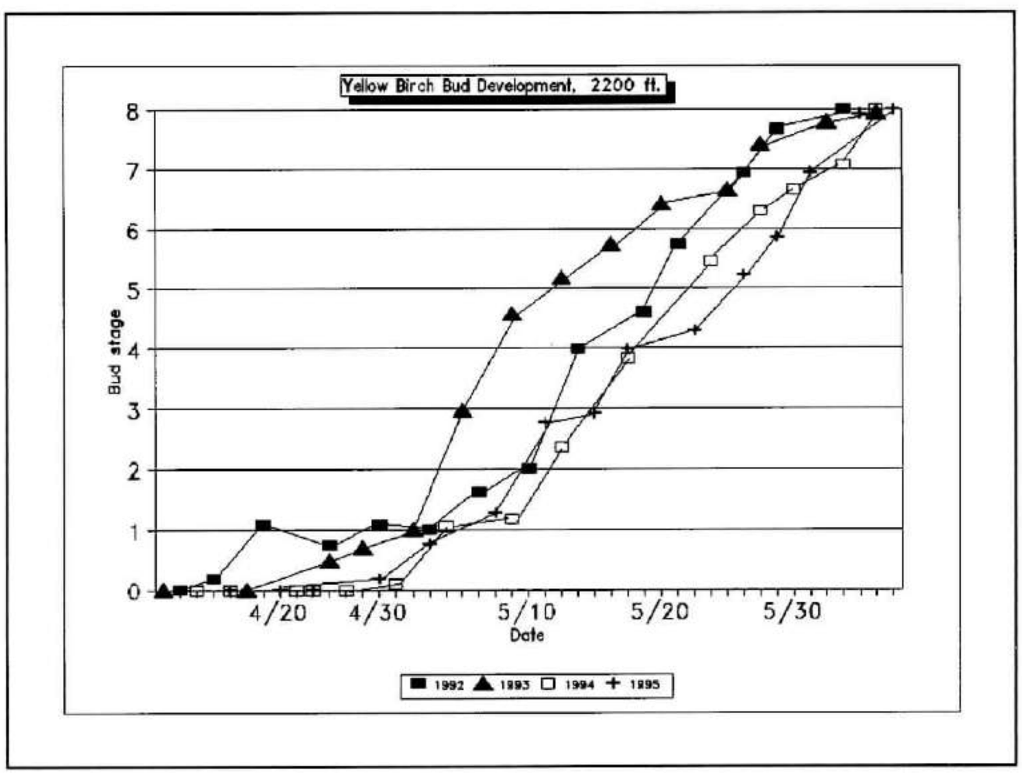
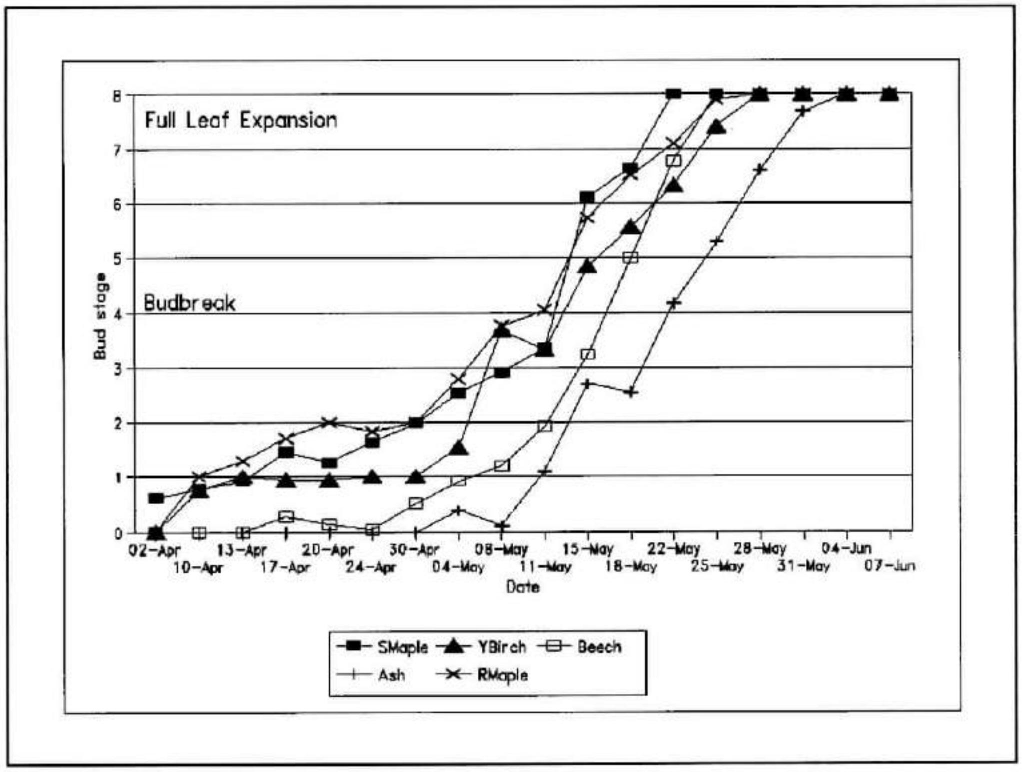


Figure 4. Bud development of species monitored at 1400' on Mount Mansfield in 1995.



FALL COLOR AND LEAF DROP

The timing of fall color at the 2200 foot elevation was slightly earlier than in the past 3 years, while lower elevation color development was similar to past years.

Sugar maple color began later than previous years at the lower elevation site, but developed rapidly, so that full color (50% color with little leaf drop) occurred during the first week of October as usual (Figure 5). Color at the higher elevation is generally earlier than at 1400 feet,with full color occurring during the last 2 weeks of September. In 1995, full color occurred during the last week of September.

Beech color development began slightly later than past years at the lower elevation site, but mirrored other years in the timing of full color during the last week of September (Figure 6). Likewise, at the 2200 foot elevation, full color developed during the last week of September. The timing of beech color at this elevation has been variable over the years, spanning a 3 week period between the 3rd week of September and the 1st week of October.

Yellow birch fall color at the 1400 foot elevation was the earliest in the past 4 years of monitoring (Figure 7). Early color developed nearly 2 weeks ahead of 1993. The timing of full color was similar to other years, during early October. At the upper elevation site, the timing of yellow birch fall color was similar to other years, with full color occurring during the last week of September.

The timing and speed of leaf drop at the low elevation site was similar to past years, occurring during the 2nd and 3rd week of October (Figures 8-10). Leaf drop at the higher elevation tends to extend over a longer time period, and to be more variable between years. The majority of leaf drop at the 2200 foot elevation occurs between the 1st and 2nd weeks of October.

In 1995, leaf drop was similar to other years. The only exception was beech at 2200 feet, which showed significant leaf drop earlier than in past years.

Comparisons between species at the 1400 foot elevation site for 1995 shows that ash is the first of these species to reach full color and drop its leaves. Sugar maple is the last species to reach full color, and has significant leaf drop similar to red maple and yellow birch. (Figure 11).

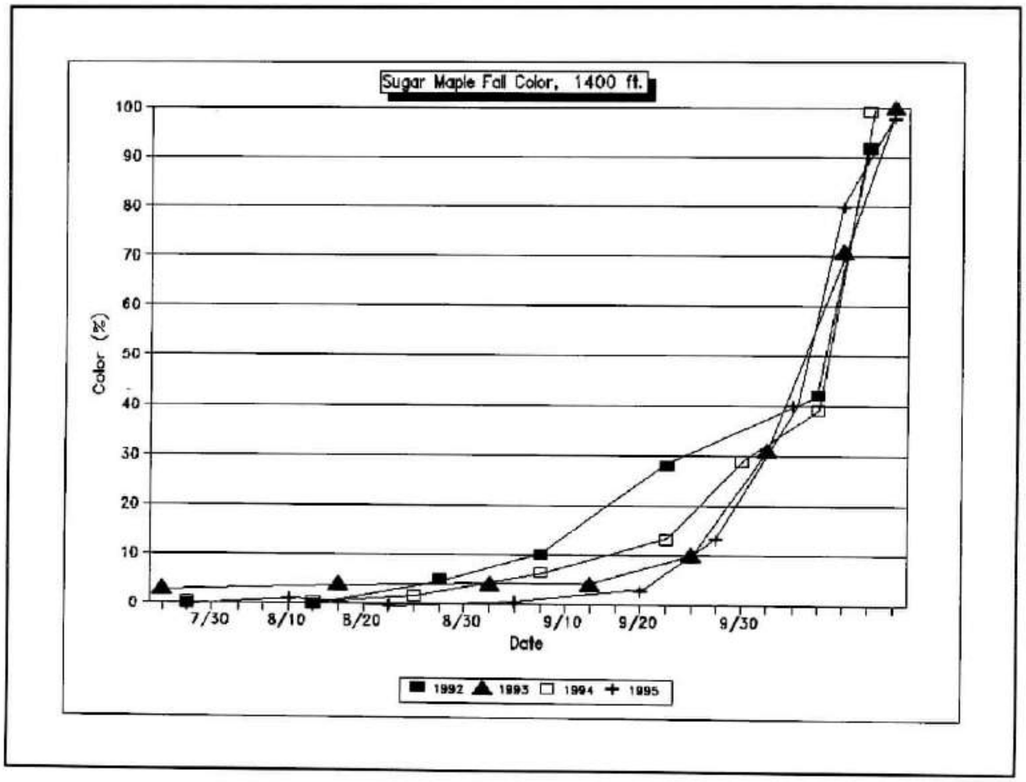
REFERENCES

Millers, I.; D. LaChance; W. G. Burkman; & D. C. Allen. 1991. North American Sugar Maple Decline Project: organization and field methods. Gen. Tech. Rep. NE-154. Radnor, PA: USDA, For. Serv., Northeast For. Expt. Sta. 26 p.

Skinner, M. & B. L. Parker. 1994. Field Guide for Monitoring Sugar Maple Bud Development. Agr. Expt. Sta. Res. Rept. 70 and VMC Res. Rept. 8, Univ. of Vt., Burlington, 31 pp.

Tallent-Halsell, N. G. (ed.). 1994. Forest Health Monitoring 1994 Field Methods Guide. US Environ. Protection Agency, Washington, D.C.

Figure 5. Timing of sugar maple fall color at 1400 and 2200 feet on Mount Mansfield from 1992-1995.



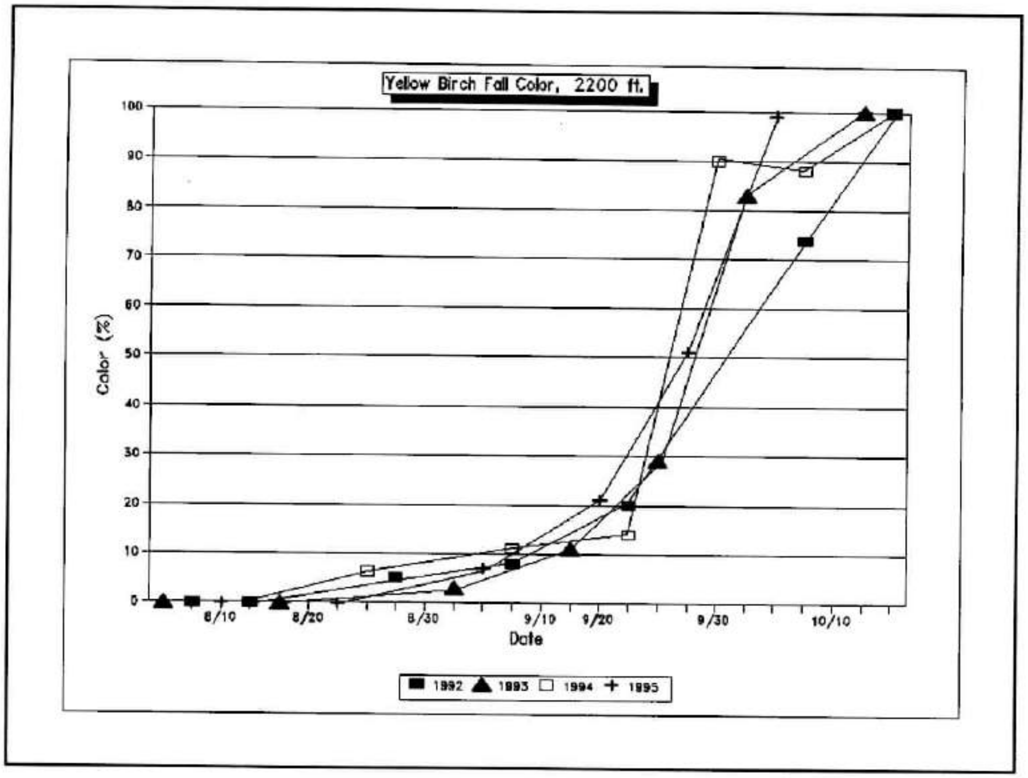
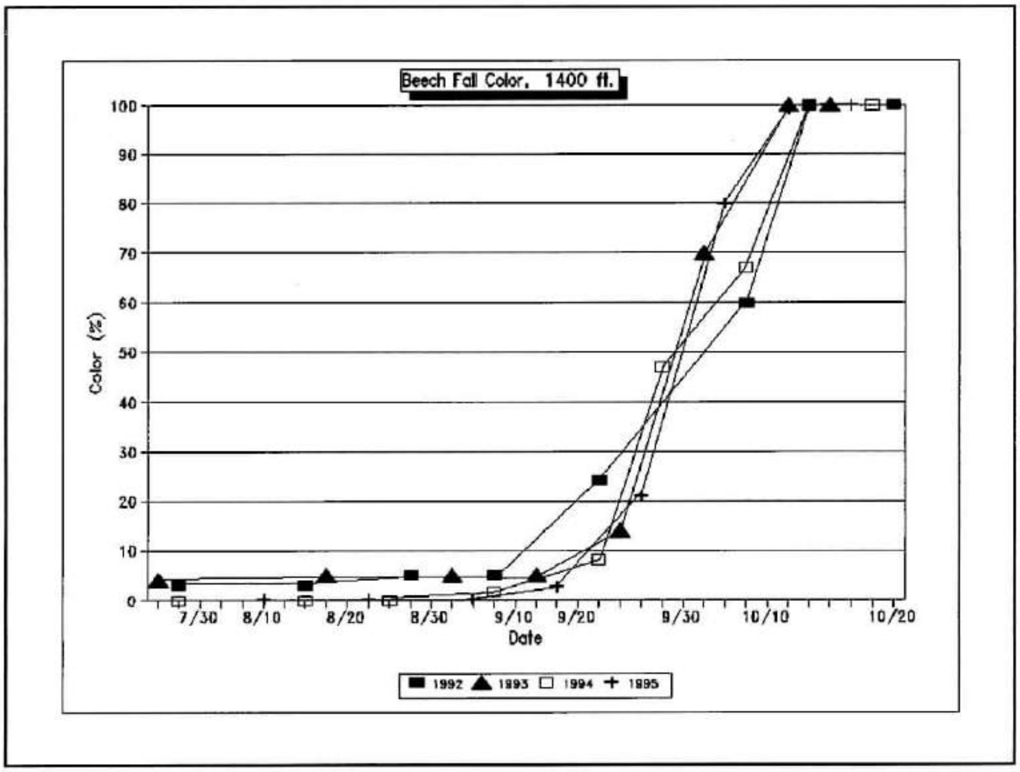


Figure 6. Timing of beech fall color at 1400 and 2200 feet on Mount Mansfield from 1992-1995.



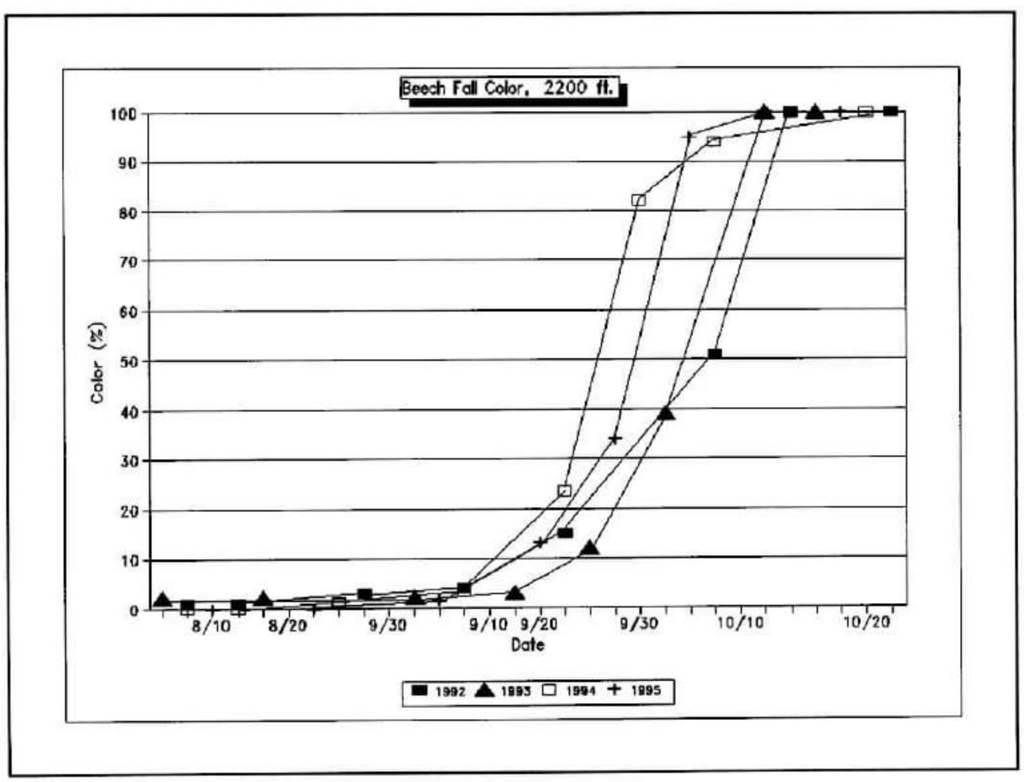
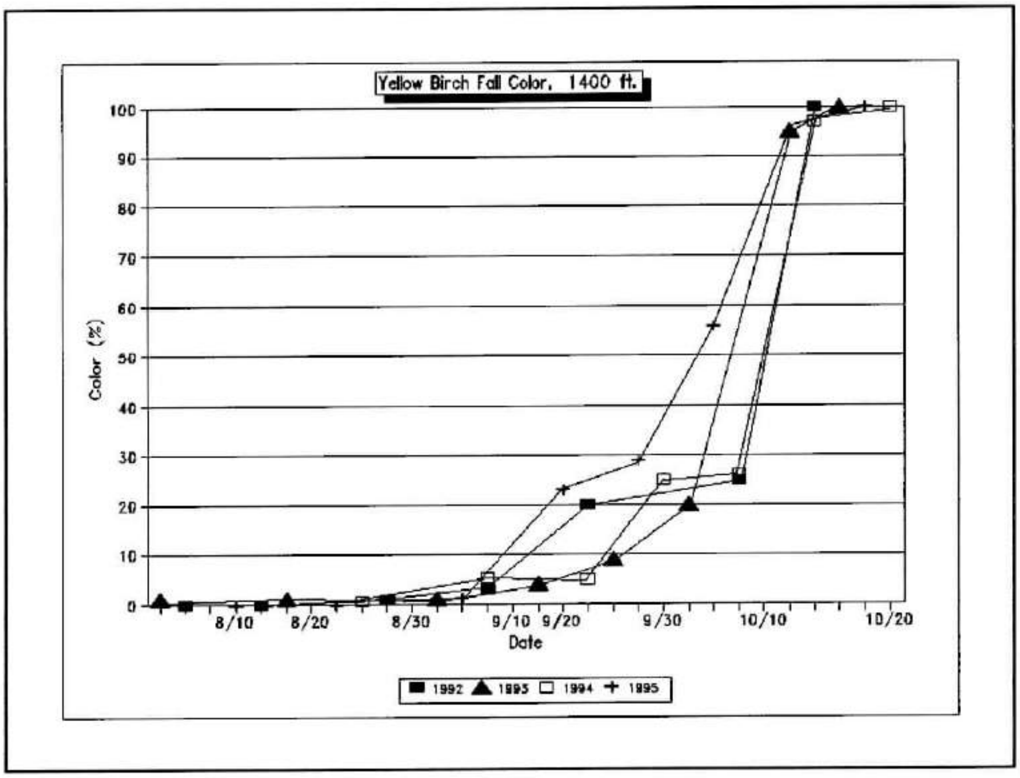


Figure 7. Timing of yellow birch fall color at 1400 and 2200 feet on Mount Mansfield from 1992-1995.



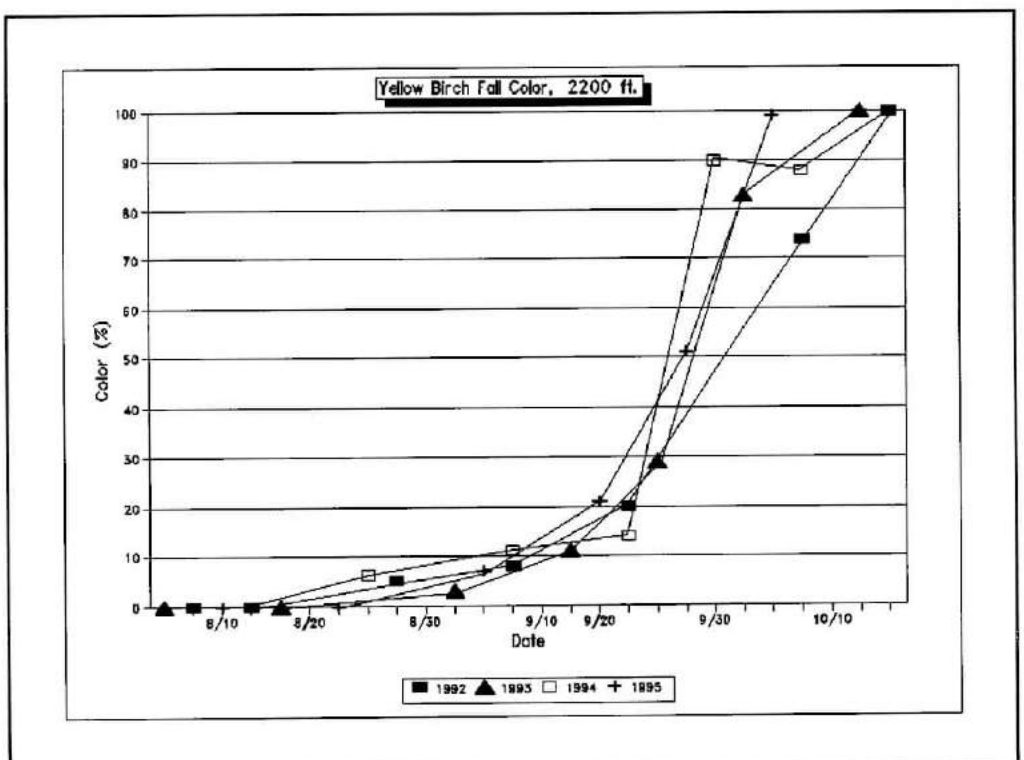
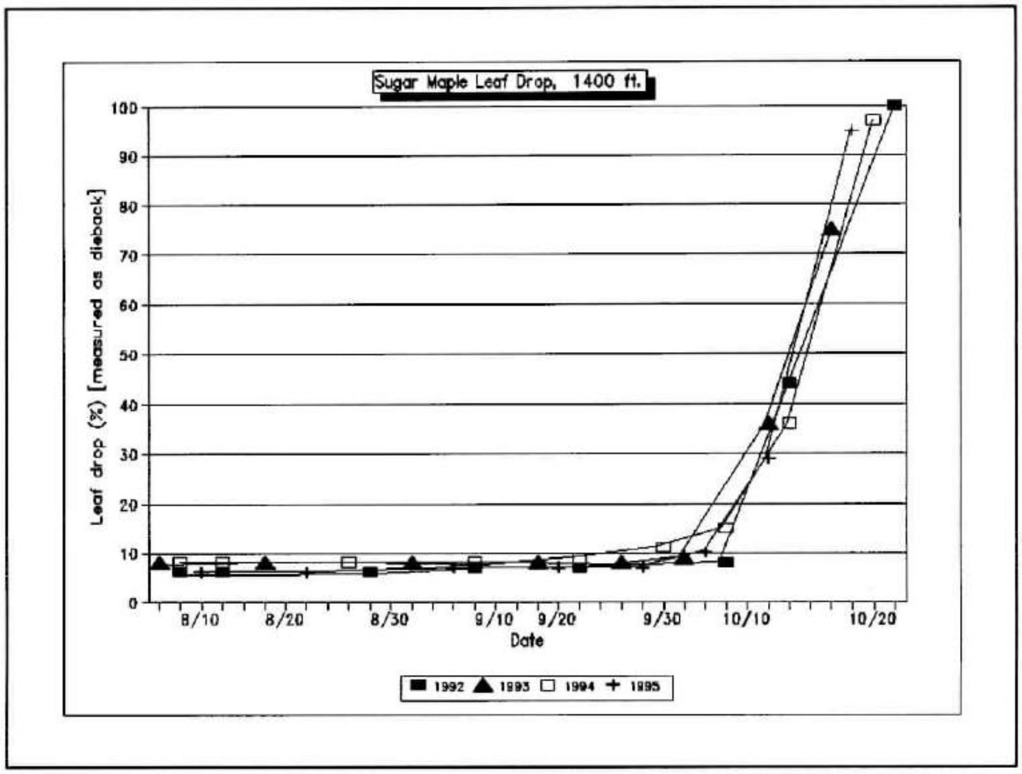


Figure 8. Timing of sugar maple leaf drop at 1400 and 2200 feet on Mount Mansfield from 1992-1995.



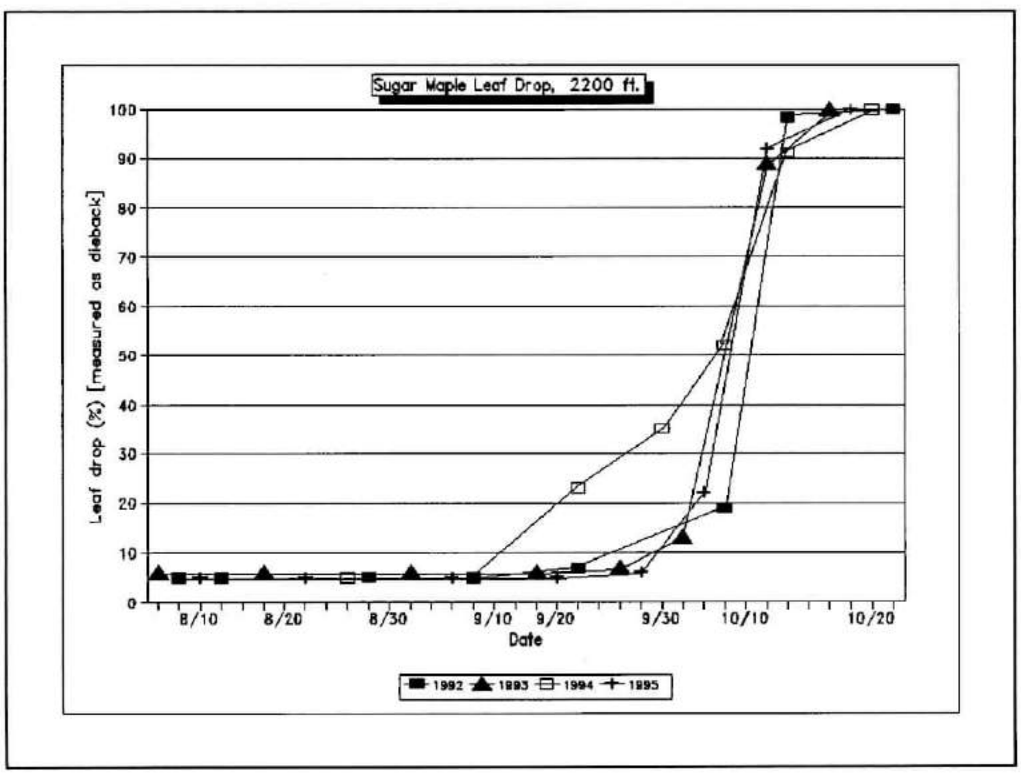
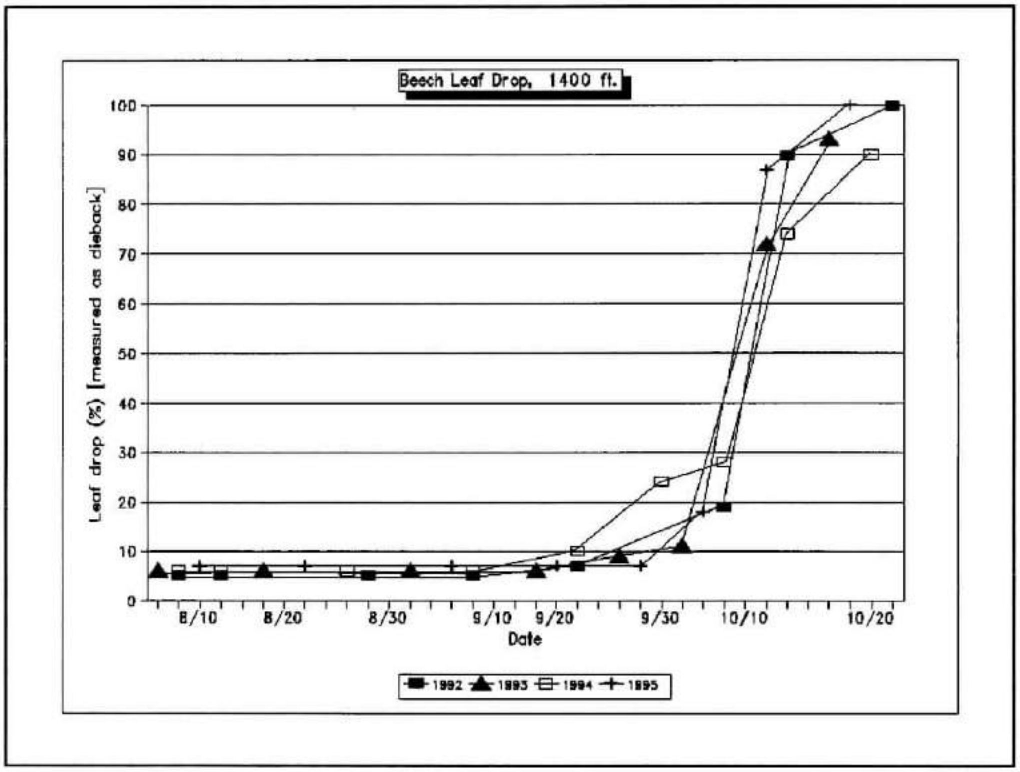


Figure 9. Timing of beech leaf drop at 1400 and 2200 feet on Mount Mansfield from 1992-1995.



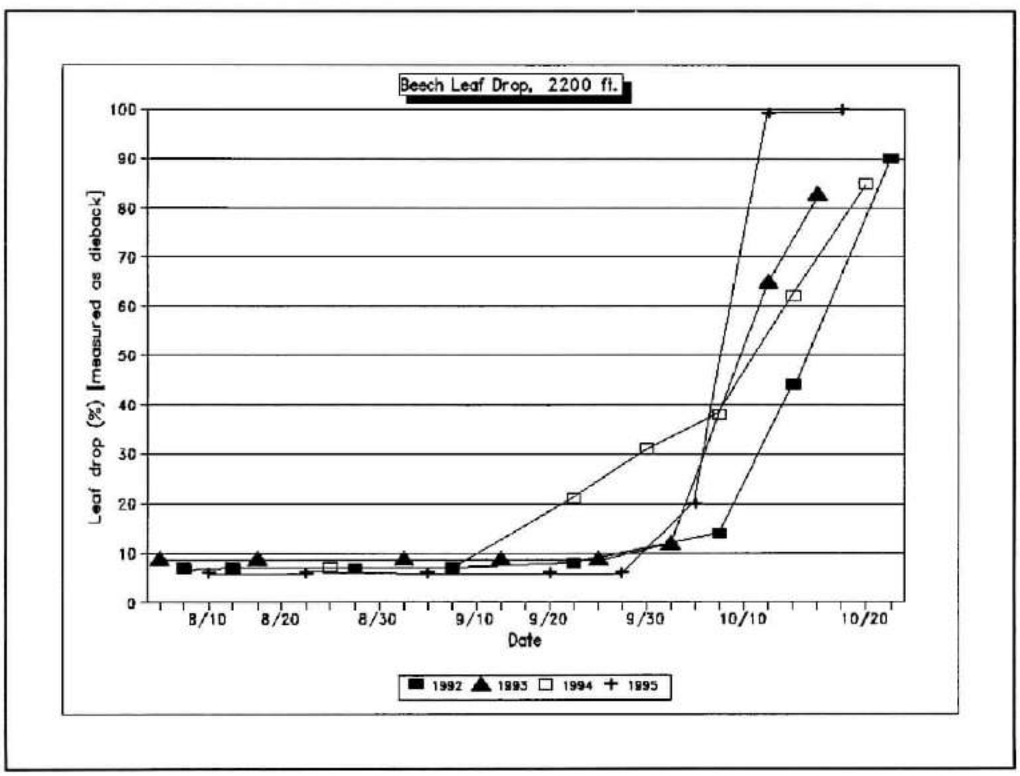
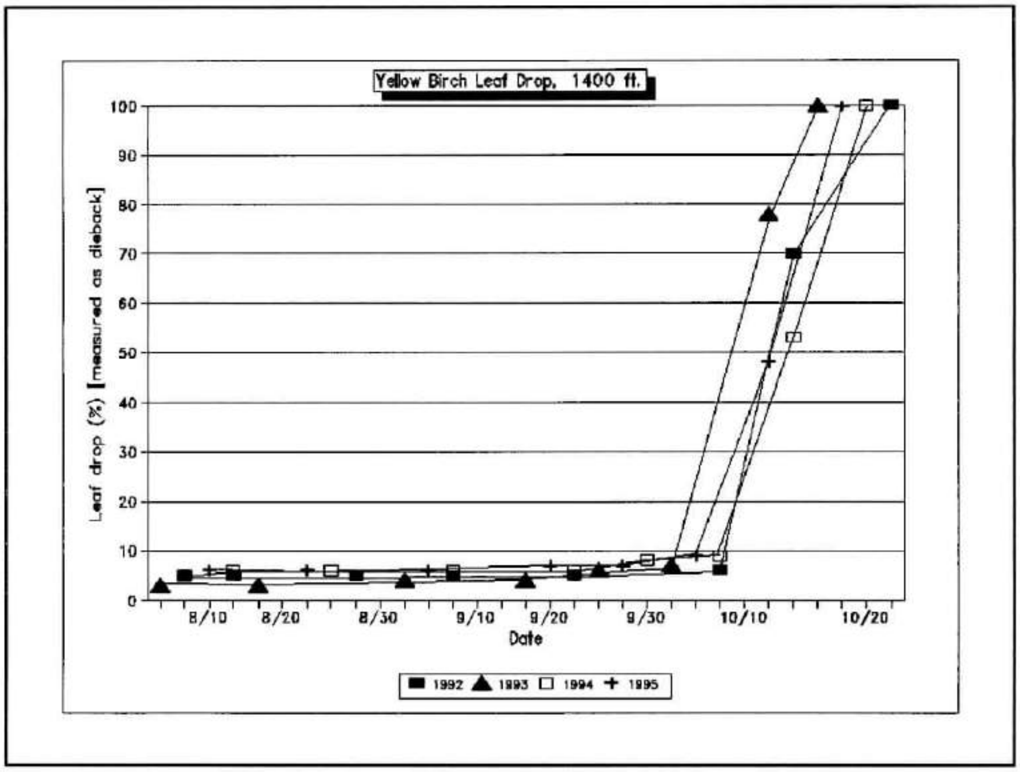


Figure 10. Timing of yellow birch leaf drop at 1400 and 2200 feet on Mount Mansfield from 1992-1995.



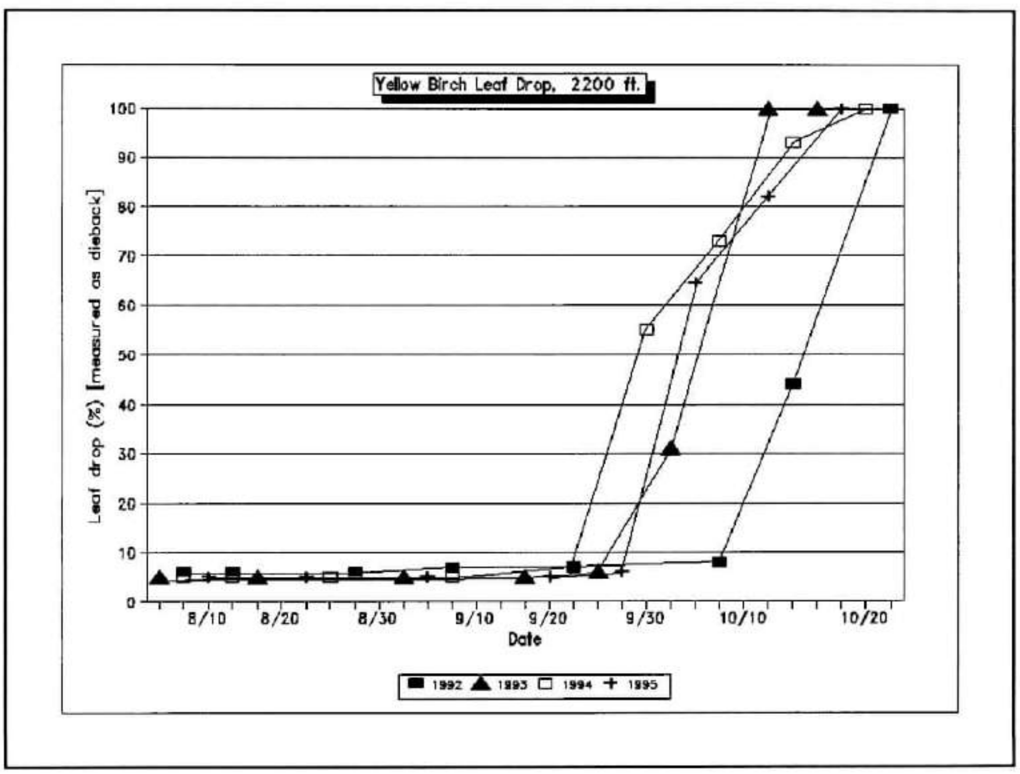


Figure 11. Fall color and leaf drop of species monitored at 1400' on Mount Mansfield in 1995.