VERMONT
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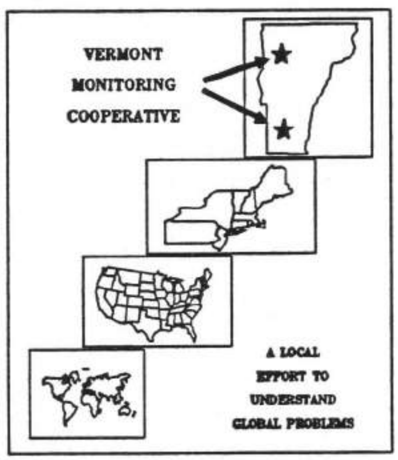
ANNUAL REPORT FOR 1992



Vermont's Intensive Forest Ecosystem Monitoring and Research Program

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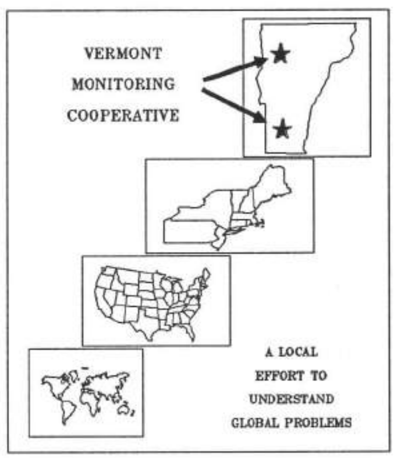

Vermont's Intensive Forest Ecosystem Monitoring and Research Program

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VERMONT MONITORING COOPERATIVE

ANNUAL REPORT FOR 1992

SANDRA H. WILMOT

TIMOTHY D. SCHERBATSKOY

Editors

VMC Annual Report Number 2

VERMONT MONITORING COOPERATIVE
ANNUAL REPORT FOR 1992

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INTRODUCTION

INTRODUCTION

The purpose of this report is to provide Vermont Monitoring Cooperative (VMC) program participants and others with information and details on forest ecosystem research and monitoring activities conducted during the current year.

Additionally, this report allows us to document other events and issues pertinent to VMC functions. In most cases, baseline information is still being gathered in these beginning years of the program. In the near future, more comprehensive discussions can be made on ecosystem changes and inter-relationships between the various components of the forested ecosystem being examined.

Information and education efforts in 1992 included: Across the Fence TV program on VMC. Presentations to forestry professionals at the Vermont Forest Pest Workshop, the Vermont Annual Foresters Meeting, the Vermont Timberland Owners Association and to visiting scientists from Latvia. At the USDA Forest Service- sponsored symposium and workshop, "The Effects of Air Pollution on Terrestrial and Aquatic Ecosystems in New England and New York", three presentations on VMC were made. A presentation on VMC was included in the Green Mountain Club Ranger Naturalists training. A VMC display appeared at the annual Maple Festival in St. Albans. In addition, high school students from Mount Mansfield Union High School in Jericho received presentations on amphibian monitoring and numerous interested students participated in summer job employment on this study. Three graduate student studies are focused on VMC projects.

An important decision was reached on the boundaries of State Lands, owned by the Department of Forests, Parks and Recreation, to be included in the **designated VMC research and monitoring site.** The State Lands within three watersheds is now designated for VMC use by Commissioner Conrad Motyka. The site consists of the Browns River, Stevensville Brook and Ranch Brook headwaters. All monitoring and research activities in these watersheds require an application be filed and reviewed by the VMC Coordination Committee to insure they are appropriate and compatible to the program, and to document locations and methodologies. Activities on UVM and private lands are approved by the appropriate land owner.

The **first annual VMC cooperators meeting** was held in Waterbury in March. The informal format provided participants with exposure to the various projects being conducted at the VMC site. This resulted in thought provoking discussions on inter-relationships between different ecosystem components.

In May, a **tour and information session** was held, with participants including: Senator Patrick Leahy and staff, UVM President Thomas Salmon, USDA Forest Service officials Tom Hamilton

(Research), Bill Sommers (Research), Ken Stolte (NFHM-ISEM), Jim Linnane (FHP), Rich Gouldin (Research); University personnel, Tim Scherbatskoy, Tom Tritton, Cathy Donnelly, Mel Tyree, Don DeHayes, Deane Wang, Bruce Parker, Larry Forcier, George Happ, John Grehan, Jim Boone and Luke Curtis; and State Personnel, Connie Motyka, Jan Eastman, Tim Van Zandt, Rich Poirot, Brent Teillon, Doug Burnham, and Sandy Wilmot; VT Department of Agriculture Commissioner, George Dunsmore; VT Sugarmakers and Industry representatives Bill Clark and Sam Cuttings, among others. Program Director for the Northeast Global Climate Change Program, Rich Birdsey, was given a fall tour of VMC activities followed by discussions with VMC cooperators on research directions and how to acheive a fully integrated research program.

Since its conception, the VMC participants have discussed the possibility of expanding research and monitoring activities to other sites around the state. One area that was considered, due to the existence of air quality monitoring equipment, was in the Green Mountain National Forest near Manchester. The GMNF was introduced to the VMC through the Waterville Valley symposium in the fall of 1992. They expressed interest in cooperating with our group to accomplish their goals of monitoring ecological effects of air pollution in the Lye Brook Wilderness Area (LBW). A letter to the GMNF Forest Supervisor expressed our interest in cooperating with them. A meeting to discuss the feasibility of combining forces in the LBW resulted in a preliminary recommendation that **LBW would become the second VMC site.** A VMC LBW Subcommittee would be formed to establish the logistics of and priorities for completing this task.

The **Intensive Site Ecosystem Monitoring Program (ISEM)**, under the USDA Forest Service-National Forest Health Monitoring Program, requested information on our site at Mount Mansfield to compare with other sites involved in this program. The following was compiled from various sources to send to the ISEM program and should serve as basic site information for the VMC site at Mount Mansfield.

Site Name: Mount Mansfield / Vermont Monitoring Cooperative

Principle Investigators and Institutions:

Sandy Wilmot (VMC Monitoring Coordinator), Vermont Department of Forests, Parks and Recreation; and

Tim Scherbatskoy (VMC Research Coordinator), University of Vermont, School of Natural Resources;

Plus 13 other major organizations including 25-30 active VMC Cooperators.

Location:

nearest town: Underhill, Vermont on west slope; Stowe, VT on east slope.

latitude and longitude: 44°31′, 72°52′

Physical Characteristics:

Elevation (range): 325 - 1325 m

Climate: Precipitation (annual total, description of seasonal distribution): 114 cm/yr, evenly distributed

Temperature (average, min, max):

	minimum	mean	maximum
low elevation	-29	10	32 °C
high elevation	-34	4	26 °C

Air Pollution:

moderate ozone (SUM60=200-400, SUM80=30-45),

moderate-severe acid deposition [4-7 kg/ha sulfate deposition and 4-7 kg/ha nitrate deposition at low elevation station; higher levels in high elevation cloud deposition zone (>900 m)],

moderate trace metals (Hg, As, Mn)

Soils: SCS or ECS classifications:

Generally moderate to severe slopes and stony;

Partial SCS Classification includes:Peru extremely stony loam (0-60% slopes), Marlow extremely stony loam (5-60% slopes), Cabot extremely stony silt loam (3-25% slopes), Lyman-Marlow very rocky loams (5-60% slopes).

Geological features and substrates:

Surveyed in 1956, resurvey planned for 1993. Generally consists of a mica-albite-quartz schist.

Vegetational Structure and Composition:

Principle forest type(s):

northern hardwood with predominantly beech, yellow birch and sugar maple

montane transition with predominantly paper birch, balsam fir, red spruce

montane spruce-fir with predominantly balsam fir

Forest structure:

overstory(see above): basal area variable depending on management history and forest type;

sugar maple stand at 415 m elevation with BA=25.7 m^2/ha, 250 trees/ha, ave. DBH=28.3 cm, two story crown structure, stand age = 110 years.

understory and ground flora (species present): inventory of understory vegetation on west slope complete in 1993, includes vascular and non-vascular flora, forest and alpine species.

Management:

Current Management Activity: all 3 watersheds are currently managed for recreational, aesthetic, natural area uses; publicly owned lands in the watersheds are divided into two distinct silvicultural management areas: one designated a no-silvicultural treatment area (control), one designated for silvicultural treatment. One treated and untreated area is designated on both west and east slopes of the mountain.

Past Management Activity: most of the land has been logged in the 1800's. Most public owned land below about 760 m has had some cutting in the last 50 years, but treatments vary over the site.

Past and Present Cultural Land-use: Historically there was a hotel near the summit of the mountain. The east slope now has an active ski area and a toll road that allows for public access. An environmental education center is planned for operation beginning in 1993 at the summit.

MONITORING ACTIVITIES:

(see VMC Work Plans for details)

Monitoring:

hydrological monitoring:

physical watershed analysis: planned for 1993, continuous on two streams, USGS-J. Shanley.

solution chemistry: 1991 to present, annually, Vt. Dept. Environmental Conservation-D. Burnham; planned for 1993, continuous on two streams, USGS-J. Shanley.

vegetation:

growth: 1988 to present, every 5 years, sugar maple, Vt. Dept. Forests, Parks and Recreation (FPR)-S. Wilmot; 1991 to present, every 5 years, hardwoods and softwoods, FPR-S. Wilmot; 1986 to present, annually, UVM-P. Hannah.

disease: since 1950's, annual aerial surveys, FPR-R. Kelley; 1980's, spruce-fir cooperative, U.S. Forest Service-Imants Millers; 1988 to present, annual pest detection-NAMP plots, FPR-S. Wilmot; 1991 to present, annual pest detection-FHM plots, FPR-S. Wilmot; 1991 to present, annual leaf survey, FPR-S. Wilmot; 1991 to present, ozone bioindicator plants, weekly through field season, FPR-S. Wilmot.

physiology: 1991 to present, tree phenology, bi-weekly to bi-monthly, FPR-S. Wilmot; 1988 to present, crown vigor ratings, NAMP & FHM, annual and 4 times/season, FPR-S. Wilmot.

diversity: 1991 to present, inventory and periodic remeasurement, Middlebury College-W. Howland.

community dynamics: 1992 to present, annual, UVM-J. Hughes.

wildlife:

diversity and populations:

1991 to present, annual:

amphibians, Middlebury College-S. Trombulak.
birds, Vermont Institute of Natural Science-C. Rimmer.
insects, UVM-B. Parker.

planned for 1994, annual, small mammals, Middlebury College-S. Trombulak.

soils:

productivity: 1990 - present, UVM-T. Wilmot; 1991 to present, Middlebury College-W. Howland; planned for 1993, periodic, UVM-T. Scherbatskoy; planned for 1994, periodic, UVM-J. Hughes.

edaphology (classification): --

weathering: planned for 1993, input/output, annual, USGS-J. Shanley.

carbon storage: --

other: meteorology, precipitation chemistry, aerosols, gases and radiation monitoring (see summary sheets on air monitoring at Mansfield)

RESEARCH ACTIVITIES: Treatments,Scope,Duration

(more details on some of these projects are included in the VMC Annual Report for 1991)

* Bicknell's Thrush as a bioindicator of change in high elevation spruce/fir forests, 1992 to present, Vermont Institute of Natural Science-C. Rimmer.
* Nutrient cycling in high and low elevation forests, long-term beginning 1993, UVM-T. Scherbatskoy.

* Environmental and pollutant gradients in the forest canopy, 1992 to present, UVM-T. Scherbatskoy.

* Development of canopy photography technique to assess canopy health, 1989-1992, UVM-L. Curtis, FPR-R. Kelley.

* Canopy ion exchange mechanisms, 1991 to present, UVM-T. Scherbatskoy.

* Balsam fir cold hardiness at high elevations, 1991 to present, Middlebury College-W. Howland.

* Growth and population dynamics of trees at their climatic-elevation limits, 1992 to present, UVM-J. Hughes.

* Data integration pilot study, Vermont and regional environmental data, 1990-1993, Vt. DEC/FPR/UVM and Lantern Corporation-R. Poirot.

* Analysis of regional precipitation and aerosol deposition patterns, 1985 to present, Vt. DEC-R. Poirot.

* Dynamics of N cycling in sugar maple stands, beginning in 1993, UVM-T. Scherbatskoy.

VERMONT ATMOSPHERIC MONITORING
1992 - 1993 STATUS REPORT

1. Meteorology
   a. Air quality site
   b. Canopy tower
   c. Middle elevation forest
   d. Mansfield summit
   e. High elevation forest

2. Precipitation chemistry
   a. NADP/NTN
   b. VAPMP
   c. Mercury
   d. AIRMoN

3. Aerosols
   a. PM-2.5
   b. PM-10
   c. Mercury

4. Gasses
   a. Ozone
   b. Ozone in canopy
   c. Mercury
   d. Dry Deposition

5. Radiation
   a. PAR and nIR
   b. UV-B

VMC ATMOSPHERIC MONITORING
1992 - 1993 STATUS REPORT

1. Meteorology

a. Air quality site
> open field
> wind speed & direction, temperature, relative humidity, barometric
pressure, precipitation (TBG)
> hourly & daily averages
> continuous, 6/88 - present, data as text files & spreadsheets

b. Canopy tower
> in & above hardwood forest at 5 heights
> wind speed & direction, temperature, relative humidity, surface
wetness
> soil temperature at 4 depths
> 15 min., hourly & daily averages
> continuous, 7/92 - present, data as spreadsheets

c. Middle elevation forest
> in hardwood forest in Underhill State Park
> wind speed & direction, temperature, relative humidity,

precipitation (TBG)
> continuous, hourly averages, 5/91 - present, data as text files

d. Mansfield summit
> National Weather Service Cooperative station
> daily max. & min. temperature, precipitation amounts
> 6/54 - present, data as hard-copy & Voyager files

e. High elevation forest
> in conifer forest and exposed ridge areas near Sunset Ridge
> wind speed & direction, air, leaf & soil temperatures
> continuous, second-minute averages, data as text files

2. Precipitation

a. NADP/NTN
> weekly wet-only precipitation amount pH, cations, anions
> analysis at CALS
> USGS funded
> at air quality site, Bennington, 200+ nationally
> 9/82 - present
> data as hard-copy, Voyager files

b. VAPMP

> daily event bulk precipitation amount, pH
> VT DEC funded
> at air quality site, Mansfield summit, 10 other VT sites
> data as Voyager files

c. Mercury
> daily event wet-only precipitation amount, pH, mercury
> analysis at U. Mich. Air Quality Lab
> NOAA funded
> at air quality site
> 12/92 - present

d. AIRMoN
> daily wet-only precipitation amount, pH, cations, anions
> analysis at CALS
> NOAA funded
> at air quality site, 12 other sites in northeastern US
> beginning 1/93

3. Aerosols

a. PM-2.5
> 3 X weekly 24 hr filter sampling (IMPROVE module A for: mass, light absorption, 21 elements
> analysis at UC Davis
> VT DEC funded
> at air quality site, 6 other in northeastern US, 50 others nationally
> data as text files or Voyager files

b. PM-10
> 3 X weekly 24 hr filter sampling (Wedding Hi-Vol) for: mass & sulfate
> analysis at VT DEC
> VT DEC funded
> at air quality site, several hundred others nationally
> data in EPA AIRS database

c. Mercury
> 2 X week 24 hr filter sampling (0.4 um) for aerosol, mercury
> analysis at U. Mich. Air Quality Lab
> NOAA funded
> at air quality site
> 12/92 - present

4. Gasses

a. Ozone
> continuous ozone concentration (photometric analysis)
> hourly average ppm, April-October
> at air quality site, Bennington, hundreds others

nationally
> VT DEC funded
> 4/89 - present (formerly in Burlington)
> data in EPA AIRS database and as Voyager files

b. Ozone in the canopy
> continuous ozone concentration (photometric analysis)
> 15 min, hourly, daily average ppm, April-December
> at 5 heights at forest canopy tower at PMRC
> USFS NEFES funded
> 7/92 - present
> data in spreadsheets

c. Mercury
> 2 X week 24 hr filter sampling (gold sand trap with 0.4 um pre-
filter) for vapor phase mercury
> analysis at U. Mich. Air Quality Lab
> NOAA funded
> at air quality site
> 12/92 - present

d. Dry deposition of S & N
> continuous filter pack sampling (DDIMS) for SO_2 and HNO_3 vapor
> weekly average um/m^3
> 15-min average meteorology (wind speed & direction, temperature, relative humidity, surface wetness, precipitation (TBG)
> at top of forest canopy tower at PMRC
> analysis at NOAA ARL
> inference of dry deposition velocities an flux
> NOAA funded
> 8/92 - present

5. Radiation

a. PAR & nIR
> continuous broadband radiation (PAR, 400-700 nm, LiCor quantum sensor & total, 400-1100 nm, LiCor pyranometer)
> 15 minute averages
> at top of forest canopy tower at PMRC
> 7/92 - present
> data as spreadsheets

b. UV-B
> continuous broadband radiation (UV-B, 285-320 nm, YES meter)
> 15 min averages
> at top of forest canopy tower at PMRC
> VT DEC funded
> beginning 5/93

DATA INTEGRATION

ECOLOGICAL DATA INTEGRATION FOR THE VMC: 1992 PROJECT REVIEW.

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

Cooperators:

VT Department of Forests Parks and Recreation, VT Air Pollution Control Division, VT Department of Environmental Conservation, VT Water Quality Division, Northeastern States for Coordinated Air Use Management, Lantern Corp.

Abstract:

Data Integration is a fundamental requirement for any study or management plan following the ecological approach to forest management as mandated by the US Forest Service. To improve our ability to integrate and use multi-disciplinary data for ecosystem scale forest management and analysis we are collecting and compiling data from multiple studies into a common format to facilitate temporal and relational comparability. In 1992 we completed compilation of several data sets including preliminary ozone data from the 1991 and 1992 ozone monitoring seasons as reported by the Northeastern States for Coordinated Air Use Management (NESCAUM), basic meteorology data collected at the Underhill State Park Meteorology station from June, 1991 through December, 1992, and precipitation data reported by the Vermont Acid Precipitation Monitoring Program (VAPMP) from June, 1980 through December, 1992. These data sets are now available in Voyager workbook, Lotus spreadsheet, and ASCII formats to all VMC cooperators. In addition to collating these data sets into common formats, a fundamental platform has been constructed into which future data from these studies can be easily incorporated.

BACKGROUND AND OBJECTIVES:

Ecological data integration is the linking of data-bases, generated from ecological and environmental monitoring and research, across spatial and temporal scales to describe ecosystem patterns and processes. The goal of the ongoing VMC data integration project is to construct an integrated ecological data-base for the VMC. The data-base will consist of data provided by investigators conducting research in cooperation with the VMC at VMC research sites (Mount Mansfield and Lye Brook). The purpose of the data base is to provide ready access to disparate data sets, allow for comparison and correlation of trends across disciplines, elucidate ecosystem processes, and to facilitate predictive modeling. This effort is intended to support the VMC research program which seeks to coordinate multi-disciplinary ecosystem monitoring and research among organizations with common interests in the understanding, management or protection of forested ecosystems.

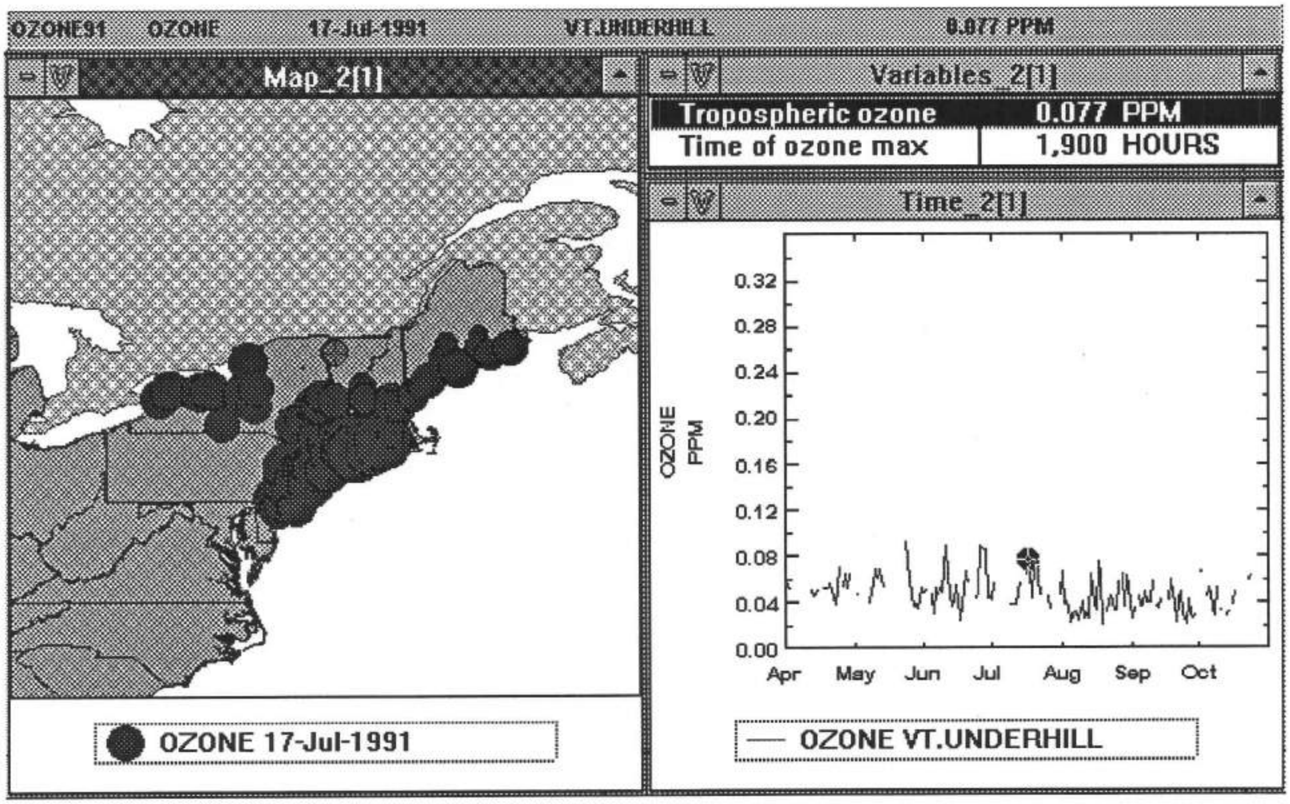
The primary objective for 1992 was to access and compile various meteorological data sets being generated by VMC cooperators with the view that this data would be the most beneficial to the greatest number of VMC researchers. Data sets targeted for this initial effort were preliminary ozone data from the NESCAUM/VMC ozone data exchange network, VAPMP precipitation data, statewide meteorological data from National Weather Service stations, and local meteorological data from Underhill State Park and the Proctor Maple Research Center. In addition to collating these data sets into common formats (ASCII, Lotus, and Voyager files), a fundamental platform would be created into which future data from these monitoring projects could be incorporated. A secondary objective was the construction of a map of the VMC site at Mount Mansfield, Vermont. Data for map construction would be obtained from existing GIS data-bases and formatted for use in Voyager Data Exploration Software.

RESULTS:

In 1992 we completed compilation of several data sets including preliminary ozone data from the 1991 and 1992 ozone monitoring seasons as reported by NESCAUM, basic meteorology data collected at the Underhill State Park from June, 1991 through December, 1992, and precipitation data reported by VAPMP from June, 1980 through December, 1992. These data sets are now available in Voyager workbook, Lotus spreadsheet, and ASCII formats to all VMC cooperators. These data sets are described in more detail in figures I-IV. A preliminary version of statewide meteorological data from the National Weather Service stations is available in Voyager format (Fig V). However, the final version will not be completed until 1993.

Creation of a site map for the Mount Mansfield area was still in process at the close of 1992. Completion of this objective was delayed by difficulties encountered in translating GIS coverages from a VAX to an IBM platform.

Fig I. NESCAUM DAILY OZONE MAXIMUMS AND TIMES OF OCCURANCE, 1991. PRELIMINARY DATA.



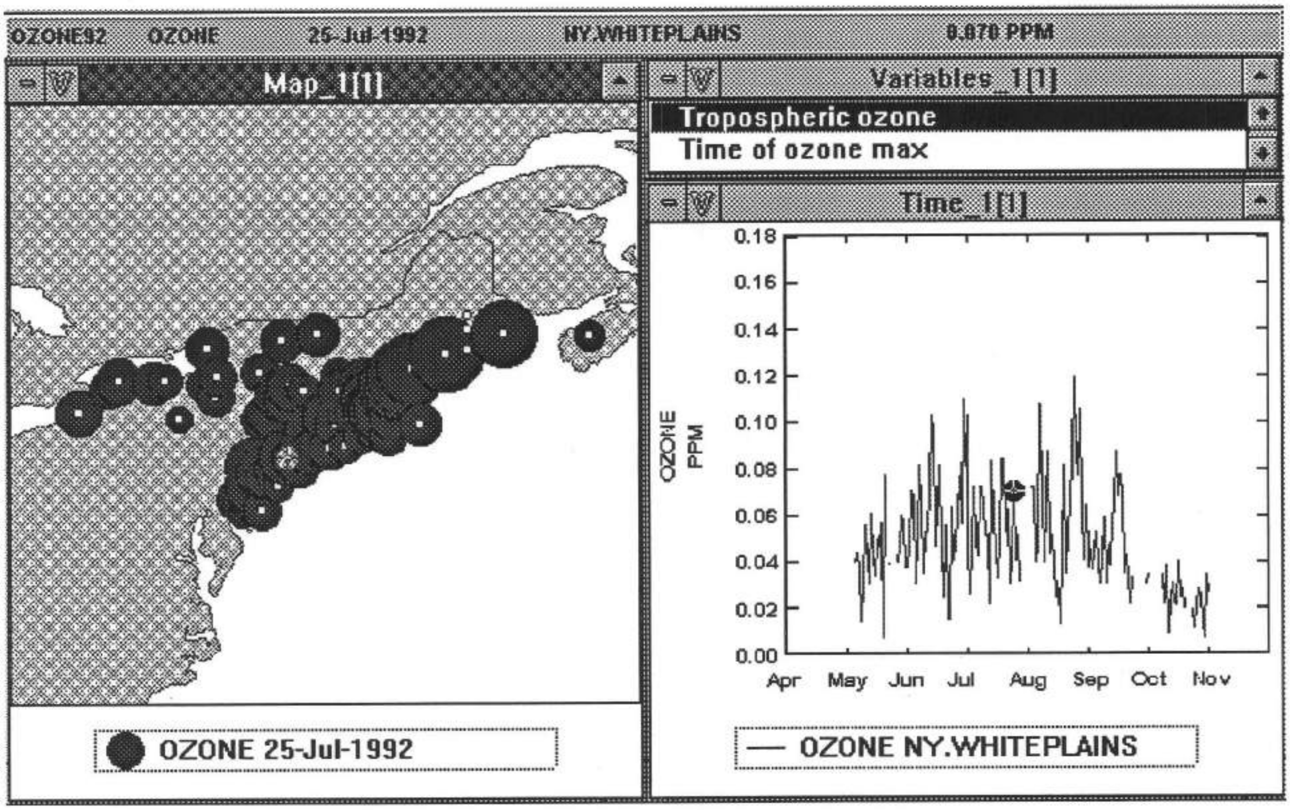
Contributors: Northeastern States for Coordinated Air Use Management
Compiled: by Ian D. Martin

This data set contains preliminary daily ozone maximum values (ppm) and first recorded time of occurance (hours) reported by NESCAUM cooperators from April 1, 1991 - October 31, 1991. The data covers 97 monitoring stations in Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont. The data set is also available in weekly ASCII or Lotus files (complete set approx. 925 kB).

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

Workbook Name: Ozone91.wkb
Required Files: Ozone91.voy , Nam1.mpd, Us.lay
Package Size: 70 kB
Related Files: Ozone92.voy, Neoz8792.voy, Neozagda.voy, Neozmoag.voy, Neozperc.voy

Fig II.NESCAUM DAILY OZONE MAXIMUMS AND TIMES OF OCCURANCE , 1992. PRELIMINARY DATA



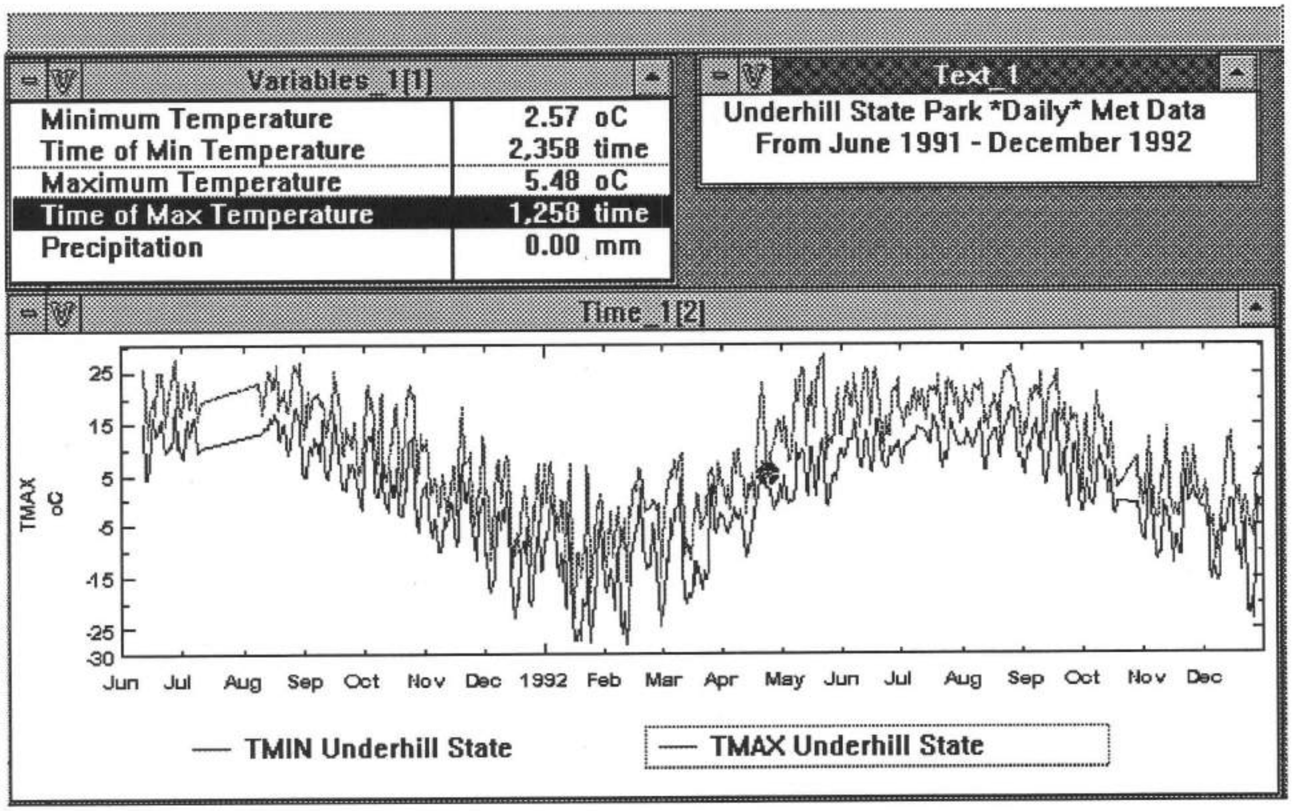
Contributors: Northeastern States for Coordinated Air Use Management
Compiled: by Ian D. Martin

This data set contains preliminary daily ozone maximum values (ppm) and first recorded time of occurance (hours) reported by NESCAUM cooperators from April 1, 1992 - October 31, 1992. The data covers 81 monitoring stations in Connecticut, Maine, Massachusetts, New Hampshire, New York, Nova Scotia (Can), Rhode Island, and Vermont. The data set is also available in weekly ASCII or Lotus files (complete set approx. 1.2 MB).

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

Workbook Name: Ozone92.wkb
Required Files: Ozone92.voy , Nam1.mpd
Package Size: 80 kB
Related Files: Ozone91.voy, Neoz8792.voy, Neozagda.voy, Neozmoag.voy, Neozperc.voy

Fig III. UNDERHILL STATE PARK METEOROLOGY STATION, JUNE 1991 - DECEMBER 1992



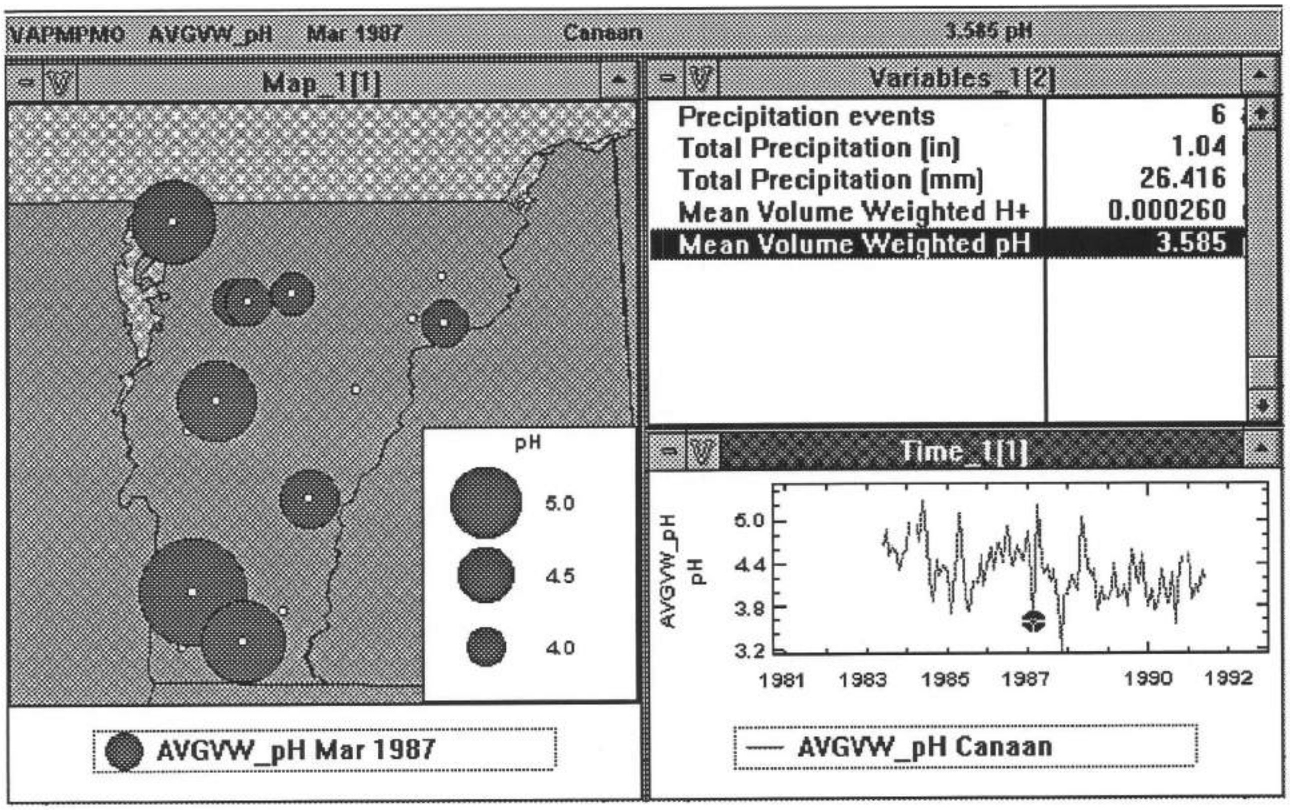
Contributors: Vermont State Department of Forests Parks and Recreation
Compiled: by Ian D. Martin

This data set contains hourly and daily meteorology data collected in Underhill State Park from June, 1991 - December, 1992. The data set is also available in either in ASCII or Lotus files (hourly 1.3 MB, daily 0.5 MB).

Variables: Daily maximum and minimum temperature (oC), daily precipitation depth (mm), hourly mean temperature (oC), hourly mean relative humidity (%), hourly mean wind speed (ms-1), hourly wind direction (deg), hourly precipitation depth (mm).

Workbook Name: under1.wkb
Required Files: underhr.voy , underday.voy
Package Size: 70 kB
Related Files: vtmetdat.voy, burlday.voy, burlingt.voy, neminmax.voy, vtprec.voy

Fig IV. VERMONT ACID PRECIPITATION MONITORING PROGRAM (VAPMP).



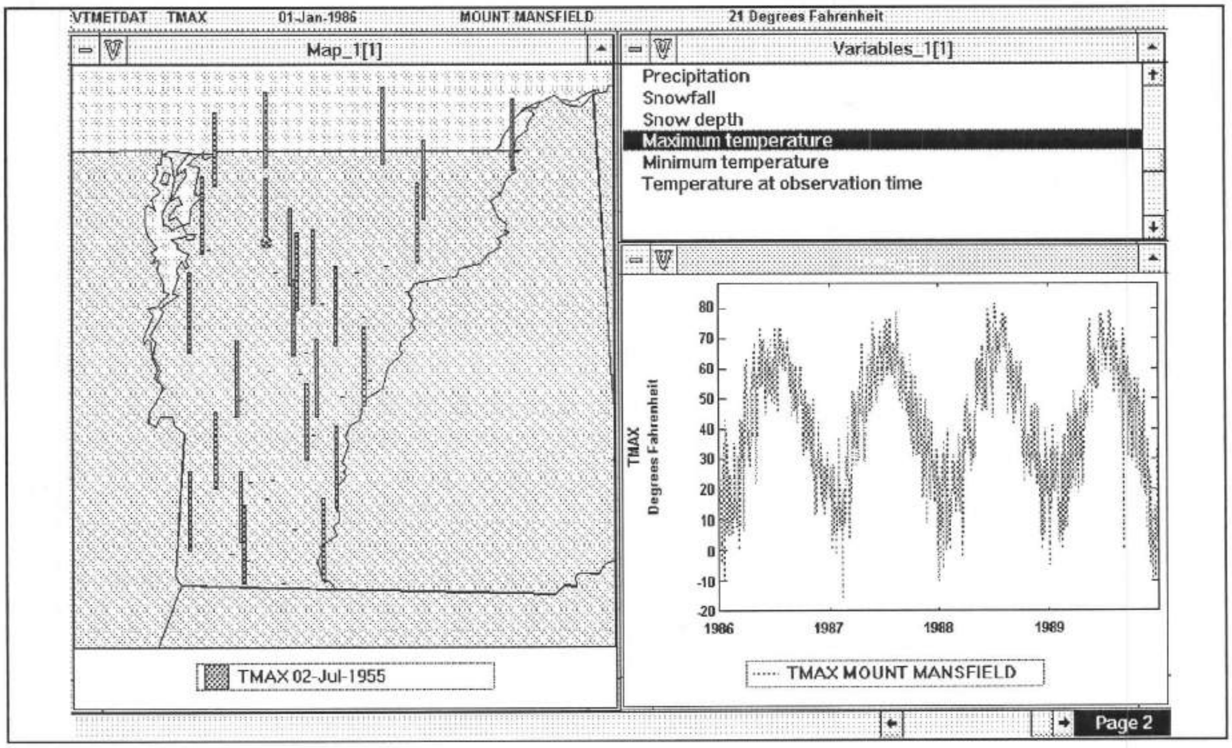
Contributors: Vermont Water Quality Division
Compiled: by Ian D. Martin

This data set contains monthly aggregate data from 16 VAPMP stations from June 1980 - December 1992. The data set is also available in daily, weekly or monthly ASCII and Lotus files (daily ASCII 900kB, weekly 400kB, monthly 75kB).

Variables: # Precipitation Events, Monthly Precipitation Depth (in and mm), Mean Volume Weighted H+, Mean Volume weighted pH

Workbook Name: Vapmpmo2.wkb
Required Files: Vapmpmo2.voy, Nam.map, Us.lay
Package Size: 45 kB

FIG. V. VERMONT METEOROLOGICAL DATA



Contributors: National Weather Service

Compiled by: Don Hay, 12/15/92

This data set contains daily weather data from all National Weather Service cooperating weather stations in Vermont for their entire period of record. The most recent data available is through December 1990, at which time there were 45 active stations. Due to the large size of this database, it is only available as a Voyager file and workbook, or as an ASCII file of variable (40 Mb) or fixed (90 Mb) length records. At this time there are known problems with this VOY file: missing temperature records appear as zero degrees F. This is being remedied in the next version of the VOY file, due in 1993.

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

Workbook names:	vtmet.wkb
Required files:	vtmetdat.voy
Package size:	9.82 Mb
Related files:	burlday.voy, burlingt.voy, neminmax.voy, underday.voy, underhr.voy, vtprec.voy

FUNDING:

This project was supported in 1992 primarily by $9,000 in grants from the VT Department of Forests, Parks, and Recreation, VT Department of Environmental Conservation, and NESCAUM.

FUTURE PLANS:

This work will continue into 1993 with the updating of previously compiled data sets and the addition of several new data sets to the VMC data-base. Data sets targeted for inclusion in 1993 are meteorological data from the Proctor Maple Research Center and forest health data from the North American Maple Project and the Forest Health Monitoring Project. All data sets compiled in this effort along with the data sets compiled through the VMC data integration pilot project will be available to VMC cooperators in 1993.

TERRESTRIAL FLORA

ANNUAL ASSESSMENTOF FOREST HEALTH ON MOUNT MANSFIELD

Vermont Department of Forests, Parks and Recreation

Sandra H. Wilmot

Cooperators

H. Brenton Teillon, Thomas Simmons, Cecilia Polansky, Pete 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 of the North American Maple Project monitors trends in the condition of sugar maple at an elevation of ca. 1400 feet. Site characterization, crown condition, and bole and crown damage are measured. In addition, 7 plots have been established following the design and measurement variables of the National Forest Health Monitoring Program. These are located along an elevation gradient, with pairs at 1400, 2200, and 3000. Only one plot was established at 3800 feet, but a second plot will be added at this elevation in 1993. Measurements taken on these plots will determine current health and create a baseline for long term monitoring. Measurements include: site characterization, understory vegetation, seedling number and vigor, sapling and tree size, crown condition, and symptoms of damage.

NAMP data on sugar maple condition has been recorded since 1988 and shows a general improvement over the first 4 years. Crown condition in 1992, however, was slightly worse than in 1991, with 94.2 % of trees considered healthy (less than or equal to 15 % dieback in crowns). No mortality has occurred on this plot since it's establishment. Light defoliation from maple leaf cutter was present, but not expected to seriously affect tree health. Heavy seed production was evident, with some reductions in foliage production as a result.

Tree health data on the other forest health plots were stratified by species, elevation and crown class (dominant and codominant trees reported). The percentage of healthy (less than or equal to 15 % dieback in crowns) dominant and codominant trees was less at high elevations than at low elevations, with 96.97 % of trees healthy in the 1400 foot elevation plots compared to

54.06 % of trees healthy in the 3800 foot elevation plot. The percentage of standing dead trees was also higher at the highest elevation plot, where 43.3 % of trees were standing dead, compared with 8.0 % in the 1400 foot elevation plots.

Balsam fir at the 3800 foot plot and red spruce at the 3000 foot plots had low numbers of healthy trees and high percentages of standing dead trees. In addition, beech and sugar maple in the 2200 foot elevation plots had unusually high numbers of standing dead trees, as compared to other Vermont surveys.

In a study of within season variation of crown condition measurements, there were no significant changes on study trees evaluated three times during the field season. This indicates that crown condition measurements can be taken from mid-June to August with similar accuracy of the variables, which is the current practice.

Introduction

The types of forests on Mount Mansfield vary depending on the elevation, site characteristics and past land use practices. Two general forest types are covered under this study: lower and mid- elevation northern hardwood forests and high elevation spruce-fir forests.

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, 7 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 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 state remeasurements are done on 12 % of the clusters and each field crew. Data entry is completed by the NAMP data analyst, and statewide data is acquired following quality check by the analyst. Metric units are used for data collection and analysis.

NAMP Plot Results

The trend in both the amount of dieback and the transparency of foliage (the amount of light coming through the crown) of sugar maples in the NAMP plot showed an improvement in tree condition from 1988 to 1991 (Table 1). However, in 1992, there was a slight increase in the amount of dieback and the transparency of crowns. The number of trees with less than 15 % dieback (% healthy trees) also decreased, although 94.3 % of trees are presently considered healthy. These may be a temporary changes in crown condition, or may indicate a trend towards poorer tree health at this site. Future years are needed to determine this.

Evaluations of crowns for damage from insects, diseases or other agents found light damage (1-30 % defoliation) from maple leaf cutter. In addition, some thin crowns were attributed to light to moderate seed crop, which often reduces either foliage size or amount.

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

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), total 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

Six new permanent plots were established in 1992 to monitor the health of forests on the west slope of Mount Mansfield. 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 (Conkling & Byers, 1992). At each elevation, one plot was established in each of the two watersheds: Browns

River and Stevensville Brook. In the Stevensville Brook watershed, no canopy trees were present at the 3800 foot elevation, so no plot was established. A total of seven plots were measured in 1992. English units are used for data collection and analysis.

Within-season variation in crown measurements was also measured to determine the optimum time for assessing tree condition. Crown dieback, transparency and density were measured three times during the field season at 3 week intervals.

Forest Health Plot Results

Results for all species combined, which includes balsam fir, red spruce, red maple, sugar maple, yellow birch, paper birch, and small numbers of beech, white ash, and black cherry, show a trend towards fewer healthy trees (trees with less than 16 % dieback) with increased elevation (Table 2). In general, where trees of each species were located in abundance at more than one elevation, greater percentages of trees at the lower elevation were healthier. The most notable change occurs with balsam fir between 3000 and 3800 feet. Only half the trees at the higher elevation were considered healthy.

This same trend is present for average percent dieback (Table 3), whereas foliage transparency (the amount of light coming through the foliated portion of the crown) doesn't follow a clear trend. Crown density decreases with elevation on plots from 2200 to 3800 feet (Table 4). Yellow birch trees in the 2200 foot plot, however, had denser crowns than those in the lowest elevation plot.

Average diameter at breast height (DBH) and percent of trees standing dead are presented in Table 5 and 6, respectively. Balsam fir, sugar maple and yellow birch trees all had larger diameter trees at the higher elevations. The hardwood tree sizes may be a reflection of land use practices. The balsam fir DBH measurements, while larger at the higher elevations, are very similar (6.76 and 7.11, low and high elevations, respectively).

SPECIES	% HEALTHY TREES BY ELEVATION			
	1400	2200	3000	3800
BALSAM FIR	---	---	100	54.05
RED SPRUCE	---	---	66.67	---
RED MAPLE	100	---	---	---
SUGAR MAPLE	100	83.33	---	---
YELLOW BIRCH	100	94.74	---	---
PAPER BIRCH	---	---	88.46	---
ALL SPECIES	96.97	90.63	89.83	54.05

Table 2. Percent of dominant and codominant trees considered healthy (less than or equal to 15 % crown dieback) in permanent plots located at 4 elevations: 1400, 2200, 3000 and 3800 feet. Minimum reported sample size = 5 trees.

SPECIES	AVERAGE CROWN DIEBACK BY ELEVATION			
	1400	2200	3000	3800
BALSAM FIR	---	---	5.6	18.78
RED SPRUCE	---	---	15.56	---
RED MAPLE	3.0	---	---	---
SUGAR MAPLE	4.0	8.33	---	---
YELLOW BIRCH	5.71	6.58	---	---
PAPER BIRCH	---	---	9.62	---
ALL SPECIES	5.3	8.59	8.90	18.78

Table 3. Average crown dieback of dominant and codominant trees in permanent plots, by species and elevation. Minimum reported sample size = 5 trees.

SPECIES	AVERAGE FOLIAGE TRANSPARENCY BY ELEVATION			
	1400	2200	3000	3800
BALSAM FIR	---	---	18.0	15.27
RED SPRUCE	---	---	13.89	---
RED MAPLE	15.0	---	---	---
SUGAR MAPLE	12.0	14.17	---	---
YELLOW BIRCH	19.29	15.26	---	---
PAPER BIRCH	---	---	18.85	---
ALL SPECIES	15.0	16.41	17.97	15.27

Table 4. Average foliage transparency (amount of light passing through foliated portion crown) of dominant and codominant trees located in permanent plots, by species and elevation. Minimum reported sample size = 5 trees.

SPECIES	AVERAGE CROWN DENSITY BY ELEVATION			
	1400	2200	3000	3800
BALSAM FIR	---	---	46.4	42.97
RED SPRUCE	---	---	46.11	---
RED MAPLE	53.0	---	---	---
SUGAR MAPLE	54.0	47.5	---	---
YELLOW BIRCH	49.29	53.95	---	---
PAPER BIRCH	---	---	43.46	---
ALL SPECIES	50.76	50.94	45.51	42.97

Table 5. Average crown density of dominant and codominant trees located in permanent plots, by species and elevation.

SPECIES	AVERAGE DBH (inches) BY ELEVATION			
	1400	2200	3000	3800
BALSAM FIR	---	---	6.76	7.11
RED SPRUCE	---	---	6.99	---
RED MAPLE	9.96	---	---	---
SUGAR MAPLE	7.23	10.08	---	---
YELLOW BIRCH	10.64	13.43	---	---
PAPER BIRCH	---	---	7.09	---
ALL SPECIES	9.18	12.9	7.26	7.11

Table 6. Average DBH of dominant and codominant trees located in permanent plots, by species and elevation. Minimum reported sample size = 5 trees.

SPECIES	PERCENT MORTALITY BY ELEVATION			
	1400	2200	3000	3800
BALSAM FIR	---	---	19.44	43.28
RED SPRUCE	---	---	50.0	---
RED MAPLE	0	---	---	---
SUGAR MAPLE	14.29	17.65	---	---
YELLOW BIRCH	11.11	0	---	---
PAPER BIRCH	---	---	5.71	---
BEECH	---	25.0	---	---
ALL SPECIES	8.0	9.8	22.5	43.3

Table 7. Percent of trees greater than or equal to 5 inches in diameter (DBH) standing dead (recent and past mortality) by species and elevation. Minimum reported sample size = 5 trees.

Within season remeasurements of 3 crown variables showed no significant changes in dieback, transparency or density ratings, despite a slight increase in the transparency and density ratings (Table 8).

DATE	DIEBACK (AVE. %)	TRANSPARENCY (AVE. %)	DENSITY (AVE. %)
6-23-92	6.6	12.3	53.5
7-17-92	5.6	13.0	54.0
8-26-92	6.0	14.1	55.4

Table 8. Results of within season remeasurement of crown variables on 2 forest health plots.

Discussion

Crown ratings in the NAMP plot showed a slight decrease in the percentage of healthy sugar maples this year as compared with last year, yet most trees were generally healthy in 1992.

Crown condition of trees on forest health monitoring plots showed that balsam fir at 3800 feet and red spruce at 3000 feet had high dieback ratings and lower numbers of healthy trees (54.5 and 66.7 % of trees healthy, respectively). In addition, there were high percentages of past and recently dead trees of these species at the same elevations.

The number of standing dead sugar maple and beech trees was also higher than normal (compared with other Vermont surveys). Since these averages included intermediate and suppressed trees, this may account for these differences. Beech bark disease is present at the site, and may account for some of the beech mortality.

These forest health measurements mark the beginning of long term monitoring at four elevations on the west slope of the mountain. Although this baseline information is of interest in describing the present condition of trees in plots, trends in health over time will provide critical information to evaluate forest health as it relates to various natural and anthropogenic stress agents.

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CANOPY ION EXCHANGE MECHANISMS
- 1992 -

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Objectives:

The broad goal of this work is to better understand mechanisms controlling foliar ion exchange (foliar leaching and uptake) in forest canopies. This is important in order to properly assess effects of changing atmospheric chemistry and climate on nutrient cycling processes in forests. Specific objectives of this project include: (1) characterizing the ion exchange rates in sugar maple during artificial precipitation events, (2) identifying the relative importance of possible sources of and sinks for exchanging ions, (3) relating tissue ion concentrations to ion exchange rates, and (4) developing a mechanistic model predicting canopy ion exchange rates.

Methods:

Integrated field and laboratory experiments were conducted with sugar maple during two growing seasons. In 1991, the objective was to identify the relative importance of foliage *vs* stems in canopy ion exchange. This was done by comparing the chemistry of foliar leachate from normal and artificially-defoliated branches, and evaluating the kinetics of ion exchange in each. Details of methods and significant findings for this portion of the study can be found in the 1991 VMC Annual Report. Also in 1991, laboratory studies examined the ion transport properties of isolated leaf cuticles from the field foliage in order to calculate ion permeability rates. These data will be used to compare ion flux between cuticle and whole-branch levels, and will be incorporated into canopy ion exchange models.

In 1992, a second experiment designed to evaluate the contribution of leaf surface deposits to canopy ion exchange was performed. This was done by comparing the chemistry of leachate from sugar maple foliage on small branches that had been previously washed with an acidic solution at pH 3.3 (deionized water adjusted to pH 3.3 with HCl), deionized water, or left unwashed. Specifically, each of 30 sugar maple branches chosen from four trees growing at the Proctor Maple Research Center in Underhill were prewashed with either the acidic solution, deionized water, or were left unwashed, and then misted with the artificial precipitation solutions at pH 3.8 or 5.3. Branches receiving the acidic solution or deionized water prewashes were rinsed afterward with deionized water and allowed to dry prior to misting. A total of six treatment combinations (3 prewashes x 2 acid mists) were used and the experiment was replicated five times for a total of 30 branches treated. Leachate samples were collected sequentially from each chamber over 15 min. intervals during the first hour and over 30 min. intervals during the second hour for a total of six leachate samples per chamber per replicate. The same branch misting chamber design and collection method used in 1991 was used for misting in this experiment. All prewash and rinse solutions were also collected and saved for chemical analysis. Following misting, all treated branches, as well as untreated control branches from each tree, were collected for leaf and stem area determination and chemical analyses. Relationships between ion concentration in the leachate and foliage tissues will be examined. Leaf cuticles were also collected from treated foliaged for additional measurement of cuticular ion permeabilities. Leachate samples were analyzed for major ions at the Institute of Ecosystem studies in Millbrook, NY. and foliage samples were analyzed at the UVM Agriculture Testing Laboratory.

Significant Findings:

Because of an unavoidable delay in completing the chemical analyses, we do not have results available to report at this time, but will be reporting results from this experiment in 1993.

Future Plans:

In 1993, we will complete our chemical and data analyses and begin work on a manuscript describing this study and our results.

Funding Sources:

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

By

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ABSTRACT

In 1992, canopy photos were taken from the same forest health monitoring points as in 1991 at the same timing in June, July and August. Photos were also taken three times in defoliated hemlock stands to compare canopy cover before and after leaf flush. All photos (Ektachrome slides) were computer-analysed to determine percent canopy cover. Canopy cover values for forest health monitoring plots in late August were similar to 1991, but June values were significantly lower ($p<0.01$) than 1991 due to cool weather and slower leaf flush. Canopy cover in two heavily defoliated hemlock stands increased 32 and 42 percent, respectively, between May and October compared to 11 percent for a lightly defoliated stand.

INTRODUCTION

Forest canopy assessments related to tree health have historically been obtained by visual evaluations done by field personnel trained in how to evaluate such things as dieback, defoliation, and crown transparency. Such procedures lack permanent documentary records, such as photographs, from which future investigators can make comparisons, or check procedures. This was the second year of a two-year project to develop a method to quantify canopy cover and provide short-term assessments as well as long-term objective documentation of changes within permanent forest plots.

METHODS

Photography

Using a 35mm camera with a 17mm wide angle lens, Ektachrome slides (IS0200) were taken beneath tree crowns by orienting the camera vertically over 141 permanent points established within the following northern hardwood forest health monitoring sites in Underhill, Vermont:

1. North American Maple Project (NAMP) 014, Proctor Maple Research Center (PMRC) in Underhill - 45 points.

2. Forest Health Monitoring (FHM) 2 at PMRC - 32 points.

3. Forest Health Monitoring 4 at Underhill State Park - 32 points.

4. Forest Health Monitoring VMC2200 at Underhill State Park - 32 points.

Photo points were arrayed 10 m apart on the NAMP grid for each subplot, and were at a different, but comparable, spacing in the FHM systems. Photo points were marked by an orange fiberglass stake.

In addition, photos were taken at ten points in each of three hemlock stands in southeastern Vermont on May 21, July 6 and October 6. Two of these stands had been heavily defoliated by hemlock looper the previous autumn, and the third had been lightly defoliated.

With certain modifications, field procedure was based on a method developed by the Institute for Ecosystems Studies (Fergione, 1985).

No weather criterion was applied, except to avoid rain and excessive breeze. The objective has been to keep the procedure user-friendly and not restricted by narrow weather windows, particularly in regions like Vermont where weather conditions can change quickly. Although cloudy or highly diffuse light conditions are ideal for obtaining good canopy silhouettes, these conditions can change without notice and could frustrate efficient data collection if strictly required.

The camera, equipped with a right-angle view finder, was mounted on the tripod with the lens facing up and the base of the camera facing true east. This arrangement, with the long axis of the film parallel to the true north-south axis, minimized the period at midday during which the sun might appear in the image. The compass should not be placed on the camera for this set-up, as a bad reading may result.

The camera tripod was erected over the photo point such that a plumb bob, hung directly under lens center, would be within 2.5 cm of the base of the photo point stake. This tolerance (about 1 in) was allowed because it would be within the ability of many field workers to estimate and was not likely to translate into significant errors in canopy estimates.

Camera height was 1 m from the base of the stake to the optical center of the lens (about 2 cm from the lens front). A meter stick was carried for this purpose. The camera was leveled with a plate-mounted bubble level that was placed on the lens. This adjustment is the most critical for repeated comparisons of images taken from the same point, as small variations in leveling tend to magnify error in portions of the image from the upper canopy.

All foliage up to 1 m from the camera lens was removed in an arc containing the image. This distance was standardized to permit highly obstructive foliage to be removed. Haphazard observation of this rule will result in images of poor comparability.

After set-up was complete, three exposures were taken: one at the camera meter's setting, one a full stop over, and one a full stop under. This procedure gives protection against small errors in the camera's automatic exposure calculation. In addition, overexposures tend to show better color and are more revealing of damage and disease conditions. Underexposures afford more sky/canopy contrast and are more suitable for image scoring.

In cases in which the sun appeared in the picture, it was blocked out with a device consisting of a film canister cap mounted on a wire. While exposures were being made, it was positioned such that the disc, at a distance of 60-70 cm from the lens, blocked out the sun.

Complete notes were taken for each set of exposures, including photo point ID, time of day, an estimate of cloud cover to the nearest 10 percent, f-stop, shutter speed, and exposure number. It was helpful to make occasional identifying notes (such as "big snag," or "solar disc used") as insurance against mix-ups of film roll # during processing, etc.

Image Analysis

In order to develop a scoring procedure for canopy cover on the slides, we compared a manual/visual method and a computer-image analysis in 1991. The term, canopy cover, is used here to refer to the percent of sky obscured by vegetation, including woody tree parts. The computer analysis system (Swathkit) was so efficient that it was exclusively used in 1992.

The Swathkit is an image analysis/weather monitoring system which integrates data collected during the calibration of spray systems for aerial applications. While primarily designed for determining the number and size of spray droplets on a card held to a small lighted port, the Swathkit can do area measurements of the sort needed to discriminate regions of different density, as found in canopy photos.

It was desirable to remove the B&W video camera from the Swathkit "blue box" and put it on a copy stand for several reasons. Its focal length and position within the box prevented it from reading the proper amount of slide and mask for comparison with the grid projection method. It was much easier to properly illuminate the slide when placed on a copy stand. The mask has the dimensions of a slide mount and has a 20 mm diameter hole in its center. It is cut from 26 gauge sheet metal and spray painted with a white enamel. Slight illumination has to be provided to the white mask from above for the camera to pick it up, since the Swathkit must see the area of interest as having a white border in order to make a correct measurement.

Best results from the lighting standpoint were obtained by replacing the 50mm lens (supplied with camera) with a 105mm lens. Focusing was simpler, the right amount of mask was readily obtained, and an even light effect was achieved. It was also far enough from the slide (.5 m) to enable the operator to see the slide in color and easily adjust the initial threshold level. Both slide and mask were held on the light table, with the mask on top, in a plexiglass holder made large enough to accommodate the largest slide (there is some variation in slide mounts). Mask and slide were always oriented the same way and any slack removed by aligning them in the same corner of the holder each time. To prevent glare from the camera, light from the light table surrounding the slide was masked out. The camera lens was always positioned the same distance from the slide and set at the same f-stop.

Swathkit software requires that complex gray-level images be partitioned into two-tone black-and-white images through a thresholding procedure before measurements are made. We were concerned that there would be many slides containing canopy elements, such as light, sunlit foliage, which would be ambiguous, that is, in the same gray level range as parts of the sky.

In order to improve discrimination and hence the accuracy of the sky/canopy ratio for each slide, we explored several color filters as options for improving contrast. In 1991, a preliminary trial showed that a Wratten #35 filter (dark purple-blue) placed behind the slide on the light table improved contrast and reduced the variance in scores of 25 slides taken over a two-day period from a single photo point, when compared with scores of the same slides without a filter.

In 1992, we ran a comparison of eight filters with the same set of 25 photos. Shades of blue (Wratten #s 35, 38A, 45, 45A, 47, 78AA) performed the best and yellow the worst. Filter #45 (blue) yielded the least variance in the 25 readings, and was selected for all 1992 slides, as well as a re-analysis of all 1991 slides to maintain comparability.

The Swathkit measures the density of an image as the proportion of dark area in an image (below threshold) to the rest of the image in the image window. To determine what score the Swathkit would give to a 100% dark image behind the mask, an opaque slide was used. That score was then used as a standard to determine the percent density of actual canopy slides.

RESULTS

VT NAMP and FHM photosurveys: 1991/1992 comparisons.

The two study years, 1991 and 1992, were distinguished by contrasting growing season temperature profiles (Figure 1), which were reflected directly in canopy cover estimates for the first two survey periods of each year. In 1991, monthly temperature averages from February through May were all at least four degrees above normal, and all other months were above normal until September. 1992 temperatures were mostly close to normal except for a below normal June and a cold July.

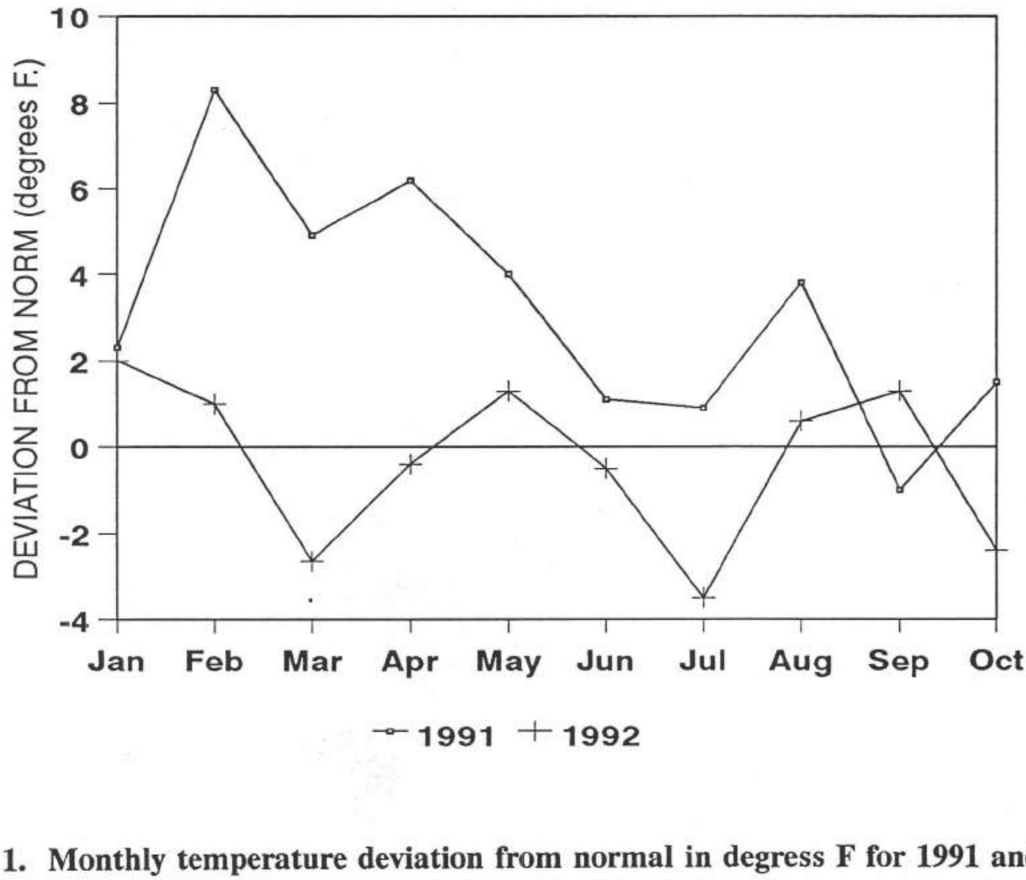

Figure 1. Monthly temperature deviation from normal in degress F for 1991 and 1992 at Burlington International Airport. Data from NOAA Climatological Data, Monthly Summary.

According to our computer-assisted image analysis, all forest health monitoring plots combined had significantly lower June 1992 readings compared to 1991 ($p<0.01$) and correspondingly greater increases in canopy cover from June to July compared to 1991. The impact of the different growing season profiles for these two years is illustrated by canopy cover data from the NAMP site in Underhill (Figures 2 and 3).

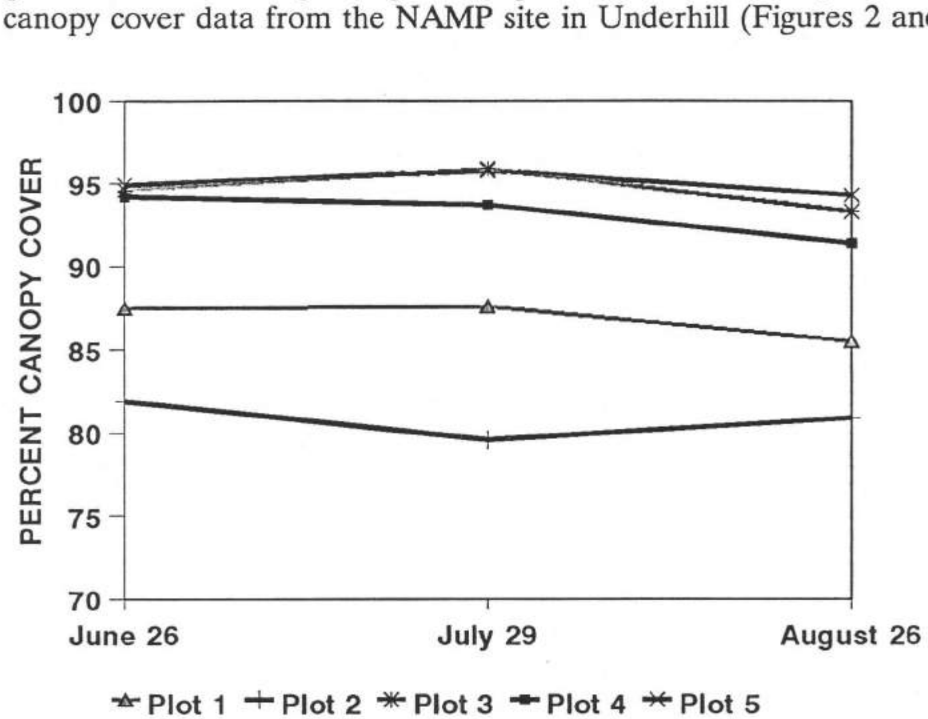

Figure 2. Canopy cover estimates obtained by Swath Kit analysis for a North American Maple Decline Project site at three sampling times in 1991. Each plot estimate is the mean of 9 photo points. Site is in Underhill, VT.

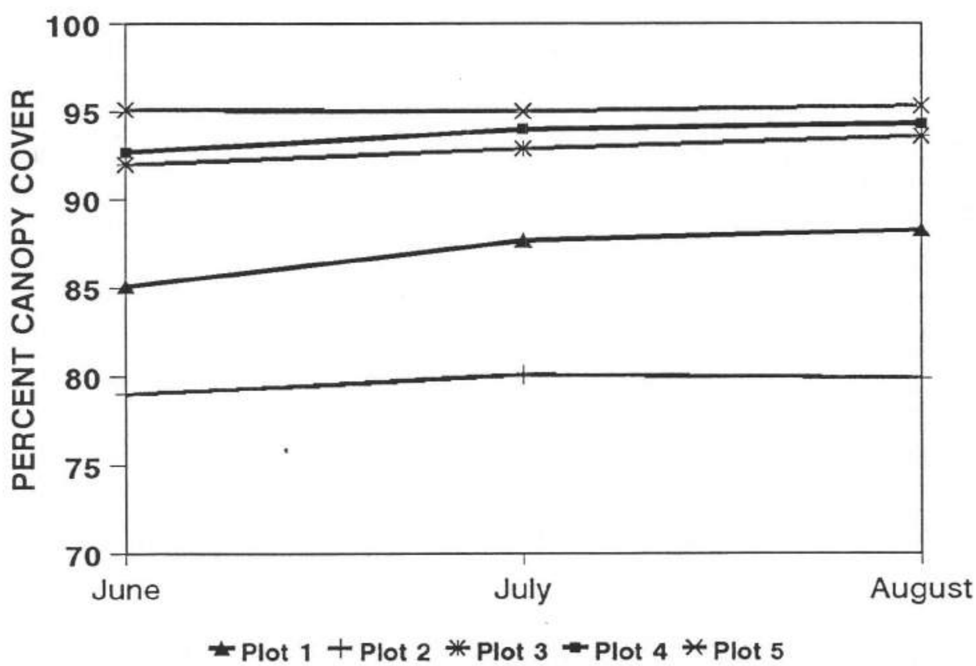

Figure 3. Canopy cover estimates obtained by Swath Kit analysis for a North American Maple Decline Project site at three sampling times in 1992. Each plot estimate is the mean of 9 photo points. Site is in Underhill, VT.

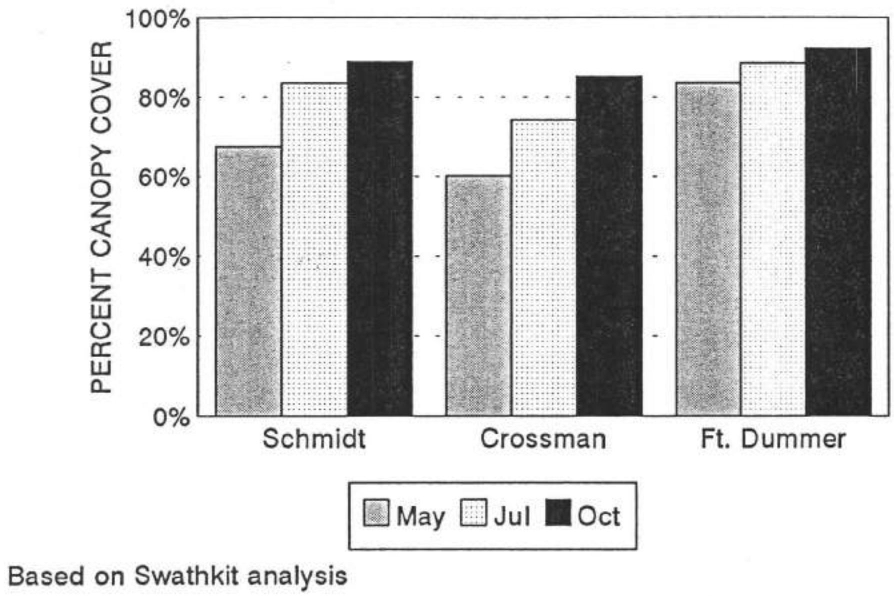

Figure 5. Percent canopy cover in three hemlock stands in Windham County, VT for three months, 1992.

DISCUSSION

Those having access to a Swathkit can expect this system or similar computer analysis systems to generate canopy cover estimates which have consistency and which can detect subtle changes in condition. The film/Swathkit system and its variations are well suited for monitoring objectives which include (1) the maintenance of a long-term record of pictures, e.g., photographs, which document canopy condition from fixed photo points and (2) periodic quantitative and repeatable assessments of canopy cover in integrated surveys of forest health. Electronic radiation-measuring tools such as the Ceptometer and the LI-COR LAI-2000 Plant Canopy Analyser (which were tested but not reported on here) are better suited to situations where neither stored images nor permanent plots are required.

Not to be overlooked is the adaptability of computer image-analysis systems for a spread of management and research objectives. The Swathkit system, although dedicated to a particular use, could be conveniently adapted not only to read canopy slides but also to measure individual leaf areas when needed. Such versatility could make the system more appealing to a wider group of users interested in acquiring and sharing new systems.

Off-the-shelf computer image analysis systems are available in a variety of forms and prices. Slide-scanning hardware is marketed as well as video camera/copy stand setups such as we have used here. Useful software features include masks which can be designed and saved to disc as permanent references. A color analysis capability is costlier at present but is likely to become standard. While color analysis of individually-customized slides will usually yield more accurate results than gray-level analyses of ambiguous images, time input will tend to be greater for both image-grabbing and tinkering in color systems. Large numbers of images collected under a variety of light conditions will tend to defy the application of standard, time-saving color enhancement programs (i.e, "macros").

Advances in film/compact disc technology will bear watching. Kodak's Photo CD system utilizes 35 mm cameras with conventional film, but the processing differs in that a compact disc is produced to store images for viewing on TV, etc. Proper computer interfacing promises to make these images accessible by image analysis software. For our purposes, advantages of this approach are a storage medium in which image aging can be minimized and from which image files can be readily pulled for analysis without further transcription. High relative cost per image is a drawback at the moment. Still video cameras with standard 35 mm lens options offer an avenue for development which is more appealing because the output is an image file which is ready for analysis, enhancement, etc.

For most users, basic requirements for any system will be the ability to mesh with other equipment and with operator skills, the potential for multiple applications, i.e., versatility, and, not least, a low probability of immediate obsolescence. Most important, long-term data comparability requires that any method be upgradable to the next generation. For now, the film/Swathkit system exploits mainstream technologies which meet this need.

FUTURE PLANS

The forest health monitoring photo points will be photographed once annually in late July, to obtain archiveable images that can be compared with data obtained in 1991 and 1992. Data analyses shows that the number of points per plot can be reduced to 5 or 6, with little change in variation. A field manual detailing the procedures for this system is being prepared and will be field tested in 1993 by two Forests, Parks and Recreation employees using NAMP plots.

FUNDING SOURCE

This project was made possible by a focus funding grant from the U.S. Forest Service.

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FOREST PEST SURVEYS ON MOUNT MANSFIELD

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Abstract:

Forest pests are monitored annually on Mount Mansfield to establish baseline information on populations existing at the site, to monitor trends in both populations and damage over time, and in combination with other information on forest stressors, to assess the impact of these agents on forest health.

A variety of potential forest stress agents are monitored, at multiple elevations. These include: forest tent caterpillar, spring and fall hemlock looper, spruce budworm, gypsy moth, maple leaf cutter, pear thrips, and ozone. Damage from other forest pests is detected both through site visits and aerial surveys.

Methodologies for each survey are described in the VMC Annual Report for 1991 and the VMC Work Plan for 1992. Highlights of pest activity for 1992 are as follows:

Spruce budworm adults were detected at all elevations monitored (1400, 2200 and 3800 foot elevations), although the lower elevations had the higher pheromone trap catches (Table 1).

A healthy gypsy moth population is present at lower elevations in a localized stand of poplars surrounded by a predominantly sugar maple forest.

Adult pear thrips were in abundance on sticky traps (over 300 adults trapped) in comparison to the 1991 total trap catch of 7 adults. Soil populations of this forest pest showed an increase in the fall 1992 samples over previous years, which follows the general trend observed in other parts of northern Vermont.

Light damage was observed on sugar maples at lower elevations from pear thrips and maple leaf cutter feeding activity.

Forest tent caterpillar and spring hemlock loopers were not detected in our traps at the three elevations monitored in 1992.

Ozone injury was detected late in the growing season (September) on one of the three species monitored. On September 21, 27% of the milkweed plants monitored showed light to moderate ozone damage to leaves. No symptoms of ozone damage were observed on black cherry or blackberry plants monitored.

Table 1. Survey results on six forest pests monitored on Mount Mansfield in 1992.

TARGET PEST	SURVEY TYPE	LOCATION	TOTAL NO. COLLECTED
Forest Tent Caterpillar	Pheromone traps	BR 1400' BR 2200' BR 3800'	0 0 0
Spring Hemlock Looper	Pheromone traps	BR 1400' BR 2200' BR 3800'	0 0 -
Fall Hemlock Looper	Pheromone traps	BR 1400' BR 2200' BR 3800'	325 total 521 total -
Spruce Budworm	Pheromone traps	BR 1400' BR 2200' BR 3800'	87 total 10 total 7 total
Gypsy Moth	Burlap banded trees	BR 1400'	4 egg masses
Pear Thrips	Sticky traps	BR 1400'	313 total
Pear Thrips	Soil samples (1991)	BR 1400'	0.8 average per sample
Pear Thrips	Soil samples (1992)	BR 1400'	8.1 average per sample

SUGAR MAPLE REGENERATION IN VERMONT'S SUGARBUSHES

Jeffrey Hughes
David Ellsworth
Timothy Wilmot
Department of Botany, University of Vermont

Abstract:

This project is the direct result of Tim Wilmot's Vermont-wide work with syrup producers. A number of producers have reported alarmingly few sugar maple seedlings and saplings in the forest understory. Other producers have reported excellent regeneration. The concern centers on the health and future of sugar maple in Vermont.

The North American Maple Project (NAMP) and National Forest Health Monitoring Project (NFHM) were instituted to study forest condition and sugar maple health in the US and Canada. These monitoring initiatives, however, are mainly limited to mature trees. Our study of regeneration, on 23 sugarbushes scattered throughout Vermont, augments these and other studies.

On each sugarbush we are quantifying density of seedlings and saplings, year of establishment of existing seedlings and saplings, causes of seedling and sapling injury and mortality, and year-to-year variability in production and viability of sugar maple seeds. From these data we hope to gain greater insight into the extent of the regeneration problem. We also hope to identify patterns or trends that will enable us to pursue the next step: to identify why regeneration is a problem in some sugarbushes but not in others. Ultimately, we hope to offer forest managers and syrup producers specific guidelines to counteract the regeneration problem before it is too late.

TREE PHENOLOGY MONITORING

Vermont Department of Forests, Parks and Recreation

Sandra H. Wilmot

COOPERATORS

H. Brenton Teillon, Thomas Simmons, Cecilia Polansky, Vermont Forestry Division.

INTRODUCTION

The objective of this project is to begin gathering baseline information on the phenology of three hardwood tree species growing at two elevations on Mount Mansfield, with the intent to identify key phenological stages for long-term monitoring. In addition, techniques for monitoring phenology will be developed where no methods exist.

Annual fluctuations in the timing of tree development can be important in detecting and explaining future changes in tree condition. Monitoring phenology annually may also aid in relating stress agent activity with tree injury.

In 1991, we began monitoring the timing and duration of vegetative and flower bud development in the spring, full leaf size, and the timing of fall color and leaf drop on sugar maple trees at the Proctor Maple Research Center (elevation 1400 ft). We expanded this project in 1992 to include sugar maple, yellow birch and beech at two elevations on the mountain, 1400 and 2200 ft.

METHODS

Vegetative and flower bud development through leaf expansion is monitored using adaptations of visual assessments of developmental stages defined by Parker and Skinner (in press) for sugar maple. At least twice weekly, from dormant bud stage (early April) through full leaf expansion (early June) buds of 5 mature and 5 sapling trees per species and elevation are assessed for development using a 45 X spotting scope. Lower and upper canopy, and sapling buds are assessed separately. Bud development is categorized into 8 vegetative bud stages and 7 reproductive bud stages (Table 1). Data are expressed as the percent of buds in each developmental stage on each sampling date.

Leaf collections are made on each canopy tree monthly from late June to late August to measure leaf size. Twenty leaves are collected from mid-canopy on each of the phenology trees using pole

Table 1. Description of phenological stages used to assess vegetative and flower bud development on sugar maple, yellow birch, and American beech trees.

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

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

pruners. Leaves are pressed, dried and processed through a leaf area meter for size determinations.

Fall color and leaf senescence are monitored using modifications of the visual crown rating system used for the National Forest Health Monitoring Program (Conkling and Byers, 1992). Each mature tree and sapling is rated bi-weekly for crown discoloration (fall color), crown dieback, foliage transparency and crown density (leaf drop measurements) from late July through mid-October. Field crews are certified under the NFHM for standardized crown rating evaluations. Field audits of field crews are made to aid in data quality assurance.

RESULTS

Bud and leaf development

Sugar maple, yellow birch and beech buds were all dormant at the beginning of field observations on April 5, 1992. Initial bud swell (V1) began first with sugar maple at both elevations and beech at the lower elevation on April 20 (Figure 1).

Sugar maple at the lower elevation reached bud break (V4) on May 8, followed by yellow birch on May 9 and beech on May 11, also at the lower elevation. The same sequence of bud break was observed at the higher elevation site, with sugar maple bud break 8 days behind the lower elevation (May 16), yellow birch bud break 5 days later than at 1400 feet (May 14) and beech bud break 8 days after the lower elevation (May 19).

Full leaf expansion (V8) was completed by May 15 for sugar maple, May 20 for beech and May 28 for yellow birch, all at the lower elevation. At the upper elevation, full leaf expansion was 13 days later than the lower elevation site for sugar maple and beech (May 28 and June 2, respectively), but only 4 days later for yellow birch (June 2).

Sugar maple flower buds reached bud break (F4) on May 8 and May 14 for the lower and upper elevations sites, respectively. Flower bud development was difficult to assess on beech and yellow birch until buds were open (F6), so bud break data is not available for these species. Open flowers were first observed open on May 11 for sugar maple and yellow birch, and May 15 for beech, at the low elevation site. At the higher elevation site, open flowers were first observed on May 15, 19, and 21 for sugar maple, yellow birch and beech, respectively.

Figure 1. Vegetative bud development of sugar maple (1a), yellow birch (1b) and American beech (1c) at two elevations on Mount Mansfield, VT.

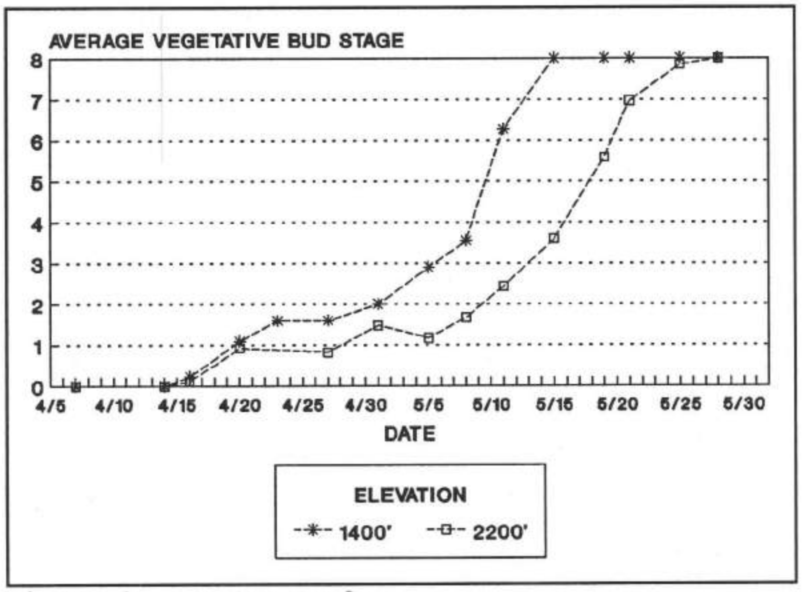


Figure 1a. Sugar maple.

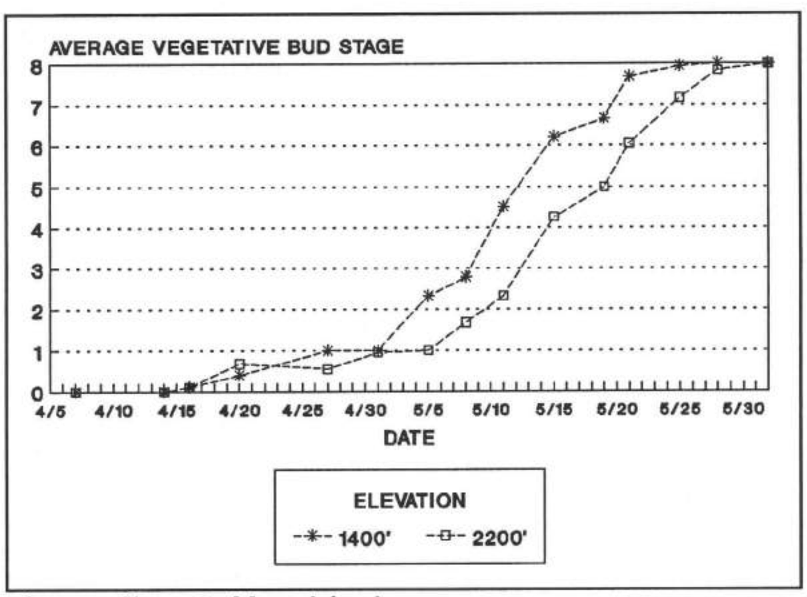


Figure 1b. Yellow birch.

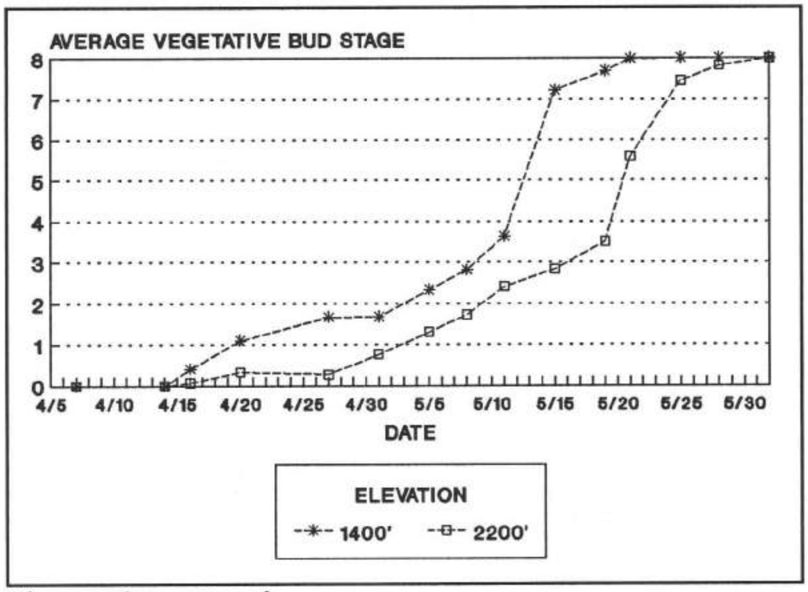


Figure 1c. Beech.

Leaf size
Full leaf size for each species was greater at the lower elevation site. Sugar maple leaves reached full size on June 26 at the 1400 foot elevation (49.86 cm^2) and on July 24 at the 2200 foot elevation (43.02 cm^2) (Table 2). Beech leaves reached full size on July 24 (high elevation) and August 25 (lower elevation), and were 35.38 and 36.96 cm^2, respectively. Yellow birch leaves reached full size on July 24 at both elevations, with leaf sizes of 24.11 and 20.95 cm^2 for the low and high elevation sites respectively.

Table 2. Average leaf size for 1992 of sugar maple, yellow birch and American beech growing at two elevations on Mount Mansfield, VT.

SPECIES	LOCATION-elevation	AVERAGE LEAF SIZE (cm^2) BY DATE		
		June 24	July 26	August 25
SUGAR MAPLE	1400 ft	49.86	39.85	41.26
	2200 ft	41.24	43.02	37.97
YELLOW BIRCH	1400 ft	24.11	21.85	22.26
	2200 ft	20.95	19.35	14.71
AMERICAN BEECH	1400 ft	34.70	29.04	36.96
	2200 ft	32.64	35.38	26.82

Sugar maple leaf size at the 1400 foot elevation site was larger in 1992 than in 1991 (49.86 cm^2 compared to 44.21 cm^2). Differences in growing conditions between the two years may be responsible.

Fall color and leaf drop
Sugar maple and yellow birch at 2200 feet were the earliest to reach full color (> 75% of crown with colored foliage) in 1992 (Figure 2a). By October 5, most species at both elevations were showing some fall color without leaf drop, and by October 13, significant leaf drop had occurred at both elevations (Figure 2b & 2c). Sugar maple at 1400 feet and beech at 2200 feet were the slowest to drop their leaves, loosing > 80 % of their leaves by October 20. The timing of fall coloration and leaf drop on sugar maples at 1400 feet were similar between 1991 and 1992 (Figure 3).

Figure 2. Fall coloration (2a) and leaf drop (2b & 2c) progression for 1992 of sugar maple, yellow birch and American beech at two elevations on Mount Mansfield, VT.

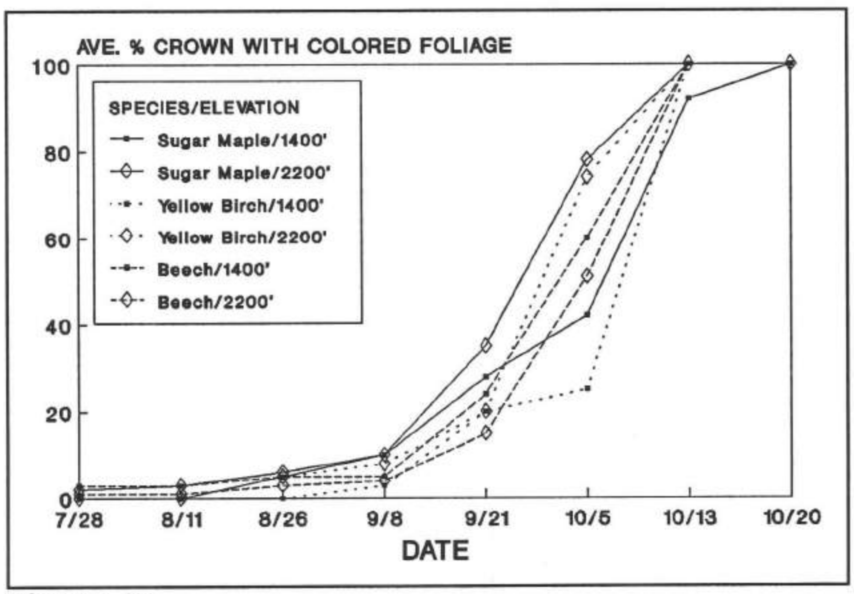


Figure 2a.

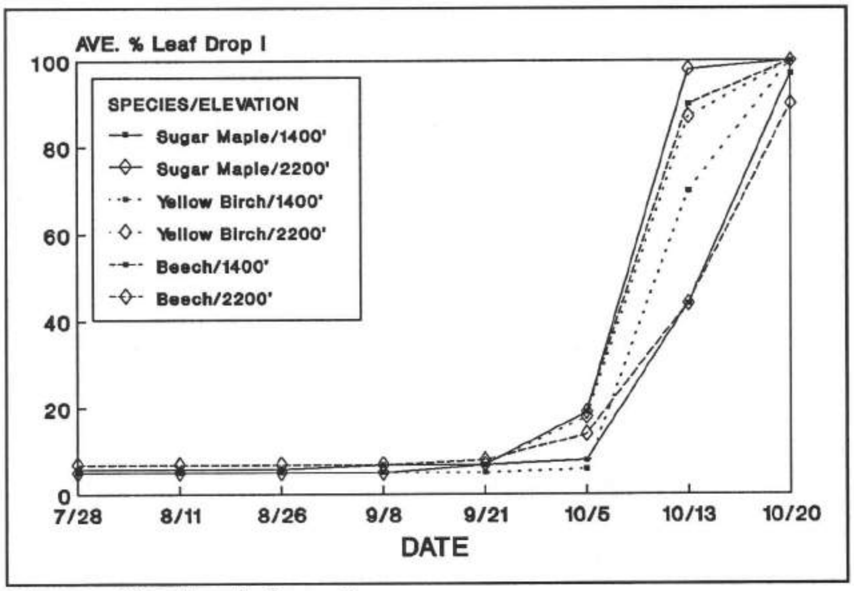


Figure 2b. Leaf drop I.

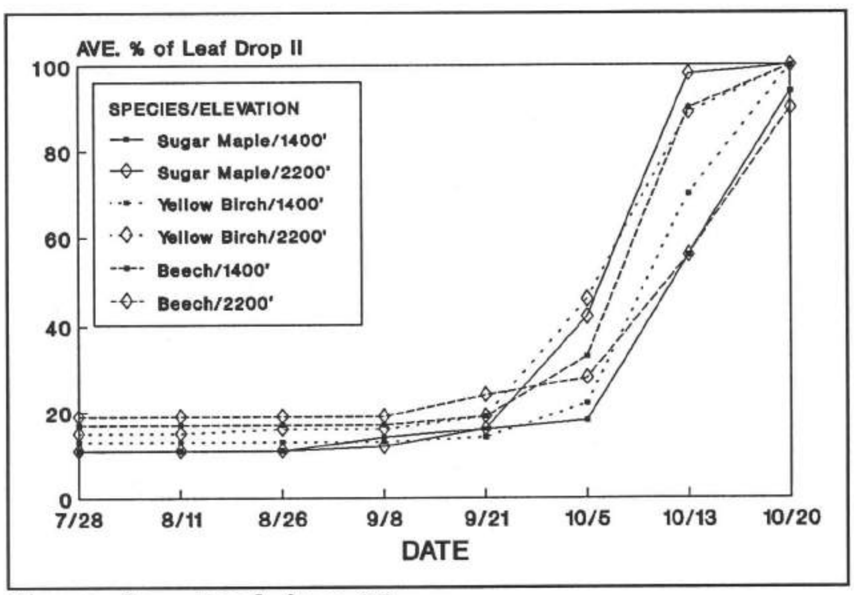
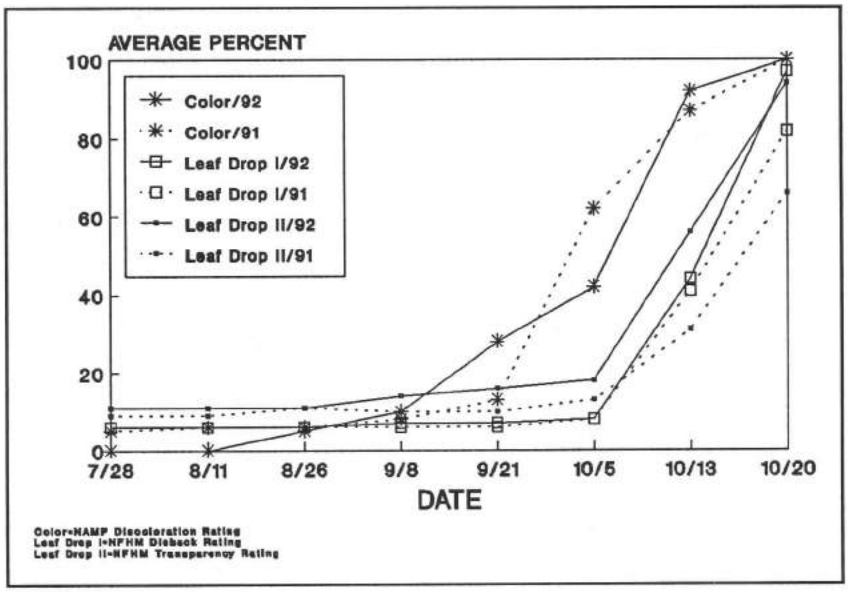


Figure 2c. Leaf drop II.

Figure 3. Sugar maple fall coloration and leaf drop comparison between 1991 and 1992, of trees growing at 1400 feet on Mount Mansfield, VT.



Discussion

At the 1400 foot elevation site sugar maple phenology has been monitored for the last two years. In 1992, bud break was 9 days later than in 1991, although buds developed faster from bud break to full leaf expansion, which was only 2 days later than in 1991. The timing of full leaf size, fall color and leaf drop was also similar between the two years. This indicates that although the season can begin slowly, development can be rapid enough to compensate for this and maintain a "normal" schedule later in the season.

As expected, vegetative bud development was later at the higher elevation site than at the 1400 foot elevation site. Full leaf development of sugar maple and beech was almost 2 weeks later at the higher elevation. Yellow birch development between the 2 elevations was less than a week apart at all stages.

Flower bud development was difficult to monitor in yellow birch and beech. The bud stage descriptions used to monitor sugar maple flower buds are not directly applicable to the other species, but with the modifications made (Table 1) were descriptive of detectable stages of flower development. An additional complication was variation between individuals in the numbers of flower buds, with some trees having very few.

Conversely, sugar maple flowering was abundant in 1992. Flower buds were fully open (F6) within days of vegetative bud break (V4) at both elevations. This may be important for assessing damage from early defoliating insects, like pear thrips, that injure leaves while in the bud break stage, and require pollen for energy and reproduction. Open flowers persisted for only 8 days at the lower elevation site, but for 13 days at the higher elevation site.

The cause or significance of smaller leaf size in 1991 than in 1992 is not known at this time. Integration of other data sets, such as weather and pest activity, with this phenology data is planned to assess interrelations between stress factors and tree phenology.

The method used to assess fall coloration using percent of tree discolored reflects visual assessments. But the techniques for assessing leaf drop using percent dieback and percent transparency need modification. Dieback captures leaf drop when it occurs on branch tips. Transparency captures leaf drop when it occurs throughout the crown. But since leaf drop varies between trees, neither could be used to depict what is seen on each tree. A new crown rating measurement for hardwoods is now being used in the NFHM program with improved accuracy. Crown density may be more appropriate since it takes into account both dieback and transparency, and therefore will be tested next year.

TREE SPECIES GROWING AT THEIR ELEVATIONAL LIMITS: BIO-INDICATORS OF CLIMATIC OR ATMOSPHERIC CHANGE

Jeffrey Hughes
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Abstract:

This new study is based on the premise that individuals growing at their elevational limits respond more noticeably to slight changes in the growing environment than individuals of the same species that are growing in the midst of their distributional ranges.

Elevational limits of sugar maple, yellow birch, paper birch, mountain birch and white ash on several Vermont mountains are being compared to evaluate the extent to which species limits are driven by elevation-related climate rather than by other variables. Density, relative density, basal area, and relative basal of the study species are being calculated, both in the overstory and understory along elevational gradients. Changes in radial growth as elevational limits are approached also are being determined. Using five-year growth increments from tree cores collected at different elevations, we are trying to determine if trees growing at different elevations track annual weather patterns equally.

We still are collecting data, but preliminary observations suggest that regeneration of all species except mountain birch is very low near the elevational limits. We hope to explore this further by installing seed traps to assess and compare annual production of viable seeds along elevational-climatic gradients.

TERRESTRIAL FAUNA

AMPHIBIAN MONITORING ON MOUNT MANSFIELD

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Abstract:

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

Highlights of our activities for 1992 include the first full year of monitoring at all 3 elevations (1200, 2200, and 3200 feet) and surveys of egg masses and pH in the Lake of the Clouds and four vernal pools. New results for 1992 include (1) the discovery of the pickeral frog (Rana palustris) in the region, bringing the total number of species known in the area to 13, (2) the development of a baseline elevational-distribution database for amphibians over the slope of Mount Mansfield, (3) observation that reproductive success of spotted salamanders and wood frogs in vernal pools occurred but was seemingly low, and (4) that the pH of these breeding ponds is very close to the lethal pH reported for spotted salamanders. Evaluations of the five key indicator species in our study (spring peeper, redback salamander, spotted salamander, wood frog, and grey treefrog) show that all five are present and at seeming abundant levels, although the length of our monitoring activities here is much too short at the present time to draw any meaningful conclusions.

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 1992 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:

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

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

Third, selected breeding ponds in the area are searched during the breeding season for eggs and males calling for mates. The number of egg masses provide an index of the abundance of each species. In 1992, pools monitored for egg masses and water pH were the West Bank of Harvey Brook, the East Bank of Harvey Brook, the vernal pool below the PMRC, the pond behind the PMRC sugar shack, and the Lake of the Clouds.

Fourth, active searches, involving turning over rocks and logs, are done irregularly during the day near the drift fences. The number of individuals of each species found in a given area in a given amount of time provide a direct measure of species presence and an index of species diversity and abundance.

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

Results and Discussion:

We have so far identified 13 species of amphibians from this area, from a total possible of 20 species known from Vermont (Table 1, Figure 4). Six of these 13 were abundant, being observed or heard on almost all visits wherever suitable habitat is found:

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

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

Spotted salamander: egg masses found in the spring in a few of the ponds in the area, particularly Lake of the Clouds, a vernal pool below the PMRC, a small pond behind the sugar shed at PMRC, and in quiet backwater along Harvey Brook.
Northern dusky salamander: streams up to 2200 feet.
Northern spring salamander: streams up to 2200 feet.
Northern two-lined salamander: streams up to 3900 feet.
Green frog: heard calling regularly from ponds throughout the area, mainly below 2000 feet.

The pickeral frog was occasionally observed, but only below 2200 feet. The occurrence of one species, the bullfrog, is still questionable; it was identified at only one site on one occasion in 1991, but was not heard in 1992. If it was indeed present in 1991 it was probably introduced to the area by humans and may have died during the winter of 1991-92.

Four species are suspected to be in the general area but have not yet been observed, perhaps due to the lack of appropriate habitat in the VMC area proper:

Blue-spotted salamander complex (includes hybrids)
Jefferson salamander complex (includes hybrids)
Four-toed salamander
Mink frog

Three other species that are known in Vermont are unlikely to be present anywhere in the area:

Mudpuppy: unlikely given the available habitat in the study area.
Western chorus frog: known in Vermont from only one site in Grand Isle County.
Northern leopard frog: unlikely given the available habitat in the study region.

We have targeted five of the species in this area as indicator species because of their current abundances, range of habitat types, and ease of investigation. We only have two years of data on these species (1991, 92), therefore it is too soon to draw any conclusions on trends in their demography. However, the following summarizes the year's results on these species (Table 2-4).

Spring peepers: commonly observed during both night-time road searches and surveys of breeding choruses. They are by far the most common species observed on the roads and had six times the number of choruses (50) than any other species.

Gray treefrogs: not observed in any searches or drift fences, but this is expected due to their secretive behavior. Four choruses were noted.

Redback salamanders: commonly found in drift fences.

Spotted salamanders: Two individuals were found in drift fences. Egg mass were located in all of the pools and the Lake of the Clouds. Although a large number of egg mass was seen in one vernal pool, none of them successfully hatched. Evidence of successful reproduction was seen only on the West Bank of Harvey Brook. Measurements of pH in these ponds indicate that they are very close to the lethal pH measured in other studies (4.0-4.5), suggesting a possible explanation for the low level of successful reproduction.

Wood frogs: commonly observed on night-time road searches, surveys for choruses, and in drift fences. Wood frogs successful bred in 3 of the 5 ponds studied, although the number of egg masses was seemingly small.

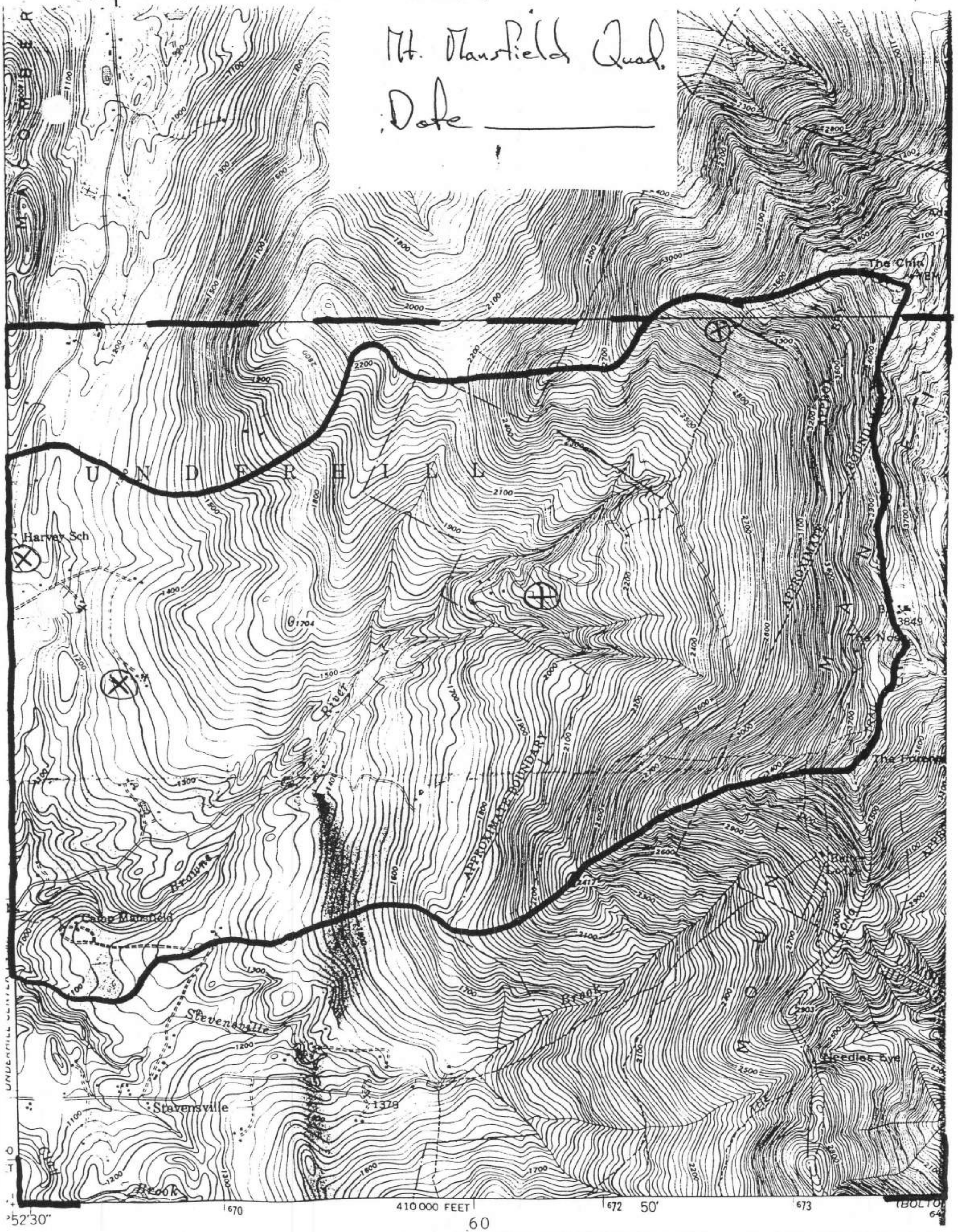
<u>Future plans</u>:

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 now will focus exclusively on monitoring the populations to build-up a picture of long-term trends in their distributions and abundances. We especially plan to expand our efforts to monitor water quality and breeding success of amphibians in vernal pools and lakes in the area.

Context:

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

Map 1. Location of drift fences (X)



Map 2. Mt. Mansfield Road Search Area

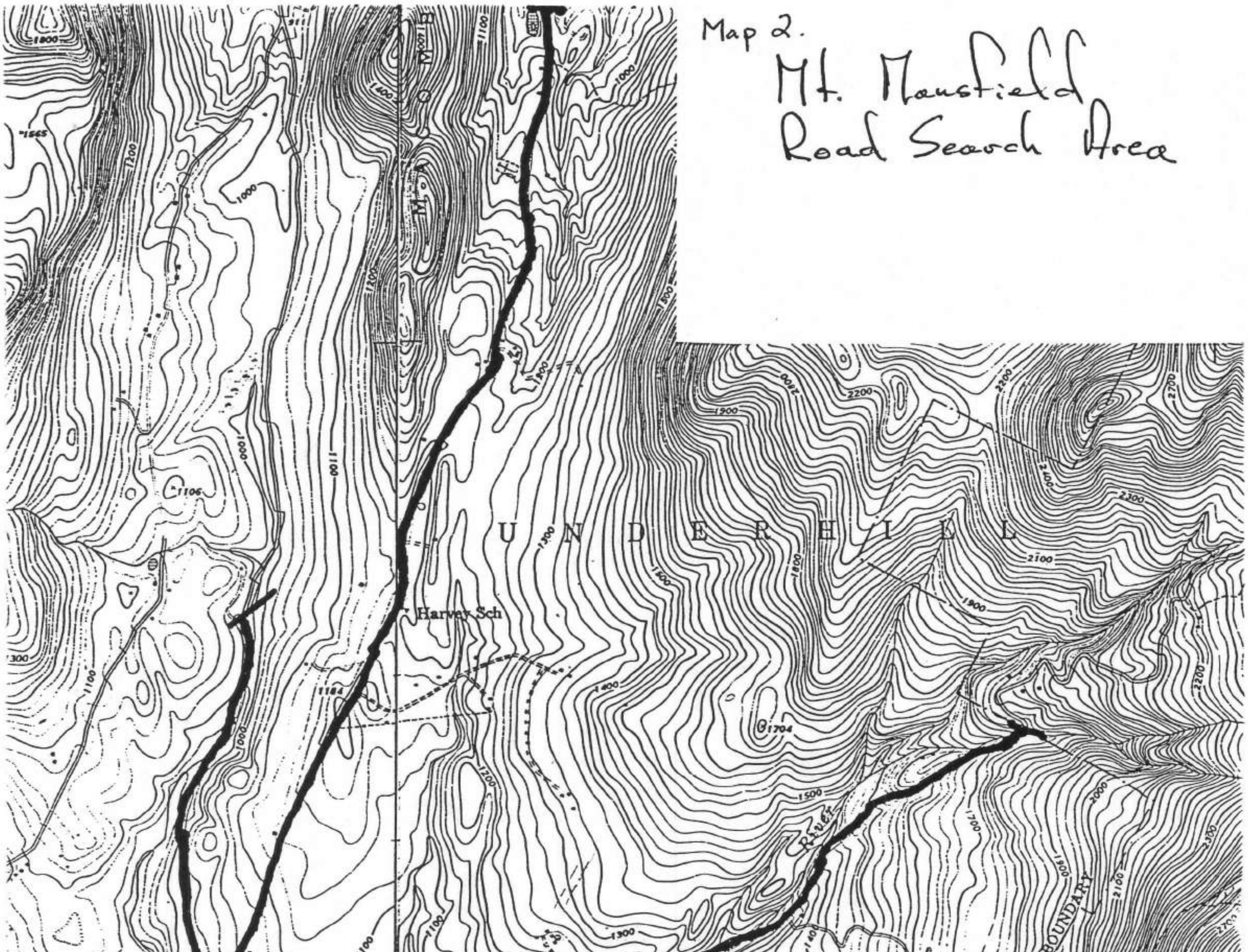
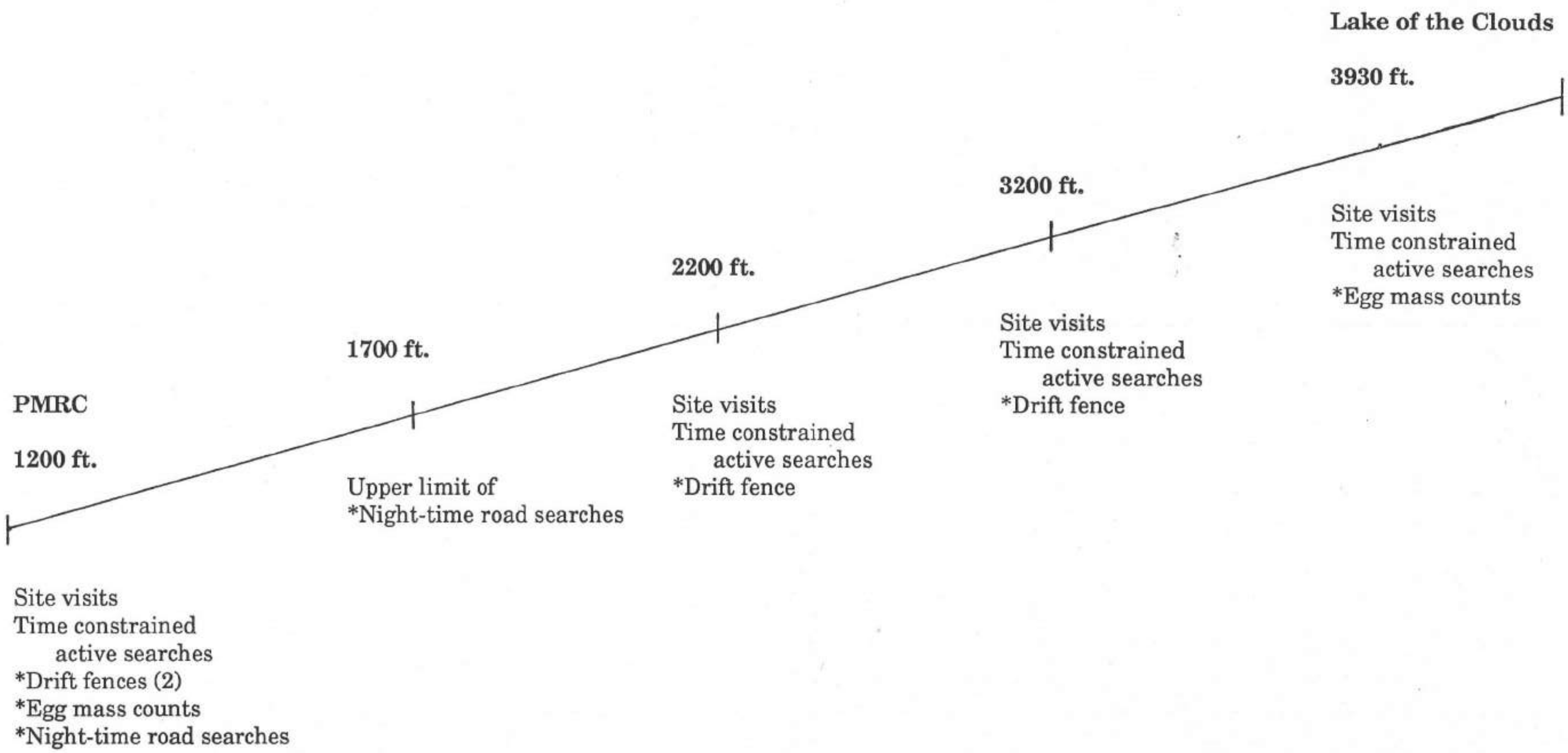


Figure 3

Mt. Mansfield Inventory Methods by Elevation



*method to be continued for long-term monitoring

Table 1. Amphibians of Mt. Mansfield, Vermont, based on surveys from Spring 1991 to Fall 1992.

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

Key

a: Status

- U = unlikely
- P = possible, based on published range maps
- S = suspected, based on published range maps and the existence of appropriate habitat within the study area
- K = known
- ? = needs verification

b: Commonality

- A = abundant, habitat is widely distributed throughout study area, and it is observed on most visits
- LC = locally common, found regularly but in only a few areas
- O = occasional, found uncommonly
- R = observed only once or twice

Figure 4.

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

PMRC

1200 ft.

Ambystoma maculatum
Bufo americanus
Desmognathus fuscus
Eurycea bislineata
Gyrinophilus porphyriticus
Hyla versicolor
Notophthalmus viridescens
Plethodon cinereus
Pseudacris crucifer
Rana catesbeiana (?)
Rana clamitans
Rana sylvatica
**Rana palustris* (92)

*new species for 1992

2200 ft.

Eurycea bislineata
Gyrinophilus porphyriticus
Plethodon cinereus
Bufo americanus (92)
Notophthalmus viridescens (92)
Rana sylvatica (92)

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

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

3200 ft.

Notophthalmus viridescens
Plethodon cinereus
Rana sylvatica

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

Not located anywhere

A. laterale x jeffersonianum
H. scutatum
R. septentrionalis
R. pipiens

Lake of the Clouds

3930 ft.

Eurycea bislineata
Notophthalmus viridescens
Ambystoma maculatum (92)
Rana sylvatica (92)
Bufo americanus (reported)

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

12 species located and confirmed

1 species unconfirmed

Table 2.

Night -time Road Search Data for Mt. Mansfield, Vermont, based on surveys from Spring 1991 to Fall 1992.

Individuals

Species name	**Common name**	**# of ind.**	**# per NTRS**	**% of total catch**
Notophthalmus viridescens	Red-spotted newt	9	1.5	6
Plethodon cinereus	Redback salamander	1	.2	1
Gyrinophilus porphyriticus	Spring salamander	1	.2	1
Pseudacris crucifer	Northern spring peeper	98	16.3	66
Rana clamitans	Green frog	5	.8	3
Rana catesbeiana	Bullfrog	1	.2	1
Rana sylvatica	Wood frog	16	2.7	11
Rana palustris	Pickerel frog	1	.2	1
Bufo americanus	Eastern American toad	16	2.7	11
Totals		**148**	**24.8**	**101**

Large Choruses

Species name	**Common name**	**# of choruses**	**# per NTRS**	**% of total catch**
Hyla versicolor	Gray tree frog	4	.7	6
Pseudacris crucifer	Northern spring peeper	50	8.3	81
Rana sylvatica	Wood frog	8	1.3	13
Totals		**62**	**10.3**	**100**

Total night-time road searches during seasons = 6

Table 3.

Drift Fence Data for Mt. Mansfield, Vermont, based on surveys from Spring 1991 to Fall 1992.

Species name	**Common name**	**# of ind.**	**# per trapping**	**% of total catch**
Ambystoma maculatum	Spotted salamander	2	.4	4
Notophthalmus viridescens	Red-spotted newt	11	2.2	24
Desmognathus fuscus	Northern dusky salamander	4	.8	9
Plethodon cinereus	Redback salamander	11	2.2	24
Eurycea bislineata	Northern two-lined salamander	4	.8	9
Pseudacris crucifer	Northern spring peeper	1	.2	2
Rana clamitans	Green frog	1	.2	2
Rana sylvatica	Wood frog	9	1.8	20
Rana palustris	Pickerel frog	1	.2	2
Bufo americanus	Eastern American toad	2	.4	4
Totals		**46**	**9.2**	**100**

Total trappings = 5

Table 4.

1992 Egg mass Data from Mt. Mansfield

Site No.	Location/Date	# of A. mac. egg masses	mean # of eggs	# of R. syl. egg masses	mean # of eggs	mean pH
1	West bank of Harvey Brook					
	May 8	6	51.3 ± 11.7	0		
	May 11	7	none hatched	2	some hatched	
	June 29	hatched				
2	East bank of Harvey Brook					
	May 8	1	10	0		
	May 11	" "		" "		
	June 26	dry				
3	Vernal pool below PMRC					
	May 8	18		36		4.65 ± .06
	May 11	" "		" "		
	June 26	dry				
4	Pond behind sugar shack					
	May 8	3	69.3 ± 10	hatched		4.4 ± .2
	May 11	" "				
	June 26	dry		dry		
5	Lake of the Clouds					
	May 15	spermato-phores		22, still calling	415 (n=2)	4.58 ± .2
	June 2	2	55 ± 21	hatched		
	July 10	1	90			

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 second year in 1992. 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. 3700 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. Eighteen species were recorded at Underhill State Park, with a maximum of 111 individuals (49 in 1991) on 26 June and a mean of 103.5 (38.5 in 1991) for both visits. Sixteen species were recorded on Mt. Mansfield, with a maximum of 141 individuals (94 in 1992) on 29 June and a combined mean of 133 (90 in 1991). Species diversity and numerical abundance were significantly higher at both sites in 1992 than in 1991. The reasons for this increase, 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

Introduction: In 1992, breeding bird censuses were conducted for a second year on two permanent study sites on Mt. Mansfield, as part of a long-term Vermont Forest Bird Monitoring Program conducted by the Vermont Institute of Natural Science (VINS). This program was initiated in 1989 with the primary goal of conducting habitat-specific monitoring of forest interior breeding bird populations in Vermont and tracking long-term changes. As of 1992, VINS has selected, marked and censused 17 permanently protected sites of mature forest habitat in Vermont (Table 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.

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

Results and Discussion: Species diversity and numerical abundance were significantly higher at both sites in 1992 than in 1991 (Table 2). Eighteen species were recorded at Underhill State Park, with a maximum of 111 individuals (49 in 1991) on 26 June and a mean of 103.5 (38.5 in 1991) for both visits (Table 3). This increase appears to have resulted in part from the switch in 1992 to a more experienced observer, and possibly from more favorable weather conditions during the two 1992 counts. However, totals of the five most abundant species at Underhill (Ovenbird, Black-throated Blue Warbler, Black-throated Green Warbler, Red-eyed Vireo, and Canada Warbler) still fall below those from VINS' six other northern hardwoods sites. We do not yet know whether the apparently low bird densities at Underhill are related to habitat variables, insect prey populations, or other factors.

Sixteen species were recorded on Mt. Mansfield, with a maximum of 141 individuals (94 in 1992) on 29 June and a combined mean of 133 (90 in 1991) (Table 4). Of ten species recorded in both years, three declined slightly, while seven increased significantly (Table 2). Gray-cheeked (Bicknell's) and Swainson's thrushes, White-throated Sparrows, Dark-eyed Juncos, and Purple Finches all increased by at least 100%. Between-year count weather (similar) or observer bias (same observer in each year) do not account for these increases. Possible changes in insect food availability, migration or breeding season weather, interspecific competition, overwinter survival, or other factors may have influenced this short-term change. However, it is premature to interpret these data, as they constitute the first two years of a long-term database. Several years of additional data collection, and their correlation with other VMC data, will be necessary to elucidate population trends of various species and groups at the Mansfield and Underhill sites.

Future Plans: Future plans include continued monitoring at both sites, as well as detailed sampling of habitat characteristics. In addition, intensive research into the population ecology and conservation status of the Gray-cheeked (Bicknell's) Thrush in Mt. Mansfield's subalpine spruce-fir zone will be continued. Preliminary studies of this (sub)species were conducted in 1992.

Funding for VINS' 1992 work at these two sites was provided by the VMC. Support for monitoring at VINS' additional 15 Vermont forest bird study sites was provided by a grant from the Merck Family Fund.

Table 1. Vermont Forest Bird Monitoring Sites - 1992

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	N. Martin
5. Galick Preserve	West Haven	Hemlock-pine	W. Ellison
6. Sugar Hollow	Pittsford	N. Hardwoods	R. Pilcher
7. The Cape	Chittenden	N. Hardwoods	C. Rimmer
8. Dorset Bat Cave	E. Dorset	N. Hardwoods	C. Darmstadt
9. Roy Mountain WMA	Barnet	Cedar-spruce	C. Rimmer
10. Concord Woods	Concord	N. Hardwoods	C. Rimmer
11. May Pond Preserve	Barton	N. Hardwoods	D. Schell
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	C. Darmstadt

Table 2. Maximum counts of individual birds recorded on Mt. Mansfield and Underhill State Park sites, combining data from both visits in 1991 and 1992.

Species	Mansfield 1991	Mansfield 1992	Underhill 1991	Underhill 1992
Yellow-bellied Sapsucker				2
Pileated Woodpecker			2	1
Black-capped Chickadee				2
Blue Jay		1		
Red-breasted Nuthatch		2		
Winter Wren	20	18		
Ruby-crowned Kinglet		4		
Veery			2	2
Gray-cheeked Thrush	10	23		
Swainson's Thrush	6	16		2
Hermit Thrush				7
Wood Thrush			1	2
American Robin	2	7		
Cedar Waxwing		1		
Solitary Vireo			1	4
Red-eyed Vireo			5	8
Blue-winged Warbler				2
Nashville Warbler	4			
Magnolia Warbler	2	4		
Black-throated Blue Warbler			11	17
Yellow-rumped Warbler	22	21		
Black-throated Green Warbler			9	14
Blackpoll Warbler	20	18		
Black-and-white Warbler				6
American Redstart				6
Ovenbird			7	20
Canada Warbler			5	8
Rose-breasted Grosbeak			7	3
Lincoln's Sparrow	4			
White-throated Sparrow	14	28	2	
Dark-eyed Junco	8	17		6
Purple Finch	2	8		
Pine Siskin		1		
Evening Grosbeak		2		
Number of individuals	114	171	52	112
Number of species	12	16	11	18

Table 3. Numbers of individual birds recorded in Underhill State Park in 1992. Maximum count for each species represents relative abundance index to be used in future analyses.

Species	11 June	26 June
Yellow-bellied Sapsucker		2
Pileated Woodpecker	1	
Blue Jay		2
Black-capped Chickadee	2	1
Winter Wren	6	12
Veery		2
Swainson's Thrush		2
Hermit Thrush	4	7
Wood Thrush	2	
American Robin	1	
Solitary Vireo	4	4
Red-eyed Vireo	8	6
Blue-winged Warbler		2
Black-throated Blue Warbler	12	17
Black-throated Green Warbler	14	14
Black-and-white Warbler	6	4
American Redstart	6	2
Ovenbird	20	20
Canada Warbler	4	8
Rose-breasted Grosbeak	3	
Dark-eyed Junco	3	6
Number of individuals	96	111
Number of species	16	17

Table 4. Numbers of individual birds recorded on Mt. Mansfield in 1992. Maximum count for each species represents relative abundance index to be used in future analyses.

Species	10 June	29 June
Blue Jay	1	
Red-breasted Nuthatch		2
Winter Wren	14	18
Ruby-crowned Kinglet		4
Gray-cheeked Thrush	23	13
Swainson's Thrush	2	16
American Robin	7	3
Cedar Waxwing	1	
Magnolia Warbler		4
Yellow-rumped Warbler	21	16
Blackpoll Warbler	16	18
White-throated Sparrow	21	28
Dark-eyed Junco	8	17
Purple Finch	8	2
Pine Siskin	1	
Evening Grosbeak	2	
Number of individuals	125	141
Number of species	13	12

Insect Diversity on Mount Mansfield

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Abstract

Insects were collected from sites at three different elevations on Mount Mansfield using the same methods and materials as reported in 1991. The 273 species of moths collected in 1991 are listed. Fly, wasp, and beetle families are listed and species identification are included where possible. A total of 58 ground beetle species collected over the period 1991-1992 are listed with respect to elevation. A brief discussion and future plans of this study are mentioned.

Introduction

In 1991 a long term survey program was developed to record the insect biodiversity on Mount Mansfield with respect to taxonomic composition and abundance. Permanent survey traps were established to compare and contrast insect diversity in three forests habitats.

The taxonomic composition of the fauna is presented for the Diptera, Hymenoptera, and Coleoptera combined for malaise and waterpan traps over 1991-1992 collecting season. The species of carabid beetles collected from pitfall traps among the three survey sites are given for 1991 and 1992 respectively, and the Lepidoptera species collected from light traps are tabulated for 1991.

Methods

Sampling sites were established at 400m elevation (Proctor Maple Research Center) in a sugar maple forest, 600m (Underhill State Park) in a mixed hardwood forest, and 1160m (Mt. Mansfield) in a sub-alpine balsam fir forest. At each site five 20m diameter plots were established. A canopy malaise trap was installed in one dominant sugar maple or fir tree (sub-alpine) in each of the four outlying plots. Six pitfall traps were installed around the plots at 60° intervals and one light trap was located in the center plot. A detailed account of field and laboratory methods is outlined in the 1991 VMC Annual Report.

Results

The Diptera species (Table 1) collected represent three suborders. The suborder Nematocera was the least abundant group with only four species of crane flies and two march flies. The Bracycera were represented by six families, with three specimens identified to genus and four to species. The representation of the suborder Cyclorrhapha comprised two divisions. Two families were present in the division Aschiza with three Syphridae being identified to species and a further 18 specimens unidentified. The division Schizophora was represented by eight families, including Muscidae, Calliphoridae, and Tachinidae.

Two suborders of Hymenoptera are represented. The suborder Symphyta comprised two sawfly families, Argidae and Tenthredinidae. The horntail family Siricidae is represented by the common pigeon tremex (*Tremex columba*). The larger suborder Apocrita comprised 10 families including a number of ichneumonid parasitoids that are not identified to species.

Two suborders of Coleoptera are represented. The Adephaga are limited to the Carabidae (ground beetles) with 58 identified species (Table 1b). The remaining beetles belong to the Polyphaga with twenty-five families represented. The family Staphylinidae (rove beetles) comprise four specimens identified to genus and seven to species. Five specimens of Elateridae (click beetles) were identified to species. Families collected in this study with known forest pest species include Cerambycidae (long-horned beetles), Curculionidae (weevils), and Scolytidae (bark beetles).

In 1991, 34 species and 1900 individuals of Carabidae were collected compared to 49 species and 1550 individuals in 1992. Six species collected in 1991 were not found in 1992. Twenty additional species were collected in 1992. Twenty-seven of 58 species were confined to one site and 15 species were found at all three sites. The highest number of individuals for any one species was 676 (*Synuchus impunctatus*). Only one individual was collected for 5 species in 1991 and 14 species in 1992.

The inventory of moths was extended to include the "micro-Lepidoptera". These records will add to the total number of species for the study areas. The species of macro-Lepidoptera for the 1991 inventory are listed along with a few representatives of the micro-Lepidoptera (Table 2). The table includes specific information on the elevational distribution for each species. Most species are present in the lower sites, but absent from the summit. The results of the 1992 survey are currently being entered into a computer data base.

Discussion

Sixty percent of the necessary identifications required to develop diversity indices to characterize and compare biodiversity at the three sites have been completed. Although comprehensive species identifications are possible for the Carabidae and Lepidoptera, many other groups will require specialist study, and this is beyond the scope of current resources. In these groups the primary emphasis will be to determine family, genus, and number of "species".

Future Plans

Waterpan traps were discontinued in 1993 because they collected relatively few specimens which were also duplicated in malaise traps. Data on the flies, wasps, and ground beetles will be used to calculate the diversity index for species richness and abundance. The malaise trap and light trap material will be represented by their ecological guilds in the same manner as the waterpan trap Diptera previously presented in the 1991 VMC Report.

Acknowledgment

Our thanks to R. T. Bell, University of Vermont; Bob Davidson, Carnage Museum of Natural History; Mike Sabourin (South Burlington); and the staff at the Canadian National Collections, for their time and expertise in determining and confirming many species identifications. Collecting, sorting, and data entry was made possible through the help of David Barnes, Pete Pfenny, and Nguyen Long (University of Vermont Research Apprentice Program). Special thanks to Judy Rosovsky for her help in the initial planning of this project.

Table 1b. Carabidae collected in pitfall traps from Mount Mansfield summit site (1160m), Underhill State Park (600m USP), and Proctor Maple Research Center (400m PMRC)

	Summit		USP		PMRC	
Species	**1991**	**1992**	**1991**	**1992**	**1991**	**1992**
Scaphinotus viduus	+[1]		+	+	+	+
Sphaeroderus canadensis	+		+	+	+	+
Sphaeroderus lecontei	+		+	+	+	+
Sphaeroderus nitidicollis	+					
Carabus seratus						+
Calsoma frigidum				+		
Nebria pallipes				+		
Olisthopus parmatus						+
Notiophilus nemoralis	+	+	+	+	+	
Notiophilus aeneus			+			
Elaphrus clairvillei		+				
Loricera pilicornis		+				
Patrobus longicornis			+		+	
Patrobus foveocollis		+		+		
Trechus apicalis		+		+		+
Bembidion semicintctum				+		
Myas cyanescens					+	+
Pterostichus adoxus			+	+	+	+
Pterostichus adstrictus	+	+	+	+	+	
Pterostichus brevicornis		+				
Pterostichus commutabilis		+				
Pterostichus coracinus	+			+		+
Pterostichus corvinus			+	+	+	+

[1] Species present.

Table 1b -continued.

Species	Summit 1991	Summit 1992	USP 1991	USP 1992	PMRC 1991	PMRC 1992
Pterostichus dillgendus			+	+	+	+
Pterostichus honestus	+	+	+	+	+	+
Pterostichus lachrymosus						+
Pterostichus lucublandus						+
Pterostichus melanarius	+		+		+	
Pterostichus mutus						+
Pterostichus patruelis						+
Pterostichus pensylvanicus	+		+	+		
Pterostichus pinguedineus	+	+	+		+	
Pterostichus punctatissimus	+	+				
Pterostichus rostratus			+	+	+	+
Pterostichus stygicus			+	+	+	+
Pterostichus tristis			+	+		+
Calathus ingratus	+	+	+	+	+	
Synuchus impunctatus	+		+	+	+	+
Agonum harrisi	+					
Agonum melanarium				+		
Agonum mutatum		+			+	+
Agonum octopunctatum	+					
Agonum palustre						+
Agonum retractum	+	+	+	+	+	+
Agonum sordens	+					
Agonum superioris				+		
Agonum trigeminum						+
Platynus decentis	+	+	+	+	+	+

Table 1b -continued.

	Summit		USP		PMRC	
Species	**1991**	**1992**	**1991**	**1992**	**1991**	**1992**
Platynus mannerheimi	+	+		+		
Platynus tenuicollis			+	+		
Amara lunicollis	+					
Disamara arenaria	+					
Harpalus caliginosus	+					
Harpalus fulvilabris						+
Harpalus somnulentus				+		
Dicaelus politus						+
Dromius piceus				+		
Cymindus cribricollis	+		+	+	+	+

Table 1. **Flies, wasps and beetles collected from Mount Mansfield 1991 - 1992 (all sites combined).**

Flies:
Order Diptera

Suborder Nematocera - long-horned flies
Superfamily Tipuloidea
Tipulidae - crane flies
4 species

Superfamily Bibionoidea
Bibionidae - march flies
2 species

Suborder Brachycera - short-horned flies
Superfamiy Tabanoidea
Xylophagidae - xyophagid flies
Rachicerus spp.
Xlophagus spp.
Stratiomyidae - soldier flies
Stratiomys spp.
Tabanidae - horse and deer flies
Chrysops sordidus
Stonemyia tranquilla
Rhagionidae - snipe flies
Rhagio mystaceus
Rhagio gracilis

Superfamily Asiloidea
Empididae - dance flies
4 species
Dolichopodidae - long-legged flies
6 species

Suborder Cyclorrhapha - circular-seamed flies
Division Aschiza
Superfamily Syrphoidea
Pipunculidae - big-headed flies
Pipunculus spp.
Syrphidae - flower flies
Helophilus latifrons
Spilomyia fusca
Syrphus spp.
Rhingia nasica
18 other species

Division Schizophora
Section Acalyptratae
Superfamily Tephritoidea
Otitidae - picture-winged flies

Superfamily Sciomyzoidea
Dryomyzidae - dryomyzid flies
Sciomyzidae - marsh flies

Unplaced families of Acalyptratae
Heleomyzidae - heleomyzid flies
3 species

Section Calyptratae
Superfamily Muscidea
Muscidae - house flies
Mesembrina latreillii
10 other species

Superfamily Oestroidea
Calliphoridae - blow flies
3 species
Sarcophagidae - flesh flies
Tachinidae - tachinid flies
Epalus signifer
19 other species

Wasps, ants, and bees:
Order Hymenoptera

Suborder Symphyta
Superfamily Tenthredinoidea - sawflies
Argidae
Arge spp.
Tenthredinidae
Tenthrido spp.

Superfamily Siricoidea - horntails
Siricidae
Tremex columba (L.)

Suborder Apocrita
Superfamily Ichneumonidea
Ichneumonidae
26 species

Table 1 -continued.

Superfamily Sphecoidea - spheciod wasps
Sphecidae - sphecid wasps
Pemphredonidae
Stigus fraternus
Stigus americanus

Superfamily Apoidea - bees
Halictidae - halictid bees
Apidae - bumble bees
Subfamily Bombinae
3 species
Anthophoridae - digger bees
Subfamily Anthoprinae
2 species

Superfamily Vespoidea - vespoid wasps
Vespidae - paper wasps and hornets
3 species
Eumenidae - potter wasps
Pompilidae - spider wasps
Auplopus archetica

Superfamily Formicoidea
Formicidae - ants

Beetles:
Order Coleoptera

Suborder Adephaga

Carabidae - ground beetles
58 species

Suborder Polyphaga
Superfamily Staphylinoidea
Leiodidae - round fungus beetles
Anisotoma spp.
Leptodiridae - small carrion beetles
Catops basilarius
Ptomaphagus consobrinus
Silphidae - carrion beetles
Silpha americana (L.)
Nicrophorus spp.
Scaphidiidae - shining fungus beetles
Baeocera spp.
Brathinidae - grass-root beetles
Brathinus nitiditus

Staphylinidae - rove beetles
Quedius perinus
Quedius spp.
Lathrobium spp.
Tachinas fimbriatus
Tachinas elongatus
Tachinas quebecensis
Tachinas spp.
Platydracus viridanus
Platydracus violaceus
Platydracus spp.
Philonthus cyanipennis
Arpedium spp.

Superfamily Cantharoidea
Cantharidae - soldier beetles
Lampyridae - lightning bugs
Ellychina corrusa

Superfamily Elateroidea
Elateridae - click beetles
Eanus maculipennis
Ctenicera vernalis
Ctericera triundulata
Ctericera spp.
Ampedus melanotiodes
Anthus acanthous

Superfamily Cucujoidea
Erotylidae - pleasing fungus beetles
Licoperidina spp.
Nitidulidae - sap beetles
Lathridiidae
Lanthridius spp.
Byturidae - fruitworm beetles
Byturus unicolor
Salpingidae
Salpingus biresens
Pyrochroidae - fire-color beetles
Dendroides canadensis

Superfamily Melooidea
Meloidae - blister beetles

Superfamily Tenebrionoidea
Tenebrionidae - darkling beetles
Upis ceranboides
Melandryidae
Penthe obliquata
Dircaea spp.

Table 1 -continued.

Superfamily Scarabeoidea
- Lucanidae - stag beetles
- Scarabaeidae - scarab beetles
  - 5 species

Superfamily Cerambycidae
- Cerambycidae - long-horned beetles
  - *Clytus rubricla*

Superfamily Chrysomeloidea
- Chrysomelidae - leaf beetles
  - *Oedionychis sabuttata*
- Alticinae

Superfamily Curculionoidea
- Curculionidae - snout beetles
  - *Sphenopherous incongruous*
  - 8 other species
- Scolytidae - bark beetles

Table 2. Lepidoptera collected in 1991 from light traps on Mount Mansfield summit (site 1 - 1160m), Underhill State Park (site 2 - 600m), and Proctor Maple Research Center (site 3 - 600m)

		Site		
Family	**Genus species**	**1**	**2**	**3**
Arctidae	*Clemensia albata*		+[1]	+
	Crambidia pallida			+
	Ctenucha virginica		+	+
	Halysidota tessellaris	+	+	+
	Hapola lecontei		+	+
	Holomelina laeta		+	+
	Hypoprepia fucosa		+	+
	Lophocampa maculata			+
	Orgyia definita		+	+
	Phragmatobia assimilans		+	
	Pyrractia isabella		+	+
	Spilosoma congrua		+	+
	Spilosoma virginica		+	+
Drepanidae	*Drepana arcuata*		+	+
	Drepana bilineata	+	+	+
	Oreta rosea		+	+
Epermeniidae	*Epermenia albapunctella*			+
Geometridae	*Anacamptodes ephyraria*		+	
	Anagoga occiduaria		+	+
	Besma endropiaria		+	+
	Biston betularia	+	+	+
	Cabera erythemaria		+	+
	Campea perlata		+	+
	Caripeta divisata	+	+	+

[1] Species present.

Table 2 -continued

Family	Genus species	Site 1	Site 2	Site 3
Geometridae	*Dysstroma hersiliata*		+	+
	Dystroma truncata		+	+
	Ecliptoptera silaceata		+	+
	Ectropis crepuscularia		+	+
	Ennomos magnaria		+	+
	Epirrita autumnata	+	+	+
	Eubaphe mendica			+
	Euchlaena tigrinaria		+	+
	Eugonobapta nivosaria		+	+
	Eulithis destinata	+		
	Eulithis diversilineata			+
	Eulithis explanata			+
	Eulithis propulsata	+	+	
	Euphyia unangulata	+	+	+
	Eupithecia coagulata		+	
	Eupithecia herefordaria			+
	Eupithecia miserulata		+	+
	Euithecia sp.	+		
	Eusarca confusaria	+	+	
	Eutrapela clemataria		+	+
	Heterophleps triguttaria			+
	Homochlodes disconventa		+	
	Homochlodes lactispargari	+	+	+
	Horisma intestinata			+
	Hydrelia inornata		+	

Table 2 -continued

Family	Genus species	Site 1	Site 2	Site 3
Geometridae	*Hydrelia prunivorata*		+	+
	Hypagyrtis piniata		+	+
	Hypagyrtis unpunctata		+	
	Iridopsis larvaria		+	+
	Itame coortaria		+	+
	Itame pustularia		+	+
	Lambdina fiscellaria	+	+	+
	Lomographa glomeraria	+		+
	Lomographa vestaliata		+	+
	Melanolophia signataria	+		
	Melanolophia sp.	+	+	
	Mesoleuca ruficillata		+	+
	Metanema inatomaria		+	+
	Nacophora quernaria		+	
	Nematophora limbata		+	+
	Nemoria mimosaria		+	+
	Nemoria rufrifrontaria			+
	Nemoria sp.			+
	Operopthera bruceata		+	+
	Orthonama centrostrigaria			+
	Orthonama obstipata		+	+
	Paonias excaecatus	+	+	+
	Perizoma basaliata		+	
	Pero honestaria			+
	Pero hubneraria			+
	Pero sp.	+	+	+

Table 2 -continued

		Site		
Family	**Genus species**	**1**	**2**	**3**
Geometridae	*Plagodis alcoolaria*		+	+
	Plagodis fervidaria		+	
	Plagodis phlogosaria			+
	Plagodis serinaria		+	+
	Probole alienaria		+	+
	Prochoerodes transversata		+	+
	Rheumaptera hastata			+
	Scopula limboundata		+	+
	Selenia kentaria	+		
	Semiothisa aemulataria		+	+
	Semiothisa bisignata	+	+	+
	Semiothisa minorata			+
	Semiothisa pinistrobata	+	+	+
	Semiothisa ulserata	+		+
	Sicya macularia		+	+
	Stamnodes gibbicotata			+
	Tetracis cachexiata		+	+
	Tetracis crocallata		+	+
	Trichodezia albovittata		+	+
	Venusia cambrica	+	+	+
	Xanthorhoe ferrugata		+	
	Xanthorhoe labradorensis	+	+	
	Xanthotype urticaria		+	+
Hepialidae	*Korscheltellus gracilis*	+	+	+
	Sthenopis auratus		+	
Lasiocampidae	*Malacosoma americanum*		+	+

Table 2 -continued

Family	Genus species	Site 1	Site 2	Site 3
Lasiocampidae	*Malacosoma disstria*		+	+
	Orgyia definata		+	
	Tolype velleda			+
Limacodidae	*Euclea delphinii*			+
	Tortricidia testacea		+	+
Lymantriidae	*Dasychira dorsipennata*		+	
	Lymantria dispar		+	+
Noctuidae	*Abagrotis alternata*			+
	Achatodes zeae		+	+
	Acronicta americana		+	+
	Acronicta fragilis	+	+	+
	Acronicta innotata	+	+	+
	Acronicta superans	+		+
	Acronista hasta		+	+
	Agroperina dubitans	+		+
	Agrotis ipsilon	+	+	+
	Amphipoea americana			+
	Amphipyra pyramidoides		+	+
	Amphipyra tragopoginis	+		
	Anaplecoides prasina		+	+
	Anathix puta			+
	Anthix rulla		+	+
	Anomogyna dilucida			+
	Anomogyna fabulosa	+		+
	Anomogyna homogena	+		
	Anticarsia gemmatalis			+

Table 2 -continued

Family	Genus species	Site 1	Site 2	Site 3
Noctuidae	*Apamea finitima*	+		
	Autographa precationis	+	+	+
	Baileya dormitans		+	+
	Baileya opthalmica			+
	Balsa labecula			+
	Balsa tristrigella			+
	Bomolocha abalienalis			+
	Bomolocha baltimoralis			+
	Bomolocha deceptalis		+	
	Bomolocha edictalis	+	+	+
	Bomolocha sp.			+
	Caenurgina crassiuscula			+
	Callopistria cordata		+	
	Callopistra mollissima		+	+
	Catacola amatrix			+
	Catacola blandula			+
	Catacola mira		+	+
	Catacola subnata		+	
	Catacola ultronia		+	
	Charadra deridens	+	+	+
	Chytolita morbidalis		+	
	Chytonix palliatricula		+	
	Colocasia propinguilinea		+	+
	Conservula anodonta			+
	Diachrysia aeroiodes		+	+
	Diarsia jucanda		+	

Table 2 -continued

Family	Genus species	Site 1	Site 2	Site 3
Noctuidae	*Elaphria festivoides*			+
	Elaphria versicolor			+
	Eosphoropteryx thyatyroid	+		
	Euplexia benesimillis	+	+	+
	Eurois astricta		+	+
	Euxoa tessellata	+		
	Faronta diffusa	+		
	Feltia herilis			+
	Feltia tricosa		+	
	Feralia comstocki		+	+
	Graphiphora haurspica		+	+
	Helotropha reniformis			+
	Homoglaea hircina		+	
	Homorthodes furfurata			+
	Hypena humuli		+	+
	Idia americalis		+	+
	Idia conesia		+	
	Idia lubricalis		+	+
	Idia rotundalis		+	+
	Lacinipolia olivacea			+
	Lacinipolia renigera	+		+
	Lacinipolia lorea		+	+
	Lithacodia carneola		+	+
	Lithacodia concinnimacula		+	+
	Lithacodia muscosula		+	+
	Lithacodia synochitis		+	+

Table 2 -continued

Family	Genus species	Site 1	Site 2	Site 3
Noctuidae	*Lithophane grotei*		+	
	Lithophane hemina			+
	Lithophane patefacta	+		+
	Melanchra adjuncta			+
	Morrisonia confusa			+
	Nedra ramosula			+
	Nephalodes minians	+	+	+
	Ochropleau plecta	+	+	+
	Oligia illocata	+	+	+
	Oligia mactata	+	+	+
	Orthodes crenulata			+
	Orthodes cynica	+	+	+
	Orthosia hibisci			+
	Pachypolia atricornis			+
	Palthis angulalis		+	+
	Papaipema impecuniosa		+	+
	Papaipema inquaesita			+
	Papaipema sp.		+	+
	Papaipema unimoda		+	
	Parallelia bistriais		+	+
	Peridroma saucia	+		
	Phlogophora periculosa	+	+	+
	Platypena scabra			+
	Platypolia anceps	+		+
	Platysenta videns	+		
	Plusia putnamia	+	+	+

Table 2 -continued

Family	Genus species	Site 1	2	3
Noctuidae	*Polia detracta*		+	
	Polia imbrifera		+	+
	Polia latex		+	+
	Polia nimbosa		+	+
	Pseudaletia unipuncta	+		
	Pseudaletia vecors		+	+
	Renia sobrialis			+
	Rivula propinqualis		+	+
	Spaelotis cladestina			+
	Suneria bicolorago	+	+	+
	Syngrapha rectangula	+	+	
	Trichoplusia	+		
	Xanthia togata			+
	Xestia adela	+	+	+
	Xestia bicarnea		+	+
	Xestia dolosa		+	+
	Xestia normaniana		+	+
	Xestia smithii	+	+	+
	Xylena nupera	+		
	Zale minerea		+	+
	Zanclognatha cruralis			+
	Zanclognatha laevigata		+	+
	Zanclognatha ochreipennis	+	+	+
	Zanclognatha protumnusali		+	+
	Zanclognatha sp.			+
Notodontidae	*Clostera albosigma*		+	+

Table 2 -continued

Family	Genus species	Site 1	Site 2	Site 3
Notodontidae	*Clostera strigosa*		+	
	Dasylophia anguina		+	
	Dasylophia thyatiroides		+	
	Ellida caniplaga		+	
	Furcula borealis			+
	Gluphiia septentrionis		+	+
	Heterocampa biundata			+
	Heterocampa guttivitta	+	+	+
	Nadata gibbosa		+	+
	Nerice bidentata		+	
	Odontosia elegans		+	
	Oligocentra semirufescens		+	+
	Peridea ferruginea		+	+
	Peridea basitriens		+	+
	Perridea sp.		+	
	Perizoma basiliata		+	
	Phlogophora iris	+	+	+
	Phoesia rimosa		+	
	Schizura ipomoeae		+	+
	Schizura leptinodes		+	+
	Schizura unicornis		+	+
	Symmerista albifrons		+	+
Pyralidae	*Herpetogramma theseusalis*			+
	Pyrausta bicoloralis		+	+
Saturniidae	*Actias luna*	+	+	+
	Antheraea polyphemus		+	+

Table 2 -continued

Family	Genus species	Site 1	Site 2	Site 3
Saturniidae	*Dyrocampa rubicunda*	+	+	+
	Synanthedon acerni		+	
Sphingidae	*Laothoe uglandis*	+		
	Lapara bombycoides	+	+	
	Pachysphinx modesta		+	+
	Paonias myops		+	+
Thyatridae	*Habrosyne scripta*	+	+	+
	Pseudothyatira cymatophor		+	+
Tineidae	*Acrolophus morus*		+	+
Tortricidae	*Clepsis melaleucana*	+	+	+
	Clepsis persicana	+	+	+
	Eulia ministrana			+
	Olethreutes quadrifidus		+	
	Phaneta ochroterminana		+	
	Rhyacionia buoliana			+
	Sparganothis tristriata		+	

SURFACE WATERS

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

by the
Vermont Department of Environmental Conservation

SUMMARY

Aquatic macroinvertebrates were sampled at two sites in the upper Brown's River drainage basin using standardized sampling methods. The macroinvertebrate communities were dominated by mayflies, stoneflies, and caddisflies and were fairly typical of high-qaulity, high-elevation, high-gradient streams in the Green Mountains. Slight differences in community structure suggest potential differences in watershed character. 1992 is the second year of DEC sampling at these sites. Comparison of data between years shows considerable annual variation within certain structural components of the macroinvertebrate community. Overall biological integrity at both sites is excellent.

INTRODUCTION

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

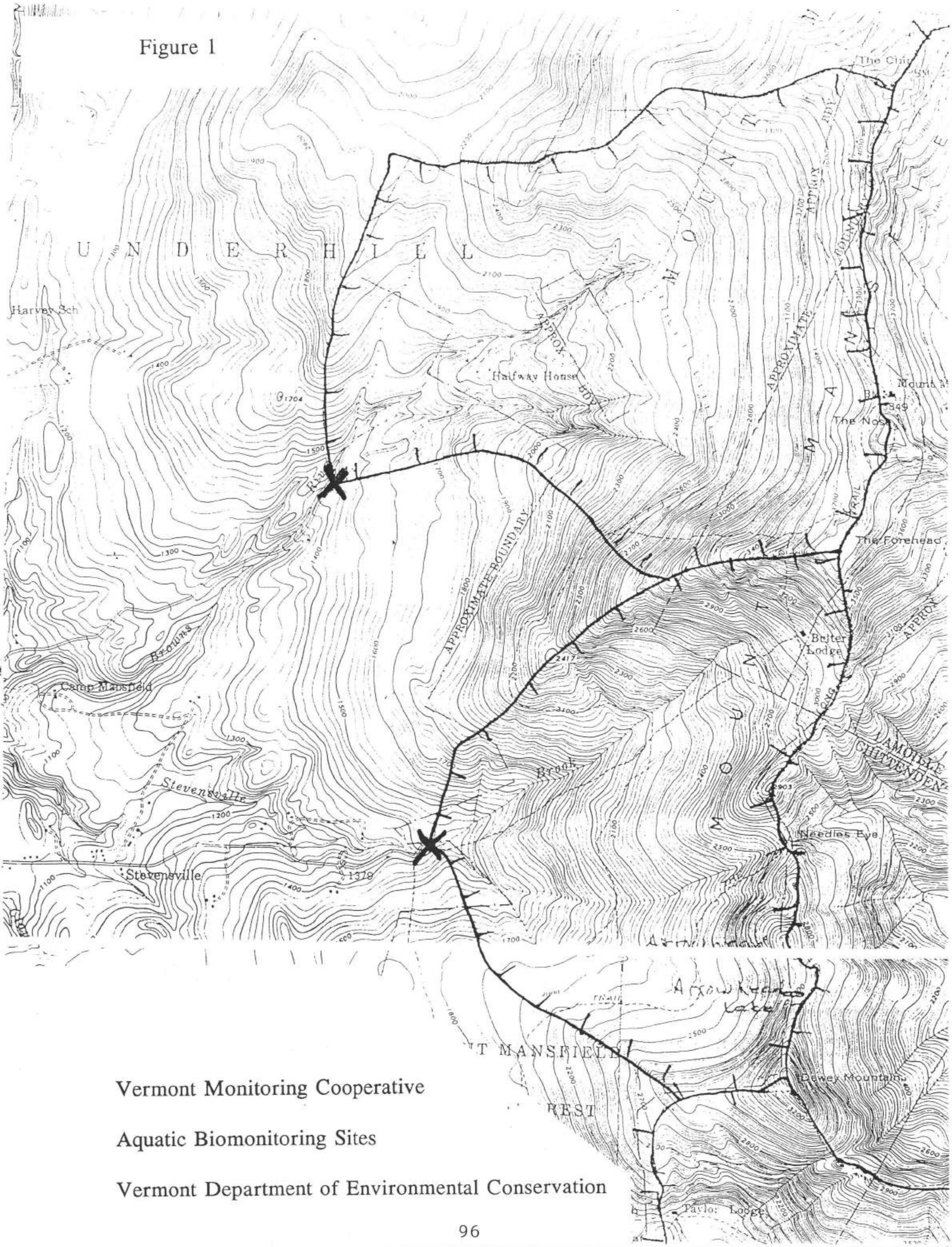
LOCATION

The two sampling sites are located in the upper reaches of the Brown's River watershed - one on Stevensville Brook and one on the Brown's River upstream of its confluence with Stevensville Brook (Figure 1). Both sampling sites are located at an elevation of 1400 feet. The Stevensville Brook site is located about 50m above the bridge at the parking lot for the Nebraska Notch trail (lat 44 30 21:long 72 50 45) and drains approximately 5.2 km^2 of forested watershed. The Brown's River site is located about 100m above the last bridge before the State Park gate (lat 44 51 09:long 72 31 28) and drains approximately 6.1 km^2 of forested watershed. Both sites were sampled on October 19, 1992.

METHODS

Duplicate samples of aquatic macroinvertebrates were collected from riffle areas using a standardized "kick-net" procedure used by DEC at all ABN sites. The use of standardized sampling methods results in an equal sampling effort applied to all sites sampled, providing a quantitative basis for making comparisons between sites. The sampler

Figure 1



Vermont Monitoring Cooperative

Aquatic Biomonitoring Sites

Vermont Department of Environmental Conservation holds a 500u mesh D-frame net in the stream and vigorously disturbs the substrate immediately above the net, dislodging macroinvertebrates associated with the substrate and allowing them to be carried into the net by the current. A sample consists of all the organisms and detritus that are dislodged from the substrate during two minutes (as timed by a stopwatch) of active substrate disturbance. Organisms are removed from the net, placed in labeled jars, and preserved in alcohol or formalin. A habitat evaluation of the sample site is conducted at the time of sampling. Temperature, pH, alkalinity, and specific conductance of the water column are measured at the time the sample is collected. Samples are returned to the DEC laboratory in Waterbury where organisms are separated from the detritus, sorted into taxonomic groups, and identified to the lowest possible taxonomic levels using appropriate identification keys. Data are tabulated and entered into a computer data management system using Paradox software and IBM-compatible DOS-PC systems. Data can be outloaded in a variety of formats, including ASCII, dBase, and Lotus.

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

RESULTS

In 1992, 39 and 43 taxa of aquatic invertebrates were identified from Browns River and Stevensville Brook respectively (Tables 1 and 2), compared with 36 and 35 taxa in 1991. In general, the composition of the invertebrate communities was typical of high elevation oligotrophic streams draining steep forested watersheds and were dominated by species of mayflies, stoneflies, and caddisflies. There were some differences between the two streams.

As in 1991, Stevensville Brook had lower pH and alkalinity than Browns River and had fewer organisms per unit sampling effort.

	pH	Conductance (uS)	Alkalinity (mg/l)
Stevensville Brook (1991)	5.94 (6.05)	25.0 (25.0)	1.00 (1.01)
Brown's River (1991)	6.64 (7.05)	42.0 (36.0)	10.0 (6.41)

There were seven and six taxa that made up 4% or more of the community composition at Stevensville Brook and Brown's River respectively, indicating good eveness of taxa distribution within the community. In Stevensville Brook, two mayfly taxa (Baetis sp. and Epeorus sp.) and a dipteran (Micropsectra sp.) were the three dominant taxa (50%), followed by four stonefly taxa. The same three taxa were dominant in the Brown's River (66%) followed by a stonefly, caddisfly and dipteran. Taxa richness and diversity indices indicate excellent diversity at both sites, with slightly greater diversity indicated at Stevensville Brook.

Physical characteristics at the two sampling sites were very similar: stream velocity was 1.3 and 1.5 feet/second at Stevensville and Brown's respectively; substrate composition was similar with 35% boulder, 30% cobble, 20% course gravel, 10% gravel, and 5% sand at both sites; canopy cover (shading) was 80% at both sites; sampling depth averaged 0.2 m at both sites.

DISCUSSION

Two years of data provide a first glimpse into the annual variation at the two sites. Observations from the 1991 sampling were generally true for the 1992 sampling, although the differences between watersheds were less dramatic in 1992. 1991 was apparently a strong stonefly year as evidenced by the overwhelming dominance of stonefly taxa in Stevensville Brook and, to a lesser extent, in the Brown's River. The relative abundance of stoneflies was greatly reduced at both sites in 1992, due primarily to reduced numbers of the Leuctridae Family of stoneflies and increased abundance of mayflies and Chironomid dipterans. The following Table describes the major community structure and function differences observed between the 1991 and 1992 samples by comparing the relative abundance (per-cent composition) of the important taxonomic and functional groups. The major differences are highlighted.

Taxonomic Order	**% Comp Stevensville 1991 - 1992**	**% Comp Brown's 1991 - 1992**
Diptera	9.5 - 19	**16 - 47**
Ephemeroptera	**2.0 - 40**	26 - 29
Plecoptera	**76 - 28**	**43 - 13**
Trichoptera	12 - 13	14 - 10
Functional Group		
Collector/Gatherer	**7.8 - 54**	**39 - 74**
Collector/Filterer	5.4- 5.4	8.0 - 6.3
Predator	18 - 9.8	15-12
Detrital Shredder	**67 - 28**	**36 - 6.8**

The community structure differences between 1991 and 1992 described above resulted in some differences in the functional composition of the macroinvertebrate communities. In general, functional composition at the two sites showed greater similarity in 1992 than in 1991 with less dominance by detrital/leaf shredders at Stevensville (due to the reduced stonefly numbers) and an increase in fine particulate feeders (primarily Baetid mayflies).

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

Attribute[1]	Statewide Range	Stevensville 1991 - 1992	Brown's 1991 - 1992
Mean Richness	25.5 - 51	27.5 - 37.5	29.5 - 29.0
EPT Richness	13 - 29.5	18 - 20.5	19.5 - 17
Biotic Index	.52 - 2.03	**.52** - .96	.71 - 1.27
% Mayflies	2 - 47	**2** - 40	26 - 29
% Stoneflies	6 - 76	**76** - 28	43 - 13
% Diptera	9 - 53	**9** - 19	16 - 47
% Collector/Gatherer	8 - 74	**8** - 54	39 - **74**
% Detrital Shredder	3 - 67	**67** - 28	36 - 7

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

Several of the attributes for the 1991 Stevensville Brook sample represent extremes of the Statewide distribution for streams of similar size and elevation. The 1992 attributes are well within the Statewide range. Overall biological integrity at both sites, as determined from community attribute evaluation, is excellent.

DEC will continue monitoring these sites on an annual basis. Continued monitoring will permit future evaluation of annual variability observed during the first two years of sampling. More intensive sampling could perhaps lead to some clearer definition of the observed differences in community structure between the two watersheds and provide some information relative to the factors causing these differences.

db\vmc-1992.rep

Biometric Definitions and Attributes

MR	Mean Richness - the average number of taxa found at a site. The number of taxa found at a site is a basic measure of community diversity. Taxa richness can increase with moderate ecosystem enrichment and can decrease from toxic stresses or habitat impairment.
EPT	EPT Richness - the average number of taxa from the sensitive insect orders Ephemeroptera, Plecoptera, Trichoptera. The taxa from the orders are often the first to decrease due to toxic or habit stresses.
MEPT/MR	Mean EPT Value/Mean Richness - the ratio between the average number of EPT taxa and the total taxa at a site. The ratio will generally decrease in areas of environmental stress.
Bio Index (BI)	Hilsenhoff - 1982 - A measure of the community's tolerance of organic enrichment, based on the indicator organism concept where tolerant species are given a higher value (from 0-5) and sensitive species a lower value. The relative abundance of the different species in the stream community determine the overall BI value for the site. Index values less than 1.75 indicate a clean undisturbed site.
Indicator Taxa	The percent composition of those taxa that seem to typify the stream ecosystem type of a site. If as a group they become less dominant then the stream's ecosystem has been altered in some way to the benefit of other taxa.
Percent Plecoptera	The percent composition of the insect order Plecoptera (stonefly) at a site. The relatively high proportion of Plecoptera in these small streams is typical and ecologically significant. The Plecoptera will generally decrease in proportion to the other insect orders when stream temperatures increase or food supplies shift.
Percent Oligocheata	The percent composition of the order Oligocheata at a site. The Oligocheata are not often found in these high gradient mountain streams. They become a significant

component of these communities only when sedimentation and sand are deposited in the substrate from erosion impacts.

Percent Shredders The percent composition of the functional group known as leaf shredders. Leaf shredders are a significant component of undisturbed forest canopied high mountain brooks. Their decrease in dominance would indicate either a shift toward other food sources by the community or an impact to the riparian habitat of the stream.

Percent Collectors The percent composition of the functional group Collectors (filters and gatherers). The collector functional group is known as generalists. The group is typically one of the more dominant functional feeding groups in all streams averaging around 50 percent in minimally disturbed drainages. They generally become proportionally more dominant in disturbed streams either when other functional groups are eliminated due to environmental stresses or the stream is carrying increased amounts of organic silt/matter.

Location: Browns River # 20.8 Town: Underhill Site Id: 461100000208
Device: Kick Net Composites/Rep: 1

Lab Id: 92.097 Date: 10/19/92 Area: 1.00 m2 Number of Reps: 2

Order	Genera	Species	Density	% Comp	Std Err	Minimum	Maximum
COLEOPTERA			18.0	.80	6.00	12.0	24.0
	OPTIOSERVUS	fastiditus	4.0	.18			
	OULIMNIUS	latiusculus	14.0	.62			
DIPTERA			1064.0	47.04	216.00	848.0	1280.0
	ATHERIX	sp	2.0	.09			
	BRILLIA	sp	18.0	.80			
	EUKIEFFERIELLA	brehmi	16.0	.71			
	PARACHAETOCLADIUS	sp	6.0	.27			
	PARAMETRIOCNEMUS	sp	10.0	.44			
	POLYPEDILUM	aviceps	106.0	4.69	2.00	104.0	108.0
	TVETENIA	bavarica	28.0	1.24			
	MICROPSECTRA	sp	860.0	38.02	220.00	640.0	1080.0
	ANTOCHA	sp	2.0	.09			
	DICRANOTA	sp	14.0	.62			
	HEXATOMA	sp	2.0	.09			
EPHEMEROPTERA			656.0	29.00	12.00	644.0	668.0
	BAETIS	tricaudatus	332.0	14.68	0.00	332.0	332.0
	EPHEMERELLA	sp	2.0	.09			
	HEPTAGENIIDAE	unid	8.0	.35			
	EPEORUS	sp	306.0	13.53	26.00	280.0	332.0
	PARALEPTOPHLEBIA	sp	8.0	.35			
TRICHOPTERA			232.0	10.26	24.00	208.0	256.0
	PARAPSYCHE	apicalis	0.0	0.00			
	SYMPHITOPSYCHE	slossonae	28.0	1.24			
	SYMPHITOPSYCHE	sparna	2.0	.09			
	LEPIDOSTOMA	sp	38.0	1.68			
	APATANIA	sp	2.0	.09			
	HYDATOPHYLAX	sp	0.0	0.00			
	NEOPHYLAX	sp	0.0	0.00			
	DOLOPHILODES	sp	112.0	4.95	16.00	96.0	128.0
	RHYACOPHILA	fuscula	18.0	.80			
	RHYACOPHILA	carolina	30.0	1.33			
	RHYACOPHILA	fenestra	2.0	.09			
PLECOPTERA			290.0	12.82	82.00	208.0	372.0
	CAPNIIDAE	unid	2.0	.09			
	CHLOROPERLIDAE	unid	174.0	7.69	66.00	108.0	240.0
	LEUCTRIDAE	unid	22.0	.97			
	PELTOPERLA	sp	30.0	1.33			
	AGNETINA	capitata	0.0	0.00			
	ISOPERLA	sp	2.0	.09			
	MALIREKUS	hastatus	16.0	.71			
	PTERONARCYS	sp	6.0	.27			
	PTERONARCYS	dorsata	0.0	0.00			
	TAENIONEMA	sp	38.0	1.68			
LEPIDOPTERA			2.0	.09	2.00	0.0	4.0
	ARCHIPS	sp	2.0	.09			

Location: Browns River # 20.8 Town: Underhill Site Id:
Device: Kick Net Composites/Rep:
Lab Id: Date: Area: m2 Number of Reps: 2

Order	Genera	Species	Density	% Comp	Std Err	Minimum	Maximum
TOTAL			2262.0	100.00	318.00	1944.0	2580.0

Location: Stevensville Brook # 2.1 Town: Underhill Site Id: 461143000021
Device: Kick Net Composites/Rep: 1

Lab Id: 92.098 Date: 10/19/92 Area: 1.00 m2 Number of Reps: 2

Order	Genera	Species	Density	% Comp	Std Err	Minimum	Maximum
COLEOPTERA			1.0	.11	1.00	0.0	2.0
	OPTIOSERVUS	fastiditus	1.0	.11			
DIPTERA			176.8	18.70	20.77	156.0	197.5
	BEZZIA	sp	1.9	.20			
	BRILLIA	sp	10.5	1.11			
	CRICOTOPUS	sp	11.3	1.20			
	EUKIEFFERIELLA	brevicalar	4.8	.50			
	PAGASTIA	sp	.9	.10			
	PARACHAETOCLADIUS	sp	7.5	.79			
	PARAMETRIOCNEMUS	sp	6.7	.71			
	POLYPEDILUM	aviceps	6.8	.72			
	RHEOCRICOTOPUS	sp	16.3	1.73			
	THIENEMANNEMYIA	sp	6.0	.63			
	TVETENIA	bavarica	1.0	.11			
	MICROPSECTRA	sp	91.6	9.69	13.62	78.0	105.2
	PROSIMULIUM	mixtum	1.9	.20			
	SIMULIUM	tubersom	3.8	.41			
	DICRANOTA	sp	1.9	.20			
	HEXATOMA	sp	1.9	.20			
	TIPULA	sp	.9	.10			
	MOLOPHILUS	sp	.9	.10			
EPHEMEROPTERA			379.5	40.15	6.54	372.9	386.0
	BAETIS	tricaudatus	271.7	28.75	.31	271.4	272.0
	EURYLOPHELLA	funeralis	7.7	.81			
	EPEORUS	sp	100.1	10.59	5.92	94.2	106.0
TRICHOPTERA			118.2	12.50	1.85	116.3	120.0
	PARAPSYCHE	apicalis	12.3	1.30			
	SYMPHITOPSYCHE	slossonae	4.8	.50			
	SYMPHITOPSYCHE	ventura	5.7	.60			
	LEPIDOSTOMA	sp	33.8	3.57	4.23	29.5	38.0
	NEOPHYLAX	sp	2.9	.31			
	DOLOPHILODES	sp	22.9	2.43			
	POLYCENTROPUS	sp	2.9	.31			
	RHYACOPHILA	fuscula	19.1	2.02			
	RHYACOPHILA	carolina	2.0	.21			
	RHYACOPHILA	fenestra	7.8	.82			
	RHYACOPHILA	minora	4.0	.42			
PLECOPTERA			267.8	28.34	23.85	244.0	291.7
	CAPNIIDAE	unid	25.1	2.65			
	CHLOROPERLIDAE	unid	43.8	4.63	9.77	34.0	53.5
	LEUCTRIDAE	unid	69.2	7.32	2.77	66.5	72.0
	NEMOURIDAE	unid	10.9	1.16			
	AMPHINEMURA	sp	23.2	2.46			
	PELTOPERLA	sp	42.7	4.52	12.69	30.0	55.4
	ACRONEURIA	carolinesis	.9	.10			
	TAENIONEMA	sp	52.0	5.50	20.00	32.0	72.0
DECAPODA			.9	.10	.92	0.0	1.8

Location: Stevensville Brook # 2.1 Town: Underhill Site Id: 461143000021
Device: Kick Net Composites/Rep: 1

Lab Id: 92.098 Date: 10/19/92 Area: 1.00 m2 Number of Reps: 2

Order	Genera	Species	Density	% Comp	Std Err	Minimum	Maximum
DECAPODA	CAMBARUS	sp	.9	.10			
OLIGOCHAETA			1.0	.11	1.00	0.0	2.0
	ENCHYTRAEIDAE	uid	1.0	.11			
TOTAL			945.2	100.00	35.15	910.0	980.3

Streamflow and water quality monitoring on Mt. Mansfield

James Shanley, US Geological Survey, Montpelier, Vermont

Introduction: The USGS proposes to install and operate two stream gaging and water quality stations at Mt. Mansfield. At least 30 samples annually will be collected at each site, including monthly and selected high-flow samples. Samples will be analyzed for nutrients, major inorganic solutes, silica, aluminum, and dissolved organic carbon.

The objectives of the stations are to 1) calculate a water budget, and estimate evapotranspiration, 2) quantify solute fluxes from the ecosystem, 3) assess the degree of "nitrogen saturation" in the forest, and 4) evaluate the susceptibility of the streams to acidification from atmospheric deposition and the threat of aluminum toxicity to fish.

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

Reconnaissance: A reconnaissance sampling trip was made on November 6, 1992 to collect preliminary data for the siting of the monitoring stations. Measurements of temperature, pH, and specific conductance were made at 27 sites in Browns River watershed (6.1 sq. km) and 9 sites in Stevensville Brook watershed (5.2 sq. km) (Fig. 1). As a follow-up, 3 low-elevation sites (Browns River and two branches of Stevensville Brook) were sampled for full major ion analysis on November 13, 1992.

Temperature, specific conductance, and pH are easily obtained field measurements that are useful as broad hydrochemical indicators. Specific conductance is a general indicator of the total dissolved solids, which in turn reflects the amount of rock weathering that has occurred. The Underhill State Park has a single bedrock type -- quartz-mica-albite schist. Thus, variations in conductance are likely a function of 1) variations in thickness of glacial deposits, which will affect water residence time, 2) variation in the composition of those deposits (which may be derived from outside the local area), or 3) presence or absence of fracture flow through bedrock (fracture flow promotes greater weathering). In acidic headwater streams, strong acids may be present in sufficient quantities to dominate the specific conductance. A pH less than 5.0 in clear-water streams indicates acidification by atmospheric deposition.

Stream temperature is a useful indicator of the source of water to the stream - surficial or near-surface sources vs. groundwater. In November, groundwater temperatures are much warmer than near-surface temperatures, thus a warmer stream temperature suggests that a relatively greater amount of flow is contributed by groundwater.

Results and interpretations: In general, waters draining the west slope of Mt. Mansfield are poorly buffered. Headwater streams at high elevation, in particular, are quite acidic (pH<5.0). This is attributed to relatively unreactive bedrock, limited thickness of overburden (glacial till), and limited soil development. Buffering, as indicated by pH increase to 6.0 or greater, increases as stream size increases. Buffering is greater at Browns River than at Stevensville Brook. No high elevation sites were sampled at Stevensville. However, the low elevation areas are at pH 5.5 to 6.5, compared to near 7.0 at Browns River. Of the two branches of Stevensville Brook, the North branch is the least buffered. The low pH and conductivity of these streams at a time of average flow conditions suggests that these streams are susceptible to acidification episodes, uncommon for streams of this size. Browns River has three main branches which converge above the lowest sampling point. Below this confluence, the stream is circumneutral. Water from the southernmost branch (point A, Fig. 1) was also near pH 7.0, but had lower conductance, suggesting somewhat lower alkalinity. A sampling site higher on the middle branch (point B, Fig. 1) had a strikingly low pH (5.15) and conductance (18.2). It appears that significant neutralization in the Browns River watershed occurs in the lowest 20% of the basin.

Temperatures of headwater streams in Browns River ranged from 0.9 to 4.7 °C. The warmer streams reflect groundwater inputs. Colder streams reflect more surficial hydrologic pathways and/or a long in-channel residence time that allowed cooling from the cool atmosphere. Larger stream temperatures ranged between 2 and 3 °C (Fig. 2), reflecting a balance between increased groundwater inputs and increased residence time in the larger streams. The variation in temperature of the small headwater streams suggest heterogeneity in streamflow generation mechanisms.

In the headwater streams, conductance is clearly controlled by pH (Fig. 3). Conductance is nominally higher than the minimum conductance possible for a given pH. At pH>5.5, this inverse relation shifts to a positive relation; hydrogen ion contribution becomes negligible and conductance is controlled by alkalinity and major inorganic ions. Interestingly, the conductance at Stevensville sites remains constant near 20 across a broad range of pH.

In keeping with the conceptual model, pH generally increases as flow increases (Fig. 4). The two small streams sampled at Stevensville watershed are anomalies; however, these are the lowest-gradient small streams sampled, and thus are more likely than the other small streams to be dominated by groundwater inputs. The generally greater neutralization at downstream sites at Browns River is again evident, though the upstream site on the middle branch (point B, Fig. 1) is again a notable exception (more acidic than the trend).

The major ion analysis (Table 1) confirms that Stevensville Brook is poorly buffered. The north branch was acidified (negative alkalinity) whereas the south branch had a low but positive alkalinity. As expected, the greater acidity in the north branch is reflected in greater aluminum concentrations (380 µg/L vs. 225 µg/L in the south branch). Sulfate concentrations at all sites are near 5 mg/L, similar to those in precipitation, suggesting that these basins do not retain sulfate. Sulfate is the dominant anion; nitrate concentrations are quite low at all sites. The lower alkalinities at Stevensville result from slightly higher sulfate and lower base cation concentrations relative to Browns River. The difference in the two branches of Stevensville is explained primarily by a much lower calcium concentration in the north branch.

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

Monitoring options: In view of the objective of coordinating watershed hydrology and solute flux monitoring with research on elemental cycling in forest ecosystems, the choice of monitoring sites is dependent on the degree of specificity desired. Determining solute fluxes at 1300 ft on Browns River would provide an integrated measure of biogeochemical processing of the western slope of Mt. Mansfield. But to refine the view to chemical budgets of high-elevation spruce-fir communities, for example, a smaller headwater stream is more appropriate. An upstream/downstream approach, with a station at each of the two scales, is a pragmatic solution in that it provides the specificity to evaluate a single ecosystem as well as the role of that system within the "big picture." In Browns River, particularly, investigations at these two scales has an added research interest because of the significant buffering capacity that streamwater acquires in the lower part of that basin. The upstream/downstream approach could address the mechanisms controlling this change in chemistry.

Other monitoring options include a down-basin site in each watershed (maximum integration), 2 upbasin sites in Browns River (maximum specificity, easy access), a headwater site in each basin, and the north and south branches of Stevensville Brook (possible paired watershed / watershed management studies).

Acknowledgements: Tim Scherbatskoy, Eveline Leone, and Jim Kellogg participated in the reconnaissance and Jim also collected and analyzed the samples for major ions.

Table 1. Mt. Mansfield stream chemistry

All units except pH mg/L unless otherwise indicated.

	Elevation (ft)	pH	Alk (as $CaCO_3$)	Ca	Mg	Na	K	Al (µg/L)	SO_4	NO_3 (as N)	Cl
Browns River	1280	7.05	2.07	1.86	0.47	0.34	0.21	215	4.87	0.10	0.28
Stevensville north branch	1430	4.96	-0.25	1.21	0.21	0.29	0.24	380	5.40	0.06	0.30
Stevensville south branch	1430	5.78	0.48	1.70	0.26	0.29	0.22	225	5.36	0.11	0.30

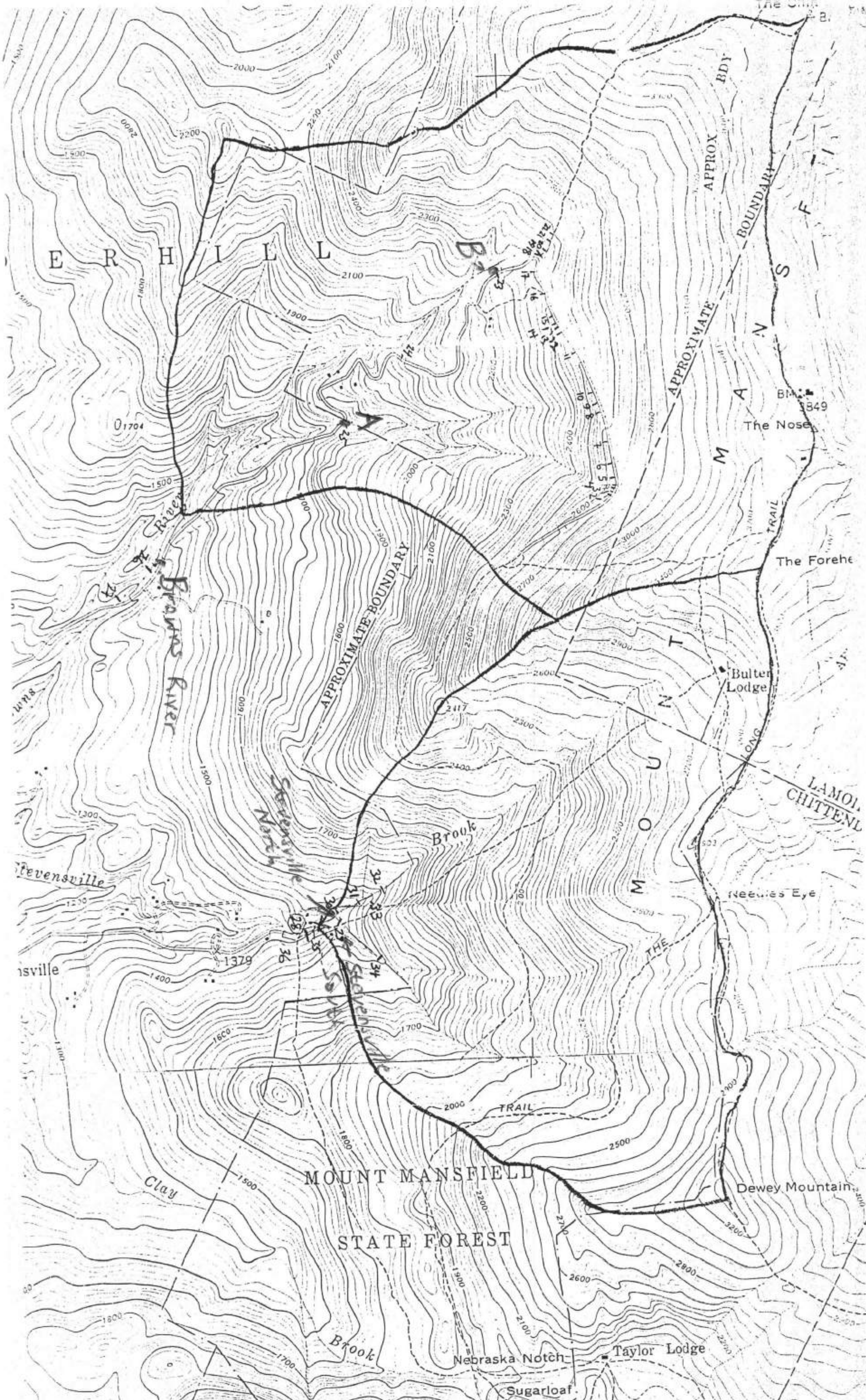
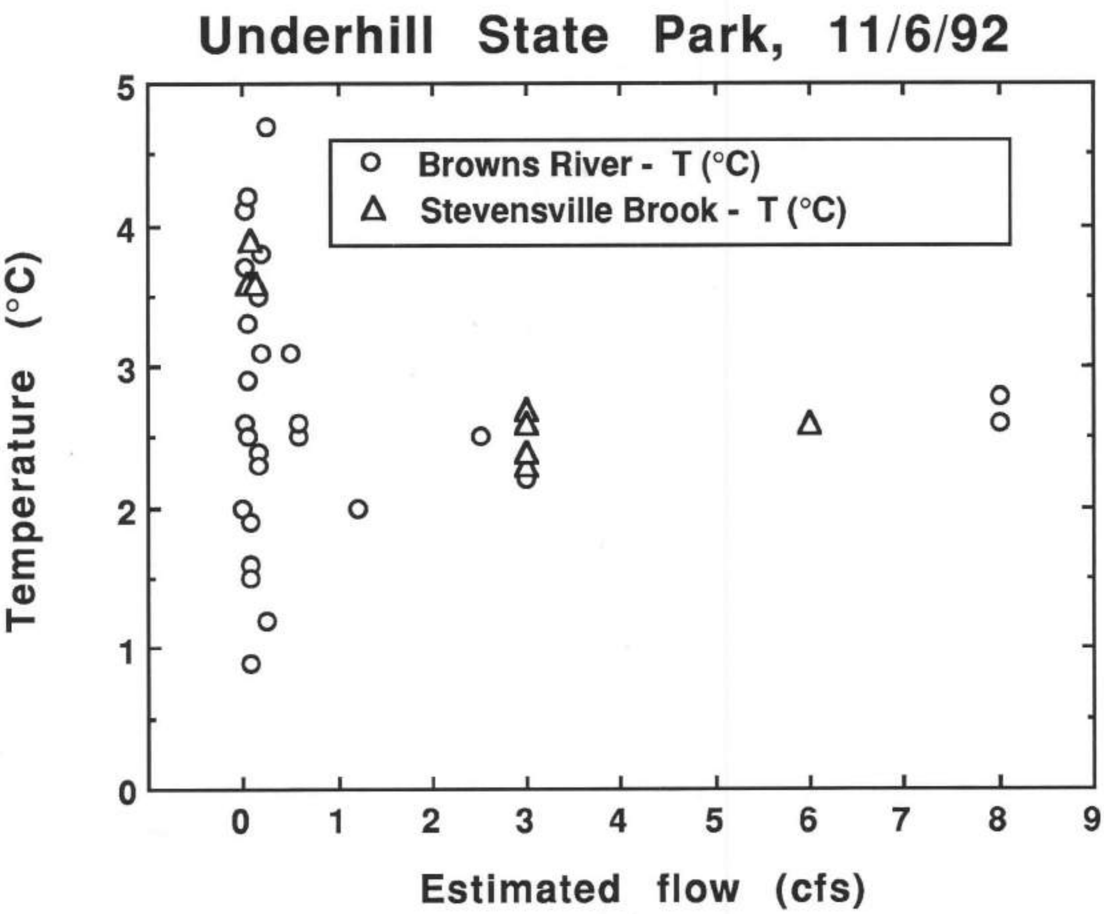


Figure 1

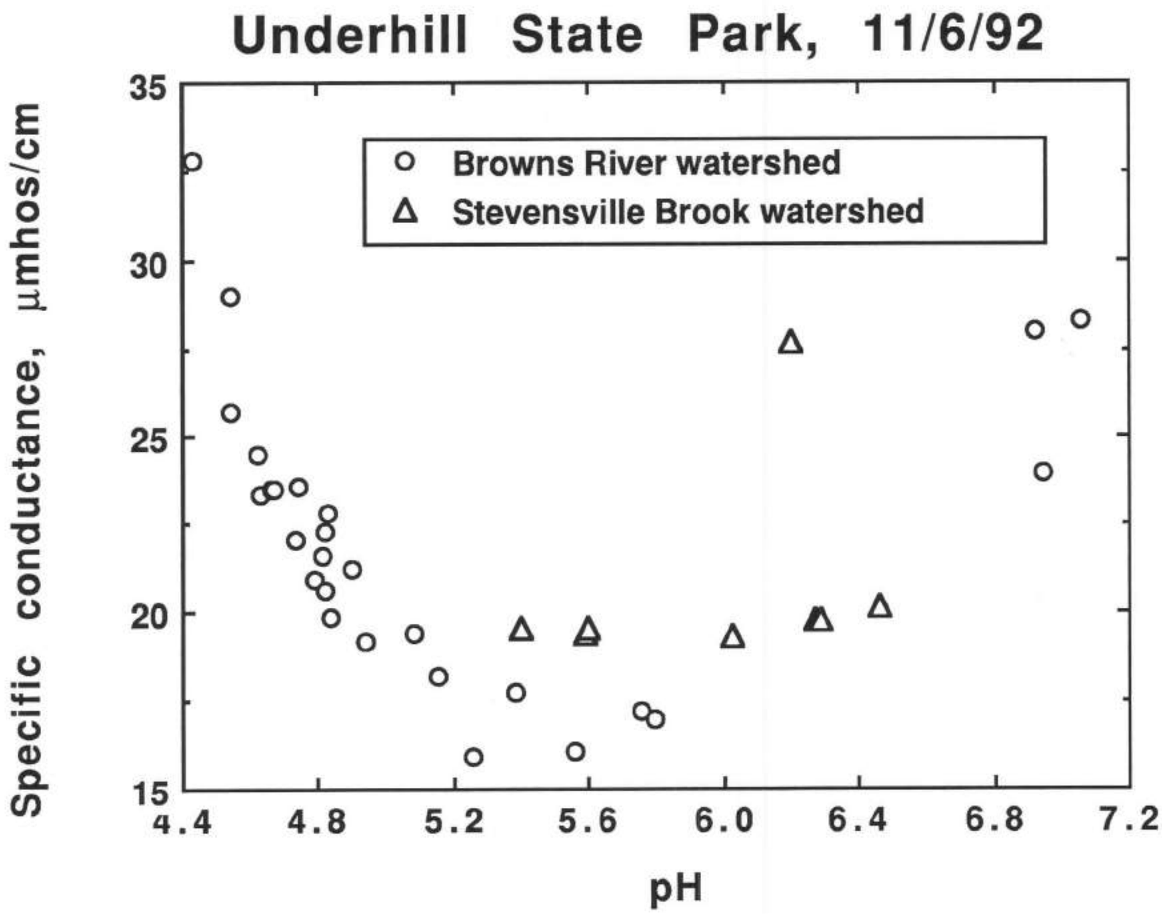
• 7 sampling site

Figure 2



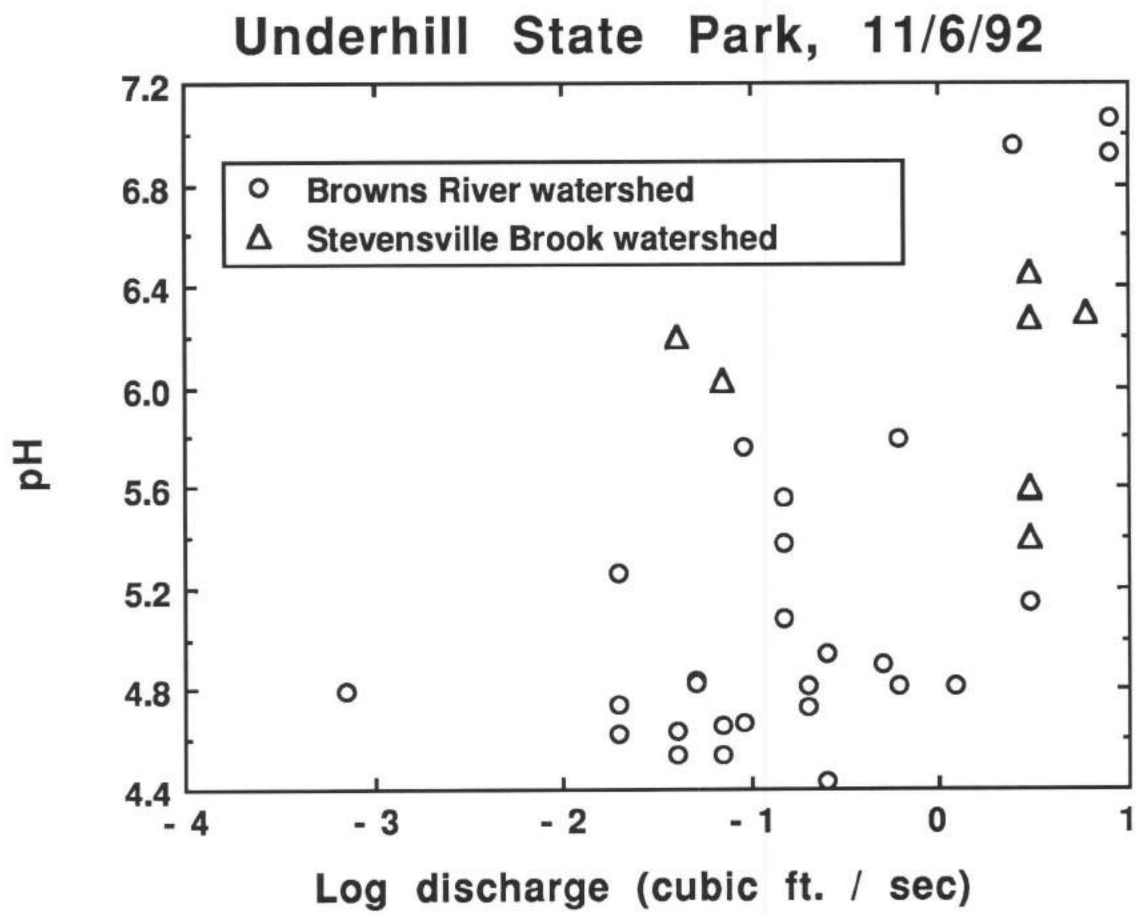
Underhill State Park, 11/6/92
Browns River - T (°C)
Stevensville Brook - T (°C)
Temperature (°C)
Estimated flow (cfs)
0
1
2
3
4
5
6
7
8
9

Figure 3



Underhill State Park, 11/6/92
Browns River watershed
Stevensville Brook watershed
Specific conductance, µmhos/cm
pH
35
30
25
20
15
4.4
4.8
5.2
5.6
6.0
6.4
6.8
7.2

Figure 4



Underhill State Park, 11/6/92
7.2
6.8
6.4
6.0
5.6
5.2
4.8
4.4
pH
Browns River watershed
Stevensville Brook watershed
- 4
- 3
- 2
- 1
0
1
Log discharge (cubic ft. / sec)

ATMOSPHERIC

MEASUREMENT OF ENVIRONMENTAL AND POLLUTANT GRADIENTS

IN THE FOREST CANOPY

Tim Scherbatskoy and Carl Waite
School of Natural Resources
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Cooperators:

Deane Wang and Scott Heald, UVM School of Natural Resources
David Ellsworth, UVM Botany Department

ABSTRACT

During spring and summer 1992 we installed instrumentation at five elevations (0.5, 7.5, 12.0, 16.0, and 24.0 m above the ground) on the VMC tower at the Proctor Maple Research Center in Underhill, VT (PMRC) to collect continuous meteorological and ozone (O_3) data. Meteorological variables continuously monitored at all five levels include: temperature, relative humidity, wind speed and direction, and surface wetness. Variables monitored at the top of the tower only (22.0 m) include total solar radiation and photosynthetically active radiation (PAR). All data are logged to a Campbell 21X datalogger or a PC as 15 min. means. Examination of monthly average temperature and relative humidity showed no significant differences in these variables among the five elevations. Absolute values for surface wetness (% of time wet) varied from month to month, but within any one month, surface wetness generally decreased with increasing height on the tower. In late summer (August) wind speeds at the lower two heights (0.5 and 7.5 m) were about 20-25% of those at the top of the tower (24.0 m) and 50% of those recorded at the top of the canopy (16.0 m). When wind speed during months with leaves present (August) and without leaves (November) were compared in vertical wind profiles, a non-linear relationship between wind speed and height was found when leaves were present. After leaf-fall, the non-linear relationship was observed only between the two lower (0.5 and 7.5 m) elevations while wind speed increased at a constant rate with height between 7.5 and 24.0 m. Ozone concentrations near the ground (0.5 m) were found to be significantly lower than the average O_3 concentrations for all heights by as much as 17 ppb. Possible explanations for reduced O_3 concentrations near the soil surface include O_3 "scavenging", believed to occur when nitrogen oxides (NO_x) react with O_3, or lack of adequate mixing of air near the ground due to a boundary layer effect. Leaf area index (LAI) estimates were made at four elevations (0.5, 7.5, 12.0, and 16.0 m) on the VMC tower using both the LI-2000 leaf area index meter and Ceptometer PAR attenuation wand. LAI estimates decreased with increasing height and estimates made with the LI-2000 were generally lower and less variable than those made with the Ceptometer wand.

Objectives:

The goal of this research is to improve our knowledge of variation in canopy-atmosphere interactions within the forest canopy using the 22 m research tower, located in a mature hardwood stand, at the Proctor Maple Research Center (PMRC). At heights of 0.5, 7.5, 12.0, 16.0, and 24.0 m above the ground (from ground-level to above the canopy) we are:

1. monitoring ambient environmental conditions (meteorology and ozone {O_3}) underneath, within, and above a northern hardwood forest canopy. Meteorological variables continuously measured and recorded as 15 minute means at all 5 heights include: temperature, relative humidity, wind speed and direction, and surface wetness. Variables continuously measured (recorded as 15 min. means) above the canopy (22 m) include: total solar radiation (400-1100 nm) and photosynthetically active radiation (PAR; 400-700 nm).

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

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

4. planning in the future to measure wind speed and direction in three dimensions and calculate ozone deposition at several heights using eddy correlation techniques.

Methods:

In April 1992, we began receiving and installing the meteorological equipment on the research tower at PMRC. Total solar radiation and PAR sensors (LICOR models 200SA and 190SA, respectively), along with the CSI 21X datalogger, were the first instruments to arrive and were installed and collecting data by mid-May. Monitoring of O_3 concentration (TECO O_3 monitor) began on 8 July at 7.5 m only, with data recorded as 15 minute means to a PC. On 23 July, the scanivalve (Scanivalve Corp., San Diego, CA), which automatically switches channels to allow consecutive sampling at different heights, was made operational and O_3 concentrations at all 5 levels on the tower were recorded as 15 minute means to a PC. In the future O_3 monitoring will begin by 1 April and continue until the end of October. Temperature and relative humidity (CSI model 207), wind speed and direction (R.M. Young AQ wind monitors), and surface wetness (CSI model 237) sensors were installed at all 5 heights, calibrated, and data collection to the 21x datalogger began on 13 August.

An attempt to quantify the phenology of leaf-out and foliage distribution around the tower was made using hemispherical photographs (fisheye lens), PAR attenuation measurements using a Sunfleck Ceptometer wand (Decagon Devices, Pullman, WA), LAI measurements using the LI-2000 (LICOR, Lincoln, NE), and a photographic sight-obstruction technique. Measurements of the first three variables began 1 May and were repeated at weekly or biweekly intervals with the most intensive sampling being conducted during the most active period of leaf-out (15 May-15 June). Measurements were taken at 0.5, 7.5, 12.0, and 16.0 m heights at an approx. 45^{o} angle from each corner of the tower and 0.5 m outside the structure of the tower. Both image analysis hardware and software were used to analyze the hemispherical photographs. The LI-2000 has its own algorithm for calculating LAI while the Beer-Lambert equation ($-Ln\{Q_1/Q_2\}/K$) where Q_1=PAR at the point of measurement, Q_2=ambient PAR without canopy interference (top of tower), and K=the coefficient of extinction estimated to be 0.65 from the research literature was used to calculate LAI from Ceptometer data. These estimated LAI values were compared to LAI measurements made on similar dates using the LI-2000. The photographic sight-obstruction measurements were made only a single time (in August) during the season.

Significant Findings:

General Trends. Monthly average temperature, relative humidity, surface wetness, and wind speed and direction at all five heights along the tower were plotted for August through December (1992). Examination of these variables showed no significant differences in temperature or relative humidity among the five heights (Fig. 1). A general seasonal decrease in average temperature at all heights was observed throughout this period. Although there was a tendency for relative humidity to decrease with increasing height, no distinct seasonal decrease pattern was observed. Absolute values for surface wetness (% of time wet) varied from month to month, but within any one month, there was a general decrease in surface wetness with increasing height, although it is not known at this time if any of the differences are significant (Fig. 1). Monthly average wind speeds in late summer at the two lower heights (0.5 and 7.5 m) were roughly 20-25% those recorded at the top of the tower (24.0 m) and 50% of those measured at the top of the canopy (16.0 m) (Fig. 2, August). By November there was a slight seasonal increase in average wind speed at all heights, but relative wind speeds at the top of the canopy (16.0 m), when compared to those at 24.0 m, had increased substantially (Fig. 2, November). In August, wind was predominantly out of the south at the three upper heights and out of the southeast at the two lower heights. Winds in November were generally out of the south at all heights.

Ozone. Examination of O_3 concentrations at all five heights on the tower revealed that although O_3 levels generally became greater with increasing height, concentrations just above the ground (0.5 m) were significantly lower by as much as 17 ppb than the average concentrations of all levels (Fig. 3). When daily maximum O_3 concentrations, based on hourly averages, were plotted against height on the tower we again found a significant increase in O_3 concentrations between the 0.5 and 7.5 m levels, but maximum concentrations did not increase with height from 7.5 to 24 m (Fig. 4). This would suggest that with the exception of the near-ground level, all other heights, including the entire canopy, were exposed to similar "threshold" O_3 concentrations. An examination of seven-hour (9 am - 4 pm) average daily ozone concentrations vs. height also showed the significant increase in O_3 between 0.5 and 7.5 m above the ground with concentrations increasing slightly, but probably not significantly, with height above 7.5 m (Fig. 4). This indicates a slight increase in "dose" levels of O_3 with increasing height above 7.5 m and suggests that mixing of the air at the upper four heights is not completely uniform. One possible explanation for the apparent reduction in O_3 concentration near the ground may be O_3 "scavenging" or break-down believed to occur when nitrogen oxides (NO_x), produced by anaerobic bacteria in the soil, react with O_3. Ozone "scavenging" is usually associated with urban sites, although, there is no reason to think it could not occur in rural areas. These lower O_3 concentrations observed near the ground could also be caused by a lack of adequate mixing of air near the ground caused by a boundary layer effect. Periods of time when differences in O_3 concentrations between 0.5 m and other heights were greatest were usually accompanied by lower wind speeds.

Vertical Wind Speed Profile: When average monthly wind speeds (m/s) were plotted against height on the tower and compared during months with and without leaves on the trees, a non-linear relationship was found to exist when leaves were present (August) (Fig. 5). Without leaves (December), a non-linear relationship held true only between the two lowest levels (0.5 and 7.5 m) while at heights above 7.5 m, wind speed increased at a constant rate with height (Fig. 5). It would appear that the presence of leaves substantially dampens wind speed within and even below the canopy. Because this relationship was examined for only a limited time frame, it must be more thoroughly examined to see if it holds true for most periods with and without leaves.

Leaf Area Index: Leaf area index (LAI) was estimated at four heights (0.5, 7.5, 12.0, 16.0 m) on the VMC research tower using both the LI-2000 and Sunfleck Ceptometer. As expected, LAI values using both instruments decreased with increasing height on the tower. LAI values from

Figure 1. Average monthly temperature, relative humidity, and surface wetness at five elevations (0.5, 7.5, 12.0, 16.0, and 24.0 m above the ground) along a vertical gradient on the VMC Research Tower at the Proctor Maple Research Center in Underhill, VT.

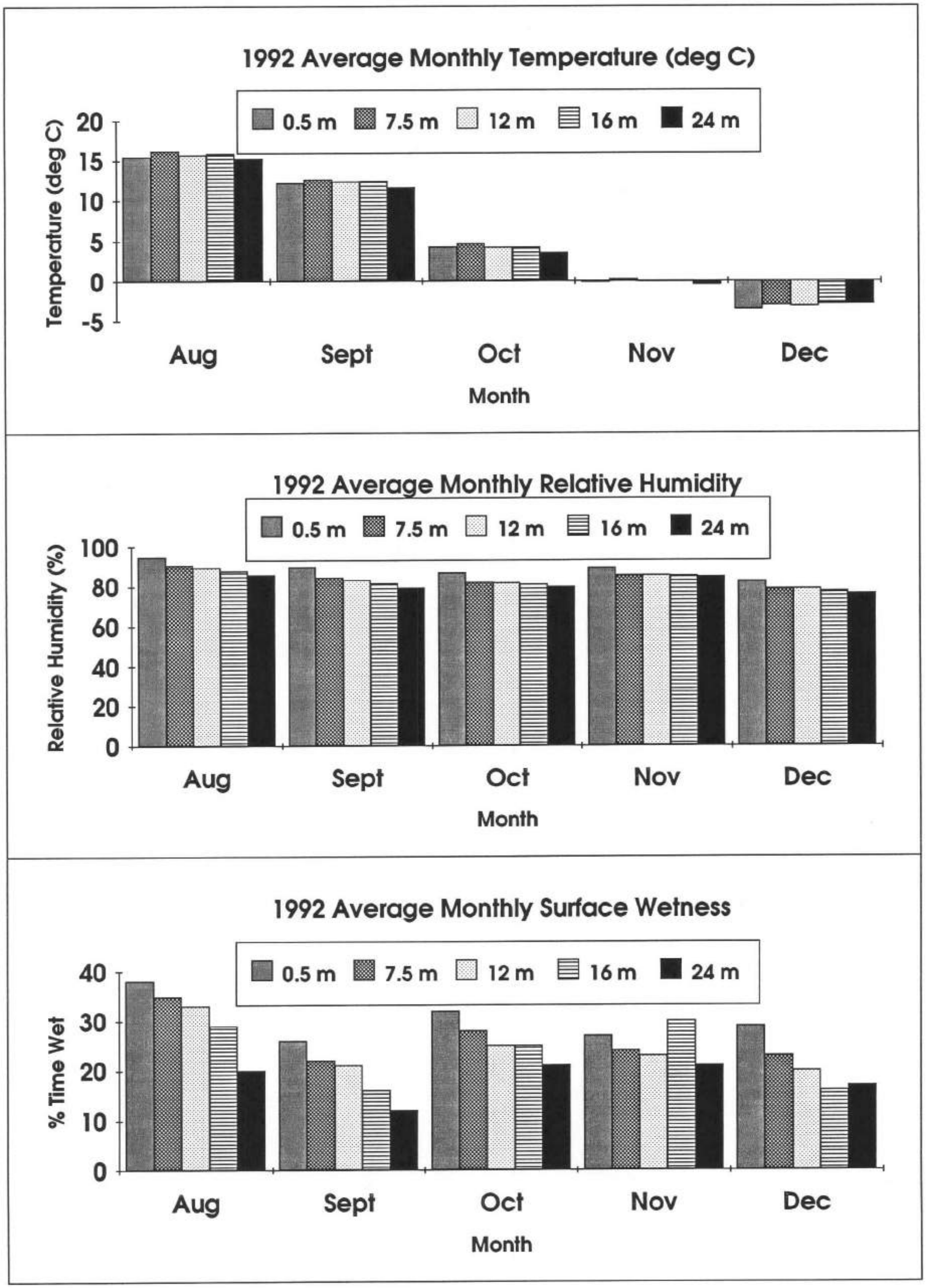
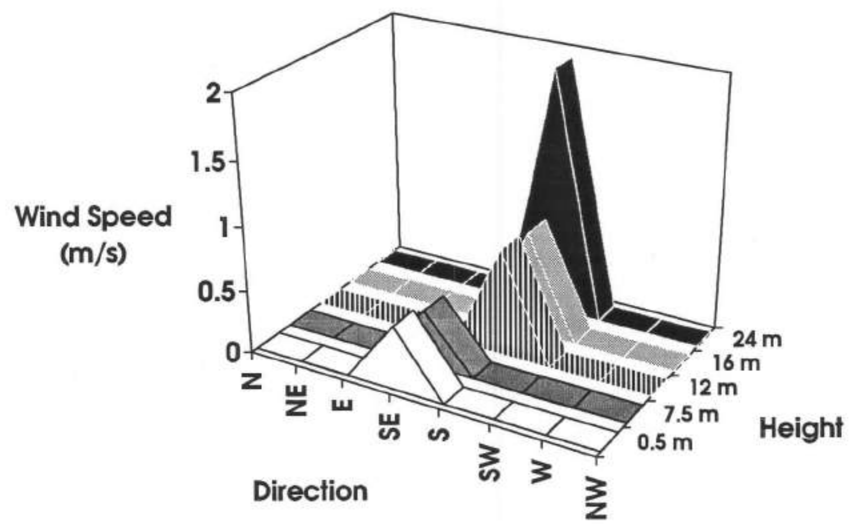
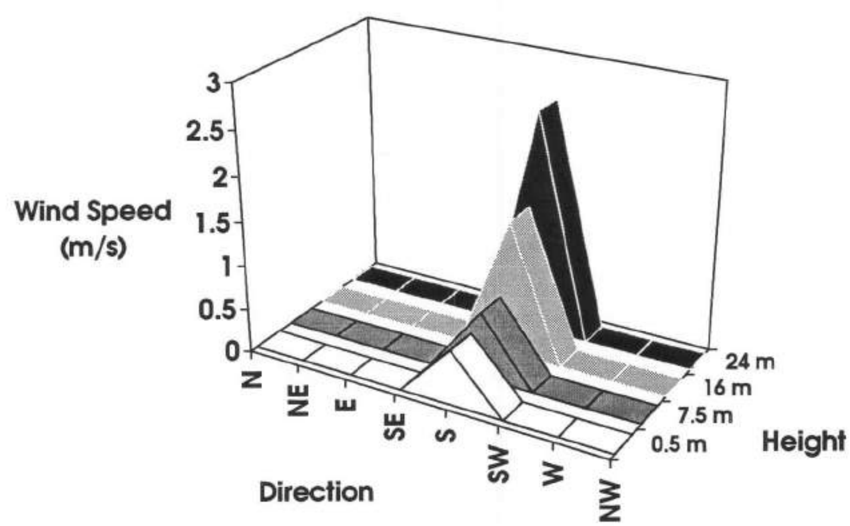


Figure 2. Average wind speed and direction in August and November 1992, recorded at five elevations (0.5, 7.5, 12.0, 16.0, and 24.0 m above the ground) along a vertical gradient on the VMC Research Tower at the Proctor Maple Research Center in Underhill, VT.





Note: No wind speed or direction data was collected at 12 m in November 1992.

Figure 3. Variation in ozone concentration with height measured at five elevations (0.5, 7.5, 12.0, 16.0, and 24.0 m above the ground) along a vertical gradient on the VMC Research Tower at the Proctor Maple Research Center in Underhill, VT and expressed as deviations from the average ozone concentration for all five elevations.

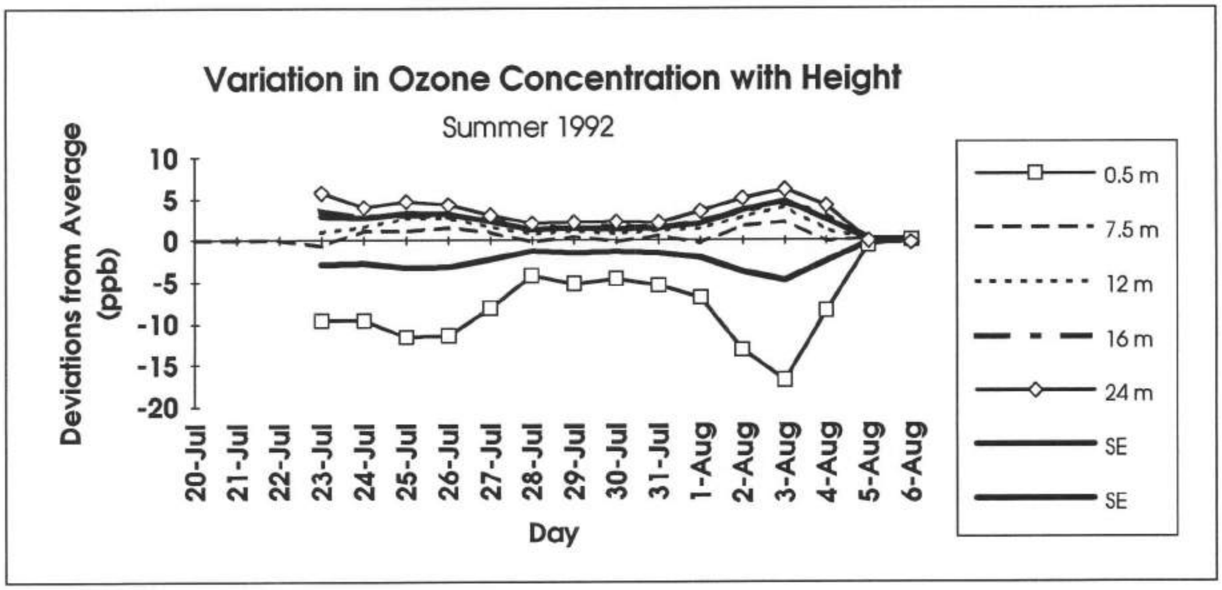


Figure 4. Vertical profiles on four representative dates during summer 1992 for one hour maximum and seven hour average (9 am-4 pm) ozone concentrations measured at five elevations (0.5, 7.5, 12.0, 16.0, and 24.0 m above the ground) along a vertical gradient on the VMC Research Tower at the Proctor Maple Research Center in Underhill, VT.

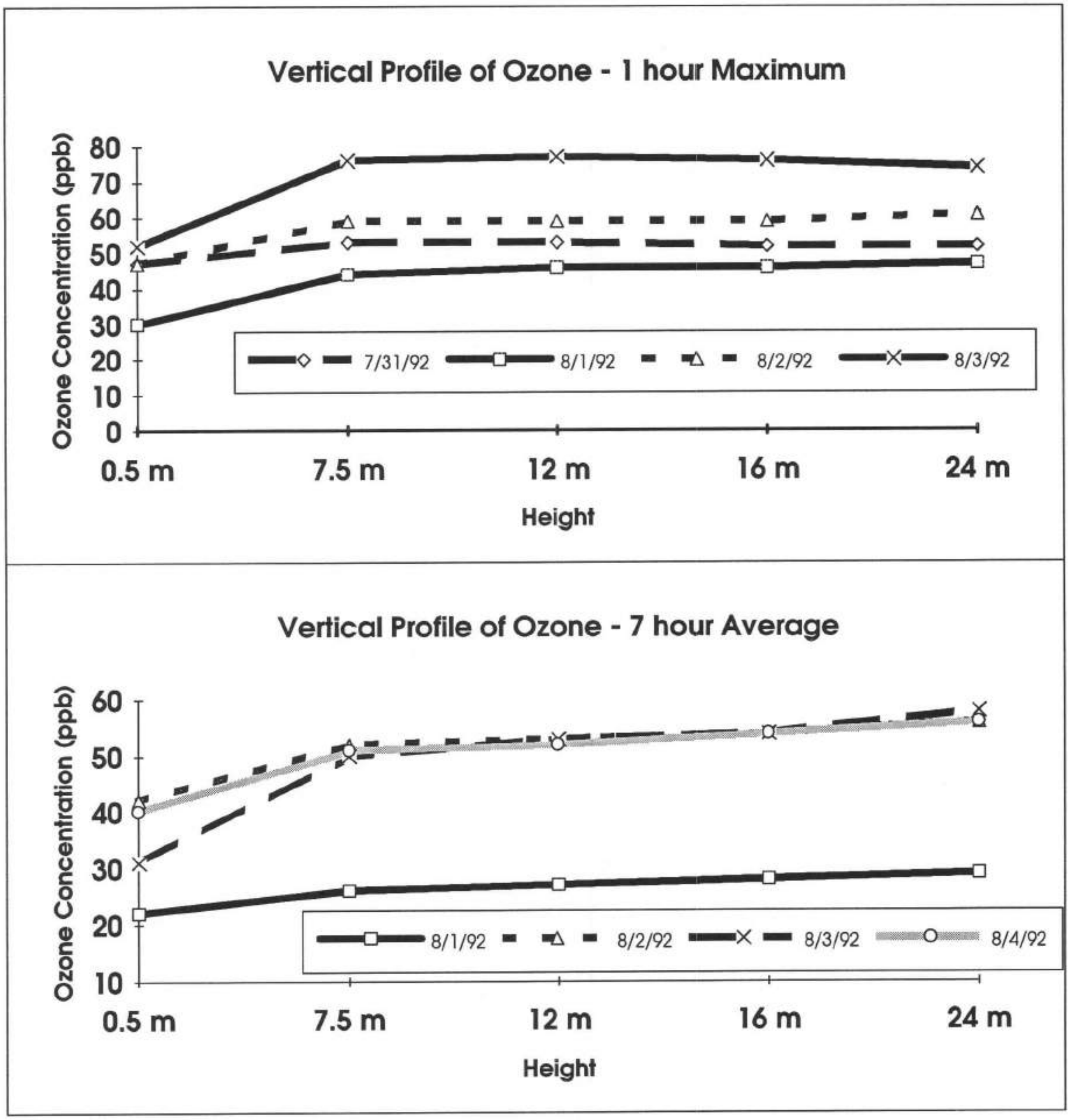
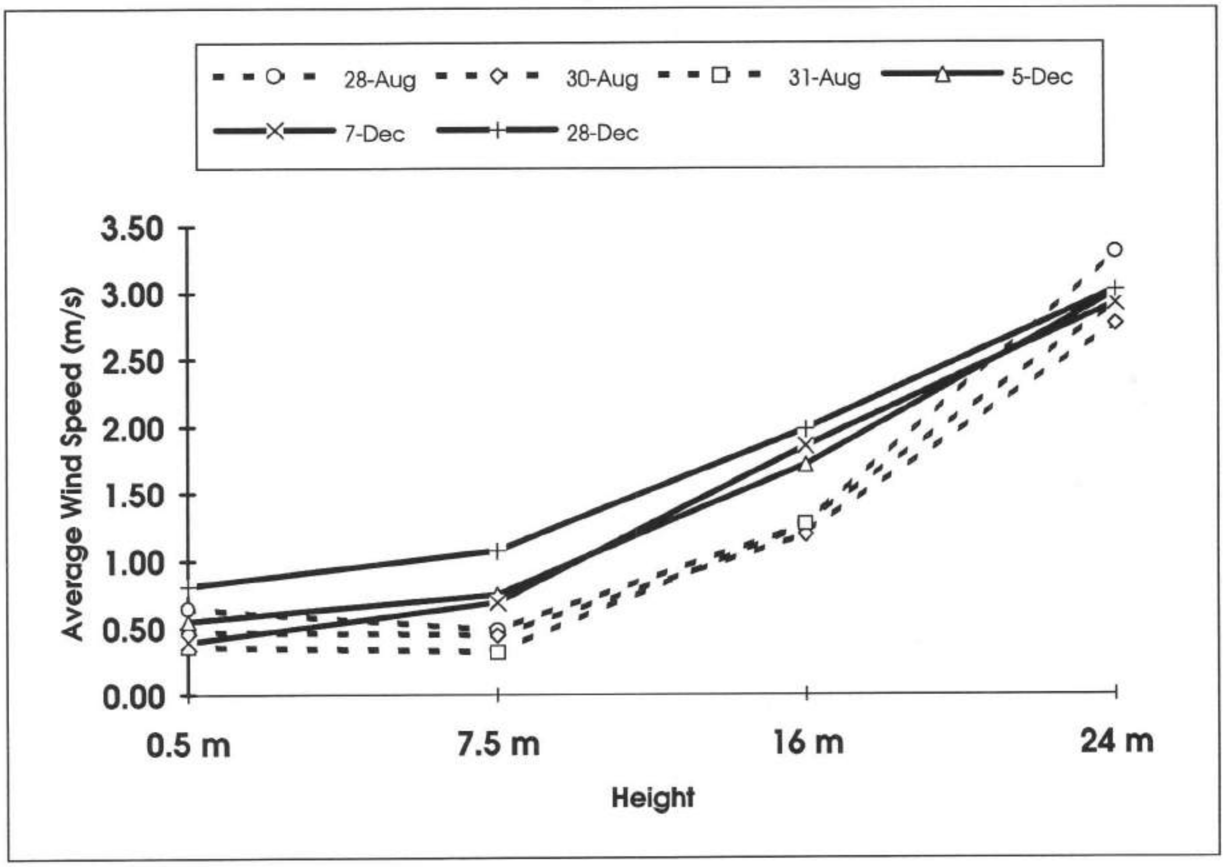


Figure 5. Vertical profiles on representative dates in August (with leaves) and December (without leaves) 1992 for average wind speeds recorded at four elevations (0.5, 7.5, 16.0, and 24.0 m above the ground) along a vertical gradient on the VMC Research Tower at the Proctor Maple Research Center in Underhill, VT.



Note: The 12 m elevation was not included because no wind speed data was collected at that location in December 1992.

Ceptometer data were generally higher and much more variable than those calculated by the LI-2000 (Table 1). Although measurements were made on different days for each instrument, measurements were done after leaves were fully expanded and both instruments use ambient PAR (above the canopy) as a base line. This limited data suggests that LAI estimates from the LI-2000 are less variable and more repeatable than those from the Ceptometer wand.

We have not yet had an opportunity to fully examine hemispherical photography or sight obstruction data collected from the VMC tower during 1992. We expect to report on these data in 1993.

Future Plans:

We plan to continue collecting data from all instrumentation on or around the tower for one to two more seasons. It was late July before all of the meteorological equipment was fully operational so we missed much of the 1992 growing season. Data from multiple years will be necessary to get even a cursory look at year to year variability. We still hope to examine O_3 deposition and flux throughout the canopy using eddy correlation techniques if funding becomes available. Early in 1993 we plan to install thermocouples in two sets of paired m^2 soil temperature plots located in the vicinity of the VMC tower. Each plot will have thermocouples installed at three depths within the soil (5, 15, 30 cm below the soil surface) and 2 cm above the soil surface. The overall objective will be to monitor soil temperature at different depths within the rooting zone of a hardwood forest. Also in 1993 we plan to purchase an ultraviolet radiation (UV-B; 290-320 nm) biometer which will be installed on the VMC tower.

Table 1. A comparison of leaf area index values determined at four elevations (0.5, 7.5, 12.0, and 16.0 m above the ground) along a vertical gradient on the VMC Research Tower at the Proctor Maple Research Center in Underhill, VT using the LICOR-2000 Leaf Area Index Meter and the Decagon Sunfleck Ceptometer PAR attenuation wand.

	LI-2000		Ceptometer	
Height	Average	Range	Average	Range
0.5 m	4.09	3.71 - 4.60	5.52	2.43 - 6.92
7.5 m	3.68	3.16 - 4.24	4.23	2.86 - 6.01
12.0 m	1.96	0.79 - 2.80	1.52	0.73 - 2.69
16.0 m	0.08	0.00 - 0.21	0.61	0.00 - 1.12

Note: Although LI-2000 measurements were made on 9 July and Ceptometer measurements on 2 July, leaf elongation was complete prior to 2 July, 1992 and measurements are comparable.

METEOROLOGICAL AND DEPOSITION CHEMISTRY MONITORING
- 1992 -

Tim Scherbatskoy
School of Natural Resources
University of Vermont

COOPERATORS:

UVM Proctor Maple Research Center (PMRC), VT Dept. of Environmental Conservation (DEC), WCAX-TV staff at Mt. Mansfield transmitter station, National Atmospheric Deposition Program (NADP), US Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), University of Michigan Air Quality Laboratory, Lake Champlain Research Consortium (LCRC), National Weather Service (NWS), and the Electric Power Research Institute (EPRI).

ABSTRACT:

Continuous monitoring of meteorology and wet and dry deposition chemistry has been conducted at the VMC Mansfield site. This work is a fundamental component of the monitoring and research activities there, providing basic information on the physical and chemical environment. Several projects are underway, including (a) basic meteorology at four locations, (b) four precipitation chemistry monitoring programs, and (c) a dry deposition monitoring program. Continuous hourly meteorology data from PMRC (400 m elevation) are available from 1988 to present, and daily temperature and precipitation data from the summit of Mt. Mansfield (1205 m) are available from 1954 to present. Data from the Vermont Acid Precipitation Monitoring Program consist of daily precipitation pH since 1980 (Mt. Mansfield summit) and 1983 (PMRC). The National Atmospheric Deposition Program, operating at PMRC since 1984, provides weekly analysis of major ions in precipitation, while the Atmospheric Integrated Research Monitoring Network, established at the very end of 1992, provides similar data on a daily basis. In cooperation with the University of Michigan Air Quality Laboratory, atmospheric mercury monitoring in precipitation, gaseous and aerosol phases was also established at the end of 1992. Finally the Dry Deposition Inferential Measurement system, started mid year in 1992, provides weekly data on dry deposition of nitrogen (HNO_3 vapor) and sulfur (SO_2) compounds.

No detailed assessment of patterns or trends in the data from these projects has been performed at this time, but the data are available from the VMC in various forms, including as Voyager files. Included in this report are representative data tables and Voyager views of the data. Also discussed here are plans for the future of these projects.

OBJECTIVES:

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

METHODS:

Several monitoring stations and programs were operated at the VMC Mansfield site in Underhill in 1992:

1. Basic meteorology (continuous temperature, dew point, wind speed and direction, standard deviation of wind direction, and precipitation amount) is monitored at the air quality monitoring station at the VMC Mansfield site at the Proctor Maple Research Center (PMRC) at 400 m. elevation. This station has remote (modem) access and has been in continuous operation since June 1988. Data are updated continuously and are stored electronically and as hard copy. Data are available from the VMC as spreadsheets (Lotus, Excel) and in 1993 will be available in Voyager format. Station supervision is by Tim Scherbatskoy and operation is now by Joanne Cummings and Carl Waite. Cooperators are Sumner Williams and Mel Tyree at PMRC. Additional meteorological data were collected at the forest research tower site and in Underhill State Park; these are described in other reports.

2. The National Weather Service (NWS) under NOAA supervises a second weather station at the WCAX-TV transmitter station near the nose of Mt. Mansfield (1205 m), one of 45 NWS cooperative weather stations currently operating in Vermont. This station has monitored temperature (daily minimum, maximum and temperature at time of observation) and precipitation amount (daily rainfall, snowfall and snow depth on the ground) since 1954. Data are collected and stored by the National Climatic Data Center. The VMC does not directly support this station, but has access to the data for this station and all others in Vermont through the NWS. Efforts in 1992 were aimed at formatting these data for Voyager and developing a system for obtaining data updates through the Vermont State Climatologist. Data are now available from the VMC in Voyager format for the period 1954-1991. Funding for this station comes from the National Weather Service and the cooperation of the WCAX-TV transmitter facility.

3. VAPMP (Vermont Acid Precipitation Monitoring Program) collects bulk precipitation samples on an event basis for analysis of amount and pH. Samples are collected at the air quality monitoring station at PMRC (400 m) and near the WCAX-TV transmitter station near the nose of Mt. Mansfield (1205 m), and at 10 other sites around Vermont. These stations have been in continuous operation since 1983 (PMRC) and 1980 (Mt. Mansfield summit). Data are collected and stored by VT DEC Water Quality Division where the program supervisor is Jim Kellogg. Data are available from the VMC in Voyager format or in other forms from the program supervisor. The site operators are Joanne Cummings with cooperation from Sumner Williams at PMRC, and the staff at the WCAX-TV transmitter facility on Mt. Mansfield. Funding to support these stations comes from the VT Department of Environmental Conservation.

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

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

6. AIRMoN (Atmospheric Integrated Research Monitoring Network) is a daily precipitation monitoring program established at the end of 1992 to provide high-resolution data on precipitation chemistry to support regional modeling efforts. There are 7 sites in the network, located in the northeastern US. Except for being a daily sampling program, it follows the protocol and measures the variables of the NADP/NTN described in (4) above; the sampler is located at the Air Quality site at PMRC (400 m). Station operation is by Joanne Cummings with supervision by Tim Scherbatskoy. The AIRMoN station was installed in December, 1992; the station is scheduled to begin monitoring in January 1993, when data will become available quarterly.

7. Atmospheric mercury is being monitored at the VMC Air Quality site in Underhill. This project was started in December, 1992 in cooperation with the University of Michigan Air Quality Laboratory and the Lake Champlain Research Consortium. This is part of a larger research project to understand the behavior and sources of atmospheric mercury and other chemicals in the Lake Champlain Basin. Daily wet-only precipitation and twice-weekly 24 hour air samples are collected and sent to UMAQL for analysis of mercury in precipitation, gaseous and aerosol phases. Precipitation is collected using a MIC Co. automated trace metal quality precipitation collector, while the air samples are collected on gold sand traps (gas phase) and quartz filters (aerosol phase). Station operation is by Joanne Cummings with supervision by Tim Scherbatskoy. Analysis is conducted at the UMAQL in Ann Arbor under the direction of Dr. Jerry Keeler.

SIGNIFICANT FINDINGS:

No major analyses of trends and relationships in these projects have been completed at this time. However, data are maintained as up-to-date as possible, and are generally available from the VMC in various forms. A major effort is underway to also make these data available as Voyager files (see the Data Integration Project). In addition, periodic reports are made available by the major sponsor of each program (e.g., NADP annual statistical summaries).

1. Basic meteorology.

Consolidation of the basic meteorology data from the VMC Mansfield site is completed, and consists of annual daily and hourly data for all variables. In 1993, monthly data summaries will be produced routinely. These data are available in ASCII text files, spreadsheets, and Voyager workbooks. Representative data, showing variables and time resolution of the raw data being collected, are presented in Table 1.

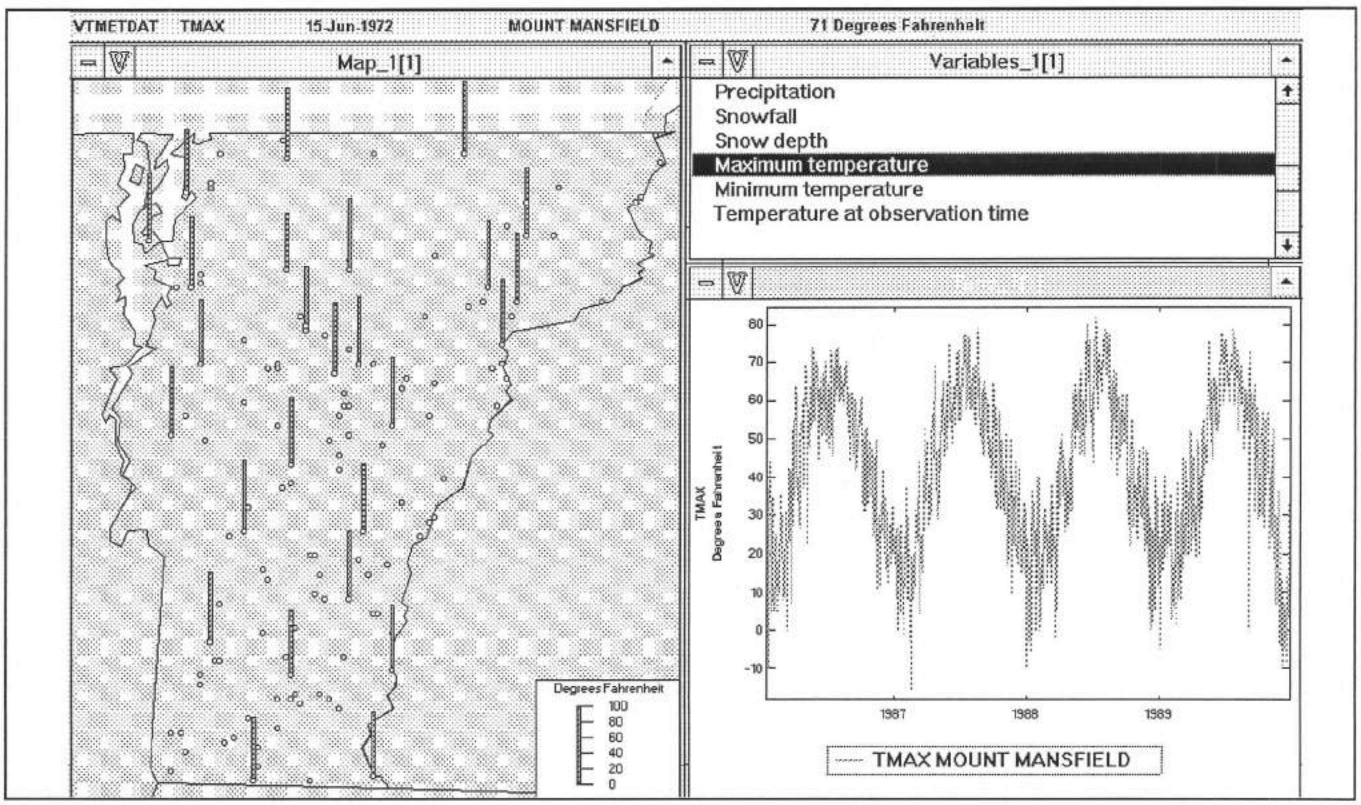
Table 1: Basic Meteorology at PMRC: portion of raw data file as logged hourly at the weather station.

date	time hr	precip cm	wdr deg	wsp mph	temp deg F	bp in	dp deg F	sd-wd deg
9/18/92	1:00	0.00	110	2.0	67.3	28.43	56.2	31.7
9/18/92	2:00	0.00	98	2.5	67.0	28.43	56.4	17.7
9/18/92	3:00	0.00	91	2.1	66.0	28.43	56.4	16.4
9/18/92	4:00	0.00	102	2.7	65.7	28.43	56.4	19.2
9/18/92	5:00	0.00	104	2.5	65.5	28.43	56.3	18.8
9/18/92	6:00	0.00	117	2.2	65.7	28.43	55.9	39.6
9/18/92	7:00	0.00	113	2.7	66.4	28.43	55.9	33.9
9/18/92	8:00	0.00	109	2.6	66.3	28.43	56.2	32.5
9/18/92	9:00	0.00	115	2.3	67.2	28.43	57.0	38.6
9/18/92	10:00	0.00	171	3.6	69.1	28.43	57.5	46.3
9/18/92	11:00	0.00	198	5.1	70.9	28.41	57.9	29.0
9/18/92	12:00	0.00	203	5.9	73.3	28.39	58.3	20.8
9/18/92	13:00	0.00	199	7.1	75.7	28.35	56.6	23.5
9/18/92	14:00	0.00	200	7.7	77.3	28.32	55.4	21.0
9/18/92	15:00	0.00	199	8.6	77.7	28.29	56.1	24.8
9/18/92	16:00	0.00	198	8.3	77.7	28.26	56.6	21.9
9/18/92	17:00	0.00	193	7.6	76.2	28.25	56.1	24.4
9/18/92	18:00	0.00	180	5.6	73.6	28.22	55.8	47.1

2. National Weather Service data.

Due to the time lag in obtaining data from the National Climatic Data Center, the 1992 data from the Mt. Mansfield weather station will not be available until May 1993. Current data is complete through 1991. Representative data, as a Voyager view, are shown in Figure 1.

Figure 1: NWS Cooperating stations in Vermont: Voyager view showing the Vermont map view and a time view for the Mt. Mansfield summit weather station.



3. Vermont Acid Precipitation Monitoring Program.

The database for VAPMP is up-to-date, but no data interpretation is planned for individual stations or the program until 1993; the last program report (from the VT Water Quality Division) was in 1986. Representative data, as a Voyager view, are shown in Figure 2. These data are available from the VMC as Voyager workbooks (see the Data Integration Project).

Figure 2: VAPMP stations in Vermont: Voyager view showing the Vermont map view and a time view for the VMC-operated station in Underhill.

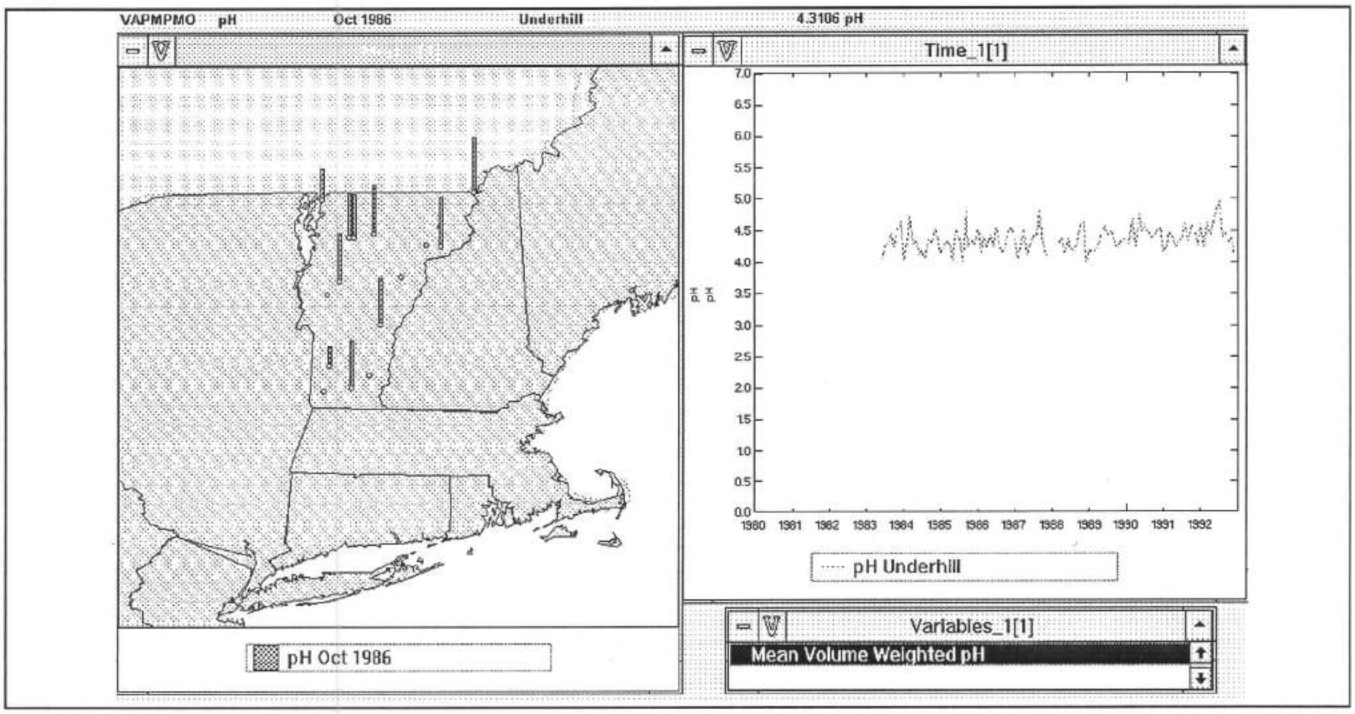


Table 2: VAPMP data: portion of raw data file for VMC station in Underhill showing daily precipitation chemistry data.

id	yr	mo	da	pH	precip (in), form		vol wtd H+
11	92	10	1	4.76	0.03	M	5.213E-07
11	92	10	12	4.81	0.72	R	1.115E-05
11	92	10	13	4.32	0.15	R	7.179E-06
11	92	10	16	3.74	0.05	R	9.099E-06
11	92	10	20	4.22	0.25	M	1.506E-05
11	92	10	27	4.26	1.46	M	8.023E-05
11	92	11	3	4.75	0.63	R	1.12E-05
11	92	11	12	4.37	0.79	R	3.37E-05
11	92	11	14	4.86	0.23	M	3.175E-06

4. National Atmospheric Deposition/National Trends Network.

Data from the NADP station are available for each 2-month period from the site supervisor, and are available for the entire network annually from NADP; the last annual data summary from NADP is for 1991. Representative data, as a Voyager view, are shown in Figure 3 and as bi-monthly data table in Table 3.

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

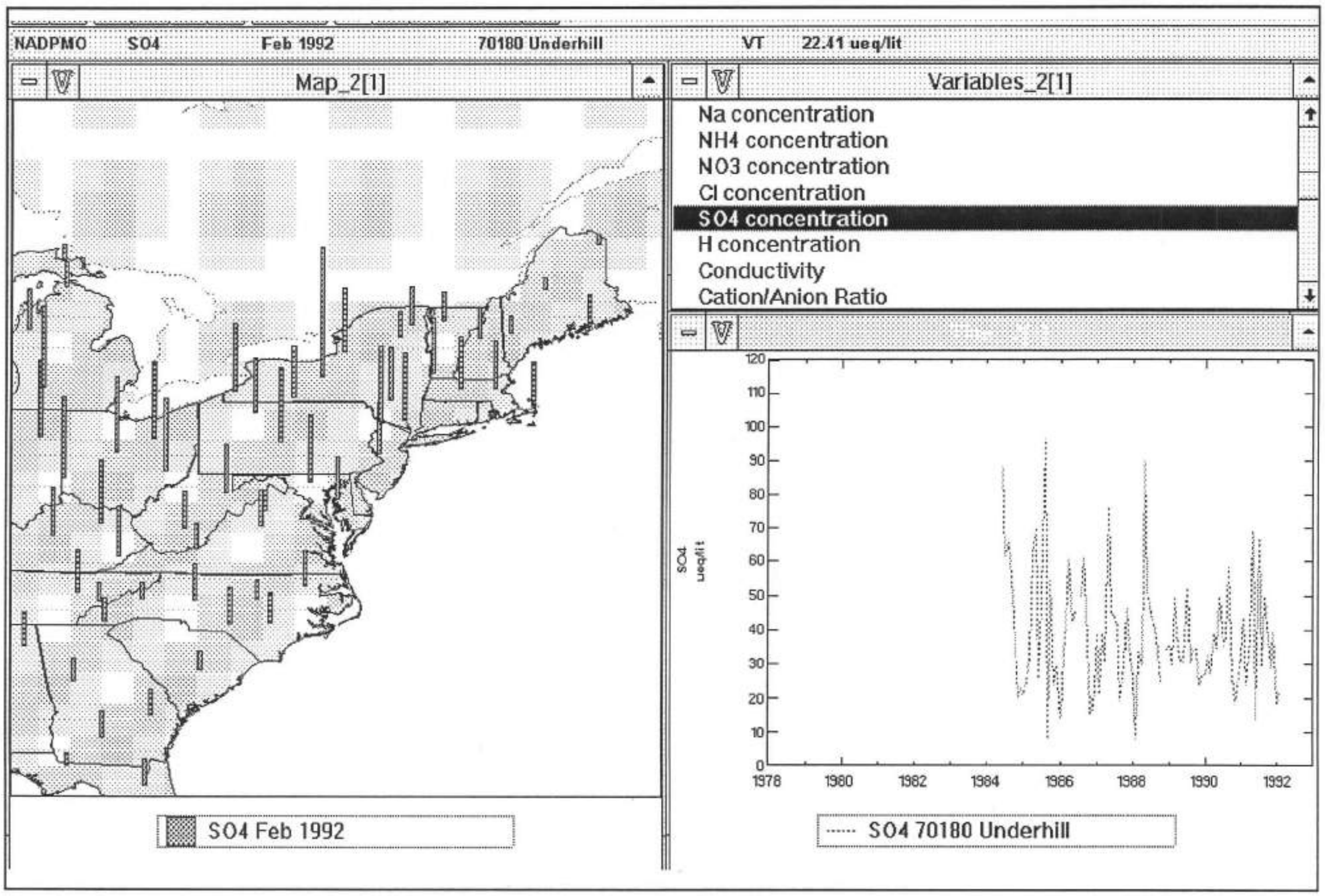


Table 3: NADP/NTN data: field and laboratory data for November, 1992 from bi-monthly data reports.

NADP/NTN CENTRAL ANALYTICAL LABORATORY - ILLINOIS STATE WATER SURVEY

FIELD PRINTOUT
PRINTOUT DATE: 11/12/1992

PLEASE NOTE - DATA WITH A SAMPLE ID LESS THAN NL14010W (MARKED WITH AN ASTERISK) HAS BEEN REVIEWED BY THE CAL FOR THIS REPORT

SAMPLE ID	LAB TYPE	DATE ON	TIME ON	DATE OFF	TIME OFF	TIME ZONE	PH LAB	PH FLD	CONDUCTIVITY LAB	CONDUCTIVITY FLD	SAMPLE VOLUME (ML)	SAMPLE DEPTH (IN.)	PRECIP. DEPTH (IN.)	LEAKAGE
*NL10730WVT99	W	072892	1032	080492	0815	LT	4.21	4.35	33.3	34.0	2837.6	1.65	1.60	NONE
*NL13160WVT99	W	080492	0815	081192	0900	LT	4.20	4.32	34.3	34.5	1663.7	.96	.98	NONE
NL14050WVT99	W	081192	0900	081892	0952	LT	4.49	4.29	18.5	21.0	887.6	.51	.31	NONE
NL17100WVT99	W	081892	0952	082592	0815	LT	3.92	3.83	66.8	85.0	121.5	.07	.08	NONE
NL17860WVT99	W	082592	0815	090192	0630	LT	4.18	4.16	37.1	38.0	2258.5	1.31	1.34	NONE
NL19950WVT99	W	090192	0630	090892	1120	LT	4.40	4.35	20.6	22.5	761.5	.44	.44	NONE
NL22620WVT99	W	090892	1120	091592	0745	LT	4.45	4.38	19.0	22.0	2456.5	1.42	1.41	NONE

PRELIMINARY PRINTOUT
DATE: 11/12/92

NADP/NTN CENTRAL ANALYTICAL LABORATORY - ILLINOIS STATE WATER SURVEY

PLEASE NOTE - DATA WITH A SAMPLE ID LESS THAN NL14010W (MARKED WITH AN ASTERISK) HAS BEEN REVIEWED BY THE CAL FOR THIS REPORT

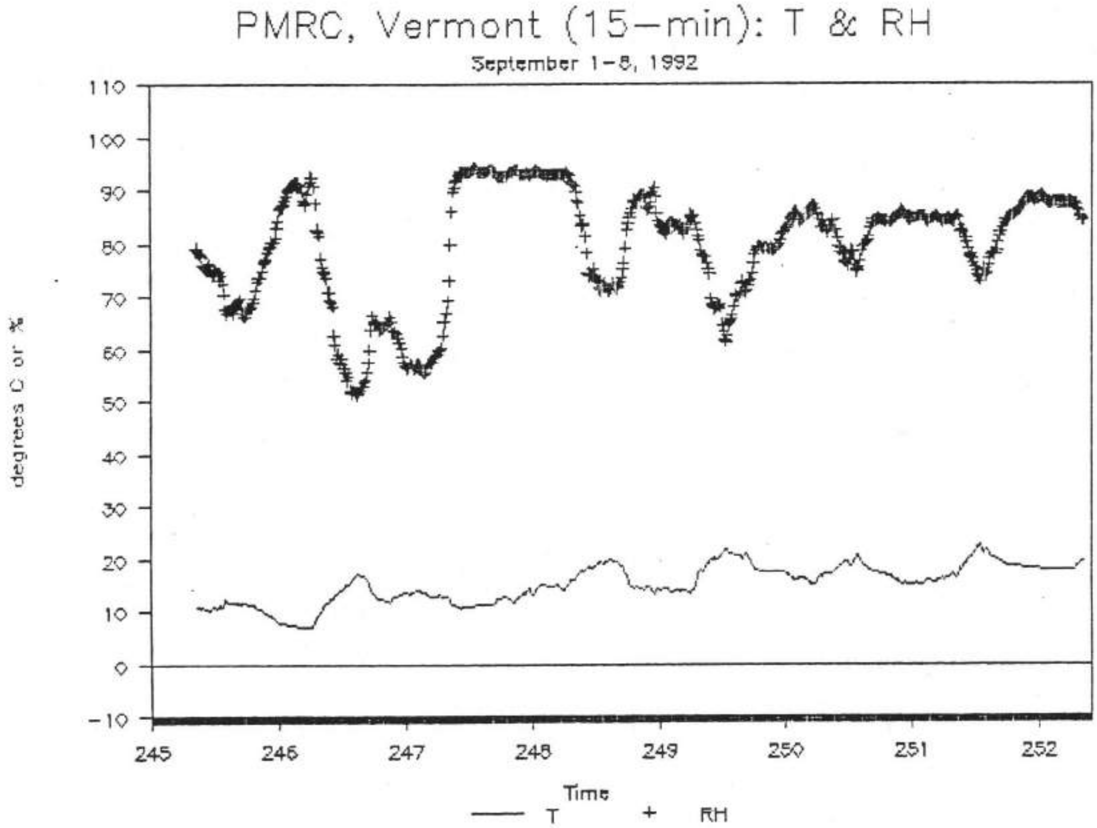
SAMPLE ID	LAB TYPE	DATE ON	TIME ON	DATE OFF	TIME OFF	CONCENTRATIONS (MG/L) CA	MG	K	NA	NH4	NO3	CL	SO4	PO4	FIELD COND. (MICROMHOS/CM)	LAB COND. (MICROMHOS/CM)	FIELD PH	LAB PH
*NL10730WVT99	W	072892	1032	080492	0815	.135	.017	.041	.042	.23	1.85	.06	3.09	<.020	34.0	33.3	4.35	4.21
*NL13160WVT99	W	080492	0815	081192	0900	.043	.008	.008	.010	.32	1.51	.07	3.46	<.020	34.5	34.3	4.32	4.20
NL14050WVT99	W	081192	0900	081892	0952	.045	.010	<.003	.009	.06	.99	.03	1.92	<.020	21.0	18.5	4.29	4.49
NL17100WVT99	W	081892	0952	082592	0815	.131	.034	.016	.050	.51	3.96	.21	7.84	<.020	85.0	66.8	3.83	3.92
NL17860WVT99	W	082592	0815	090192	0630	.182	.028	.025	.046	.61	1.65	.09	4.28	<.020	38.0	37.1	4.16	4.18
NL19950WVT99	W	090192	0630	090892	1120	.076	.022	.135	.026	<.02	1.24	.08	1.67	<.020	22.5	20.6	4.35	4.40
NL22620WVT99	W	090892	1120	091592	0745	.087	.016	.008	.043	.25	1.08	.05	2.37	<.020	22.0	19.0	4.38	4.45

SAMPLE ID	LAB TYPE	DEPOSITION(MILLIGRAMS/SQUARE METER) CA	MG	K	NA	NH4	NO3	CL	SO4	PO4	H	SAMPLE VOL(ML)	MEAS ANIONS (MICROEQUIV/L)	MEAS CATIONS (MICROEQUIV/L)
NL10730WVT99	W	5.64	.71	1.71	1.76	9.61	77.33	2.51	129.16	<.84	2.60	2837.6	96.2	85.4
NL13160WVT99	W	1.05	.20	.20	.25	7.84	37.01	1.72	84.79	<.49	1.56	1663.7	98.7	84.3
NL14050WVT99	W	.59	.13	<.04	.12	.78	12.94	.39	25.10	<.26	.43	887.6	57.1	39.2
NL17100WVT99	W	.23	.06	.03	.09	.91	7.09	.38	14.03	<.04	.22	121.5	233.4	160.4
NL17860WVT99	W	6.05	.93	.83	1.53	20.29	54.89	2.99	142.39	<.67	2.22	2258.5	118.6	113.9
NL19950WVT99	W	.85	.25	1.51	.29	<.22	13.91	.90	18.73	<.22	.45	761.5	57.4	50.6
NL22620WVT99	W	3.15	.58	.29	1.56	9.05	39.08	1.81	85.76	<.72	1.29	2456.5	68.5	57.1

5. Dry Deposition Inferential Measurement System.

At this time, no chemical data from the DDIM project have been returned to the VMC due to the time lag in chemical analysis. Meteorological data in graphical form, but not as data files, have been received. We anticipate receiving copies of both the chemical and meteorological data as computer data files quarterly in 1993. Representative meteorological data, as a graph provided by NOAA, are shown in Figure 4.

Figure 4. DDIM station representative meteorological data: 15-min temperature and relative humidity for September 1-8, 1992.



A REGIONAL COMPUTER-BASED OZONE DATA REPORTING NETWORK - 1992

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Objectives:

The goal of this project was to continue development and improvement of a real-time ozone data network available to various users in the northeastern region. Working with the Northeast States for Coordinated Air Use Management (NESCAUM), which provided financial support in the form of a grant of $3000.00, we have been using the DELPHI computer network to compile and distribute daily maximum ozone data from approximately 90 stations in the eight NESCAUM states during the April-October ozone season. These data are made available as quickly as possible to the state air programs and other selected users (e.g. forest managers, field crews, researchers) through DELPHI. Specific objectives for 1992 included:

1. Improving ease of data transferral by the states,
2. Compiling and editing all data into master files and preparing ASCII, spreadsheet and Voyager files of the data,
3. Regularly posting data and Voyager files on DELPHI for use by NESCAUM and other selected users.

Methods:

Preliminary daily ozone maximum and time of ozone maximum data from monitoring stations was submitted to DELPHI. Submissions were made either daily or weekly depending on the state and the methods employed to upload the data. Several states have automated systems for data management and submissions to the network, while other states post the data manually. Raw data files from DELPHI were then downloaded to the University of Vermont where data cleaning and formatting for redistribution was conducted.

Data cleaning consisted of running the raw data through two pascal programs to eliminate extraneous information and pre-format the data for spreadsheet compatibility. In spreadsheet form the data were screened for errors, formatted for Voyager, and organized into monthly reports for redistribution. Data formatted for Voyager was compiled and used in the construction of a 1992 Ozone Voyager Workbook which was updated monthly and distributed (see figure I).

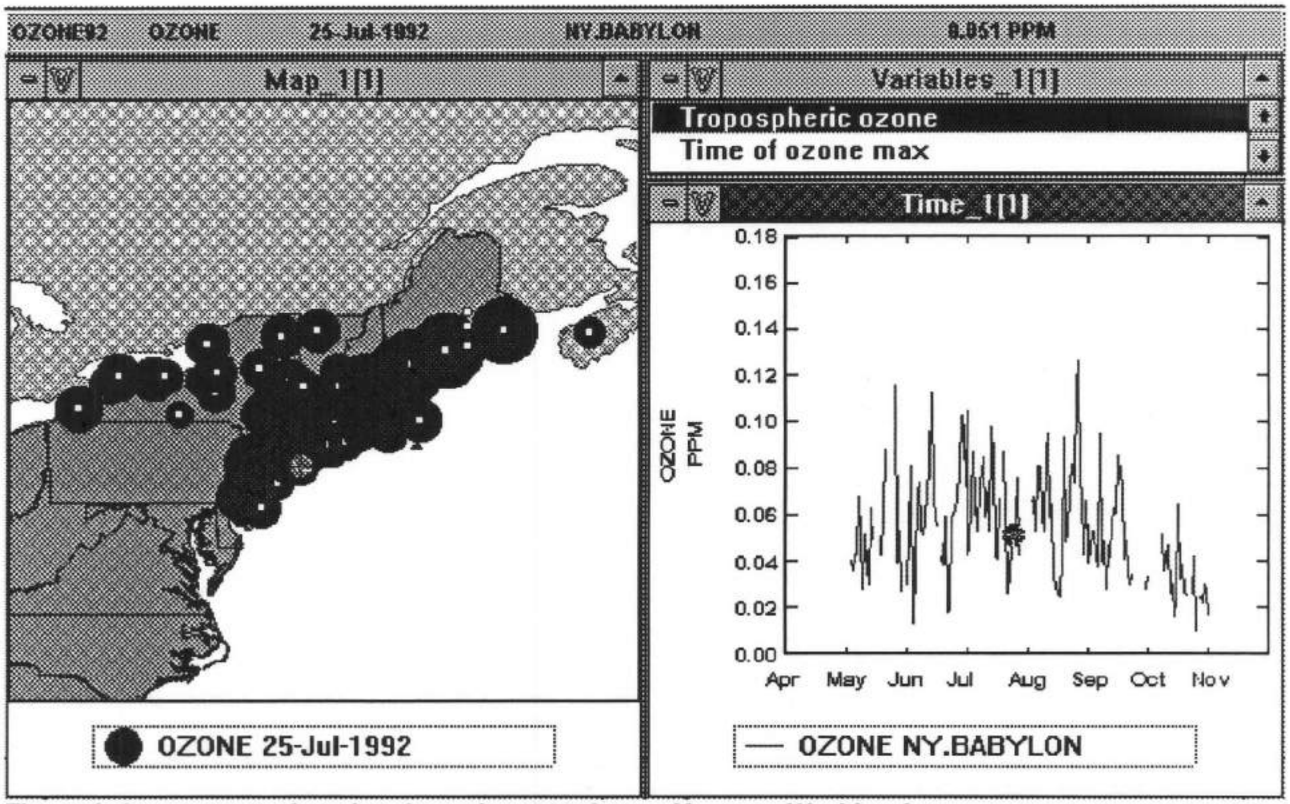

Figure I. A representative view from the 1992 Ozone Voyager Workbook.

Significant Findings:

The entire ozone data set was used to construct descriptive statistics summarizing the 1992 ozone season. Data used in this summary represented the states of Connecticut, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont and the province of Nova Scotia. Frequency distributions of the daily ozone maximum and first reported time of occurrence are presented in figures II and III.

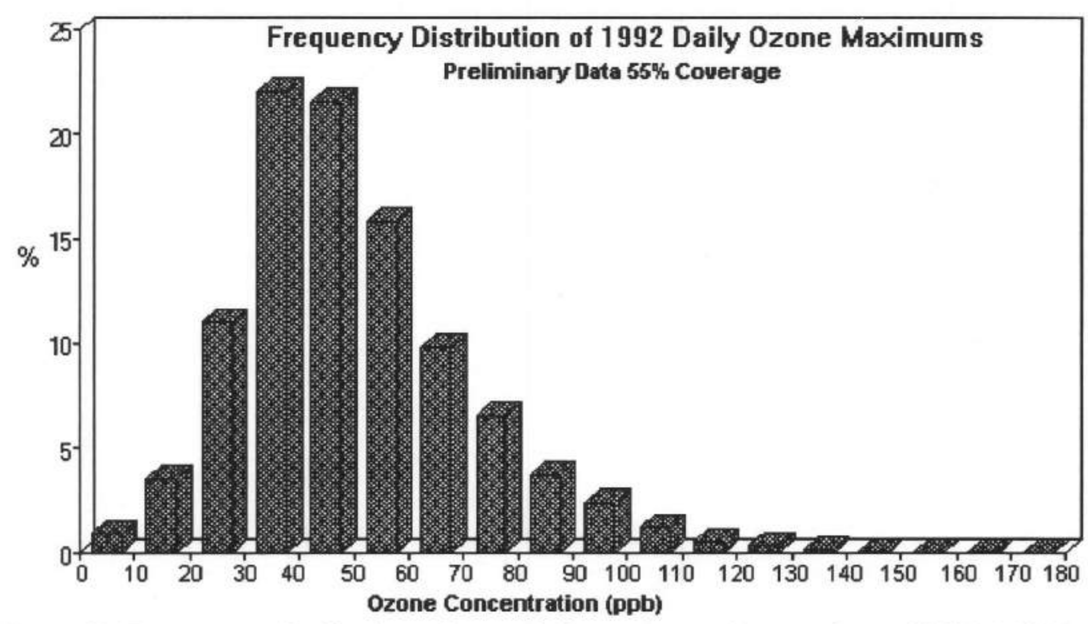

Figure II. Frequency distribution of 1992 daily ozone maximums from all NESCAUM stations including Nova Scotia.

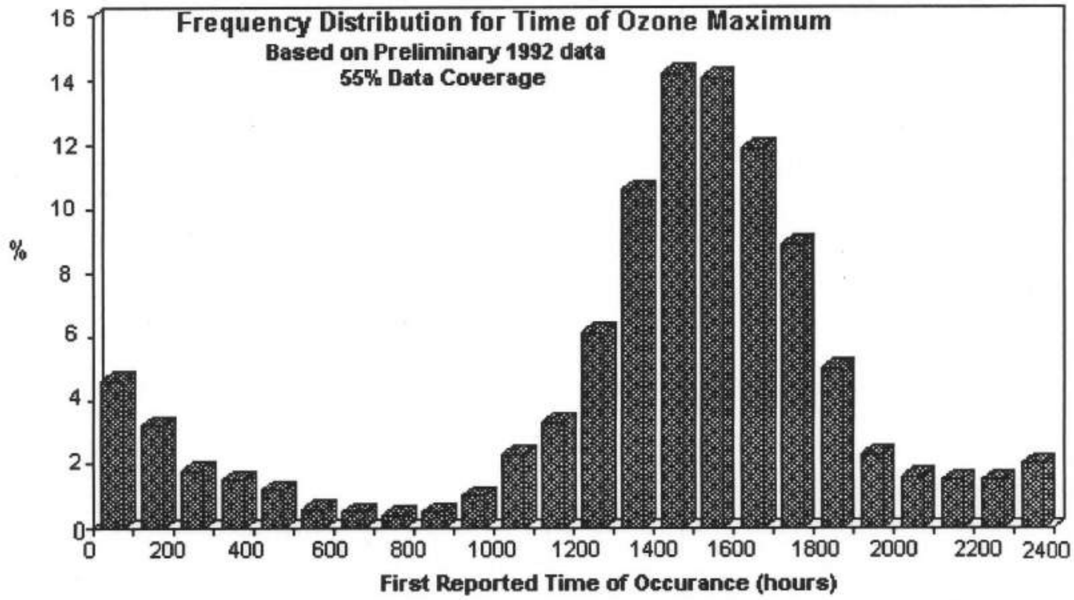

Figure III. Frequency distribution of first reported time of daily ozone maximum.

A data communications protocol was established and monthly reports in spreadsheet, DOS text, and Voyager format were available within one or two weeks of the end of the month. However, the speed and efficiency of this effort could still be greatly improved. Chief among the projects shortcomings has been the inconsistency in data reporting from participating stations. Data coverage for the entire ozone season was only 55 percent. Clearly this must be improved upon if this effort is continued.

A possible cause of reporting inconsistency may be the amount of time and difficulty encountered when submitting data to the DELPHI system. State programs which have automated systems for data submittal may provide useful models for other states to adopt. Perhaps the task of automating data uploading could be facilitated in the future by the University of Vermont.

The problem might be inherent in the DELPHI network itself. Other means of data submittal may need to be explored, such as the establishment of a network solely for the distribution of data and reports by NESCAUM and other state or province air programs. Creation of this network and subsequent revisions in the data communications protocol would also enhance the speed at which data could be processed and returned to users. At present, the system works, but it is time consuming and inefficient, with the data requiring manual error screening. Monthly data turn-around is about the best that can be accomplished. However, with the establishment of an independent ozone network and a reworking of the data communications protocol, weekly data turn around should be an achievable.

The value of this program lies primarily in the rapid availability of the data. This work has developed procedures that now permit sharing of compiled region-wide data sets on a monthly basis. The current procedures are still fairly labor intensive, however, requiring up to 10 hours per week to accomplish. Development of more automated methods is desirable.

Future Plans:

This project will continue in 1993. Additional goals for 1993 include: developing more automated procedures for transferring data from states to the computer network and for producing the compiled data files, enlarging the user network, developing pilot procedures for transmitting additional ozone data (not just the daily maximum), and transferring this system from DELPHI to a NESCAUM or EPA computer network.