VERMONT
MONITORING
COOPERATIVE

ANNUAL REPORT FOR 1991

Vermont's Intensive Forest Ecosystem Monitoring and Research Program

Reference citation

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VERMONT MONITORING COOPERATIVE:

ANNUAL REPORT FOR 1991

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and

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Editors

VMC Annual Report Number 1

TABLE OF CONTENTS

INTRODUCTION

The **Vermont Monitoring Cooperative Executive Summary Report for 1991** served to present a summary of VMC monitoring and research projects. Therefore, the function of this document is to include a more detailed accounting of some projects, as well as to document events and issues pertinent to VMC functions.

The first draft **VMC Monitoring Work Plan: 1991**, was reviewed by the Steering Committee, and approved, with suggestions on possible improvements to the program. One such suggestion was the perceived need to have both a Data Manager and a Quality Assurance/Quality Control Manager.

The possibility of a Data Manager was a topic of much discussion early in the development of the VMC. It was decided that initially, we would not use a central data management system, but rather, each VMC Cooperator would manage their own data, making it accessible to others upon demand, and reporting on it individually. However, there would be the initiation of a pilot study to integrate disparate data sets, but this would be separate from the formal data analysis and reporting. We did agree to revisit this topic in 1993-94, to assess whether or not this structure was functional.

Designating a QA/QC Manager was also discussed by the Coordination Committee, and it was decided that most VMC monitoring activities were linked to statewide or regional programs, where QA/QC was an integral part of these programs. This issue will also be revisited following several years under the present structure.

The Land Use Subcommittee was formed to address the needs of the VMC to keep communications open between public and private landowners and the VMC Cooperator's needs. The committee has not met formally, but contact and permissions are made for each new VMC project, either by the Monitoring Coordinator or by the individual VMC Cooperator.

In an attempt to formalize VMC activities on the Mount Mansfield State Forest, initial communications were made between the Commissioner of the Department of Forests, Parks and Recreation and the VMC Coordination Committee, to designate the State Lands in 3 watersheds on the mountain for use by VMC Cooperators for long-term forest ecosystem monitoring and research. The details of this designation will continue to be outlined.

A Memorandum of Understanding between the UVM PMRC and the Department of Forests, Parks and Recreation was established for activities encompassed under the Vermont Monitoring Cooperative. This agreement includes VMC use of PMRC laboratory facilities, land use, continuation of meteorological data being gathered at the PMRC and full access by PMRC to copies of VMC monitoring data and reports.

The Director of the Proctor Maple Research Center, in an attempt to keep track of the influx of activities on the 200 acres owned and operated for maple research, required that all VMC Cooperators submit a written letter to the PMRC with specific information on the types of activities, location, longevity, etc. Prior to implementing any activities, a formal letter of authorization from the Director to the Cooperator is needed.

The summit of Mount Mansfield (400 acres) is owned and operated by the UVM Natural Area Program. Activities occurring in this area require permission by the Director of this program, prior to implementation. In some cases, special procedures are required to lessen the impacts from monitoring or research activities on fragile lands.

Activities on State Lands must be approved through the VMC Monitoring Coordinator and the District's State Lands Forester. This generally includes a site visit and a written request to the Monitoring Coordinator. A more formal VMC Application is being discussed to better coordinate activities on both public and private lands and to keep track of and map locations of activities.

Initial communications were started with the Geographic Information System (GIS) Subcommittee. The recommendation of this committee was to solicit a map of the Mount Mansfield area to be printed for us by each of the 5 different offices that may have data layers: OGIS, UVM GIS, Chittenden County Regional Office, Underhill Town Office, and Lamoille County Regional Office. This will facilitate the acquisition and compilation of all high quality data layers for generation of a VMC specific map.

The Animal Monitoring Subcommittee met to discuss priorities for monitoring and research of fauna on Mount Mansfield. It was recommended that the following groups be monitored to give baseline information for subsequent research, terrestrial: insects, amphibians, birds and small mammals. The first 3 groups were monitored in 1991. We hope to implement small mammal surveys in the near future.

Acquisition of funds for the purchase and construction of a 65 ft. canopy tower was obtained from a number of sources. The location for the tower is west of the PMRC laboratory, in a mixed northern hardwood forest. The tower was successfully constructed and equipment for measuring forest meteorology and within-canopy ozone will be installed in 1992. This tower will be accessible to any VMC Cooperator wishing to conduct canopy related studies, providing the integrity of the canopy is not compromised.

As shown by the first VMC Annual Meeting, the 1991 Executive Summary Report and this report, monitoring and research under the VMC is thriving. Important existing monitoring data bases are being added to, new projects have been initiated and a coordinated VMC research program is being developed. The VMC Mansfield site has been identified by the USDA Forest Service as a potential satellite site to be included in their Intensive Site Ecosystem Monitoring Program. Significant progress has been made in the data integration project, and planning for important new research and monitoring is well under way.

<u>List of VMC documents available:</u>

Scherbatskoy, T. 1990. Planning for the Vermont Monitoring Cooperative. 32 pp. University of Vermont, School of Natural Resources, Burlington, Vermont, 05405.

Scherbatskoy, T. 1990. Status of Ecological Monitoring Data in Vermont. 52 pp. University of Vermont, School of Natural Resources, Burlington, Vermont, 05405.

Wilmot, S. & T. Scherbatskoy. 1991. Vermont Monitoring Cooperative: Monitoring Work Plan, 1991. VMC Work Plan No. 1, 52 pp. Vermont Dept. of Forests, Parks & Recreation, 103 So. Main St., Waterbury, VT 05671.

Wilmot, S. & T. Scherbatskoy. 1992. Vermont Monitoring Cooperative: Executive Summary Report for 1991. VMC Exec. Summ. No. 1, 32 pp. Vermont Dept. of Forests, Parks & Recreation, 103 So. Main St., Waterbury, VT 05671.

Wilmot, S. & T. Scherbatskoy. 1992. Vermont Monitoring Cooperative: Monitoring Work Plan, 1992. VMC Work Plan No. 1, 57 pp. Vermont Dept. of Forests, Parks & Recreation, 103 So. Main St., Waterbury, VT 05671.

ANNUAL ASSESSMENT OF FOREST HEALTH

by Sandra H. Wilmot, Vermont Dept. Forests, Parks and Recreation

Cooperators: North American Maple Project (USDA Forest Service, other states and provinces), H. Brenton Teillon, Thomas Simmons, Cecilia Polansky, Pete Reed and Ronald Kelley, VT Dept. Forests, Parks & Recreation.

Introduction

The purpose of conducting annual assessments of forest health is to provide information on condition and trends over time that will be useful in evaluating potential causes of declines.

For 1991, forest health was assessed only at one elevation and watershed, 1360 ft (415 m) in the Browns River watershed. Two types of plot designs were used to obtain forest health information. One plot was established in 1988 as part of the North American Maple Decline Project (NAMP) and a second plot was added in 1991 following the protocols used in the National Forest Health Monitoring Program.

NAMP Plot Methods

At the time of initial plot establishment, general site and stand characteristics are recorded according to 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

Site and stand characteristics for the NAMP plot are presented in Table 1.

The plot-cluster is established at 415 m (1360 ft) on a west facing slope, with a slight slope (8%). Each of the 5 plots with the cluster vary in soil conditions from well drained to poorly drained.

At the time of plot establishment, this stand was categorized as moderately declining, based on comparisons with other statewide sugar maple stands. The average stand age was estimated at 110 years. Management consisted of past grazing, thinning, and present use as an active sugarbush. As such, species composition was 98 % sugar maple.

The trend in tree condition has improved since 1988, with the 1991 assessment showing an average percent dieback at only 3.0 % and foliage transparency at 10.9 % (Table 1). No new tree mortality occurred.

Damage assessments from insect defoliators on this plot found light damage (1-30 % of crown with damaged leaves) from pear thrips feeding, and light to moderate damage (1-60 % of crown with damaged leaves) from maple leaf cutter feeding.

Forest Health Plot Methods

At the time of initial plot establishment, general site and stand characteristics are recorded according to standardized NFHM protocols (Conkling and Byers, 1992). Plot location was selected to compare stand level information on forest health from the pre-established NAMP plot with that of the NFHM program. In addition, it was desireable to determine the optimum within-season time for assessing tree condition. To accomplish this goal, crown vigor ratings were taken at 3 week intervals throughout the field season, for a total of 4 visits. Within season changes in pest damage were recorded at each visit. These revisits also served as a remeasurement for Quality Assurance. Data entry and analysis was completed by our staff. English units are used for data collection and anaysis.

Forest Health Plot Results

Specific information on species composition, understory vegetation, and tree measurements are presented in Table 2. For 1991, crown ratings showed an average crown dieback of 1.9 %, transparency of 11.0 % and density of 58.3 %. These values will be most meaningful when compared over time to consider trends in tree condition, but based on dieback ratings, 100 % of trees on these plots were considered healthy ($\leq$ 15 % dieback).

Within-season remeasurements did not find significant differences in dieback or transparency ratings between any of the dates (Figure 1). Dieback ratings ranged from 0 to 10 %, and transparency ratings ranged from 5 to 25 % throughout the season.

Discussion

Crown ratings on trees in both health plots (NAMP and FHM) showed that trees were generally healthy in 1991. Future plans to add forest health plots should improve the sample size and therefore the reliability of this information.

Moderate defoliation from maple leaf cutter was the only stress factor measured on plots that may affect the future condition of trees, especially sugar maples. Generally favorable growing conditions, good water availability during the spring season, were observed at this site.

The consistent ratings obtained during the within-season remeasurements indicate that crown ratings could be conducted any time between mid-June and the end of August. Future repetition of this work will confirm or refute this, especially during years with major stress occurrences.

References

Conkling, B. B. and G. E. Byers (eds.). 1992. Forest Health Monitoring Field Methods Guide. Internal Report. U. S. Environmental Protection Agency, Las Vegas, NV.

Millers, I., D. Lachance, W. Burkman & D. Allen. 1991. North American Sugar Maple Decline Project: organization and field methods. Gen. Tech. Rep NE-154. Radnor, PA: U.S. Dept. of Agr., Forest Service, Northeastern Forest Experiment Sta. 26 p.

Table 1. Site and stand characteristics, and annual tree health measurements (1988 to 1991) for a North American Maple Project plot located at the Proctor Maple Research Center, Mount Mansfield, Vermont.

SITE CHARACTERISTICS

ELEVATION: 415 M (1360 ft)
SLOPE (average): 15.4 %
ASPECT (average): 260 degrees
SOIL DESCRIPTION: Marlow extremely stony loam, 5-20 % slope
TERRAIN: Hilly
LANDFORM: Draw
SLOPE POSITION: Backslope
MICRORELIEF: Planar
SOIL TEXTURE: Fine Sand
SOIL DRAINAGE: Well Drained
SOIL ROCKINESS: 2-10 Boulders, No Bedrock
SITE QUALITY: Average
CROWN STRUCTURE: Both 1 and 2 Story Structured Plots
CROWN CLOSURE: Both Open and Fully Closed Plots

STAND CHARACTERISTICS

STOCKING: 250 trees/ha (101 trees/ac)
DBH (average): 28.3 cm (11.1 in)
BASAL AREA: 25.7 m2/ha (111.8 ft2/ac)
SPECIES COMPOSITION: Sugar Maple 98 % Red Maple 2 %
CROWN STRUCTURE: Two Story
CROWN CLOSURE: Open (less than 50 %)
STAND AGE: ca. 110 years

ANNUAL HEALTH MEASUREMENTS (averages)

YEAR	DIEBACK	TRANSPARENCY	MORTALITY
1988	11.3 %	27.3 %	0 %
1989	7.1	23.0	0
1990	7.6	14.0	0
1991	3.0	10.9	0

[see field manual for more details on definitions, values and protocols]

Table 2. Forest structure, species composition and tree measurements for 1991 on a Vermont Monitoring Cooperative forest health plot at the Proctor Maple Research Center, Mount Mansfield, Vermont, at 1360 ft. (415 m) elevation.

FOREST STRUCTURE

POINT NO.	NO. LIVE TREES	NO. LIVE SAPLINGS	NO. LIVE SEEDLINGS	PERCENT COVER				
				seedlg	fern	moss	herbs	shrubs
1	13	3	6	0	75	5	5	0
2	2	0	1	5	50	5	50	0
3	0	0	9	50	10	5	10	40
4	6	2	12	5	50	5	10	0

SPECIES COMPOSITION

SPECIES	% OF TOTAL LIVE TREES	% OF TOTAL LIVE SAPLG	% OF TOTAL LIVE SEEDLG
Sugar maple	90.4	100	64.3
Red maple	4.8	0	3.6
Yellow birch	4.8	0	10.7
Striped maple	0	0	14.3
White ash	0	0	7.1

TREE MEASUREMENTS (averages from July 9 data)

SPECIES	DBH(in)	CRWN CLASS	CRWN RATIO(%)	CRWN DIAM(ft2)	DK(%)	TR(%)	DEN(%)
Sugar maple	6.86	3.05	53.2	358.95	1.8	10.5	60.0
Red maple	6.50	3	45	252	0	15	40
Yellow birch	6.20	4	65	627	5	20	40
All species	6.81	3.1	53.1	366.6	1.9	11.0	58.3

Where DBH = diameter at breast height (inches)
CRWN Class = crown class, or position in canopy: 1=open grown, 2=dominant, 3=codominant, 4=intermediate, 5=suppressed
CRWN RATIO = crown ratio, or percent of total tree height living.
CRWN DIAM = crown diameter, or width of crown at drip line taken at widest point and the 90 degrees from widest point.
DK = dieback, or the percent of crown with recently dead branches.
TR = transparency, or the percent of light coming through the foliage.
DEN = density, or the percent of total possible area filled by the crown (including bole, foliage, reproductive parts, etc).

For more detail on definitions, values and procedures, refer to the NFHM Methods Manual).

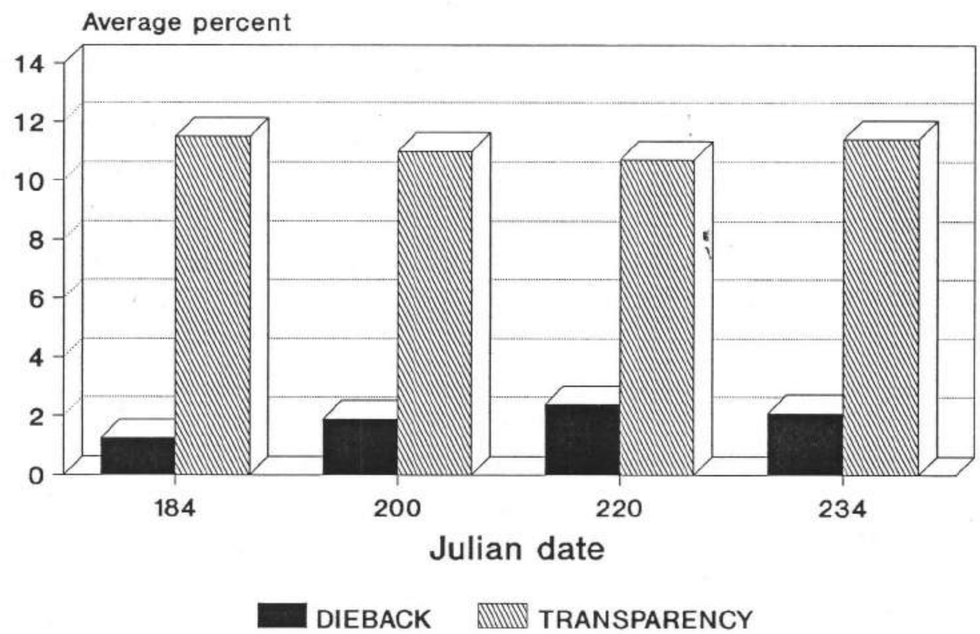


Figure 1. Seasonal variability of crown ratings for 1991 on a Vermont Monitoring Cooperative forest health plot, Proctor Maple Research Center, Mount Mansfield, Vermont, at 1360 ft (415 m) elevation.

SUGAR MAPLE TREE PHENOLOGY MONITORING

by Sandra H. Wilmot, Vermont Dept. Forests, Parks & Recreation

Cooperators: H. Brenton Teillon, Thomas Simmons, and Cecilia Polansky, VT Dept. Forests, Parks & Recreation; and Bruce L. Parker, Margaret Skinner, Luke Curtis and Jim Boone, UVM Entomology Laboratory.

Introduction

Annual changes in the timing and duration of bud development in the spring, total leaf size, and timing and duration of leaf senescents and drop are important to understanding interactions between environmental stresses and forest ecosystems. Subtle changes in tree phenology may be an early indication of larger changes to be manifested in the future.

The objectives is to measure the phenology of sugar maple trees to establish the timing of developmental events and trends, especially as they relate to changes in weather or insect and disease occurrence.

BUD PHENOLOGY

Methods

Bud development is measured from dormancy through full leaf expansion and flower senescence on five sugar maple trees at the Proctor Maple Research Center [1360 ft (415 m) elevation] using a 45X spotting scope. Observations are made at least twice weekly, and more frequently when bud development rates increase. Bud development is categorized into 8 vegetative and 7 reproductive bud stages using the guide and protocols developed by Skinner and Parker (Skinner & Parker, 1991) [Table 1]. Data are analyzed as percent of buds in each stage on each sampling date (Figure 1).

Results

Bud swelling began on Julian date (JD) 95 (April 5) and by JD 98 the average vegetative bud stage was V1 (initial bud swell). Following JD 113 (April 23), the rate of bud development increased more rapdidly. Bud break (V4) occurred by JD 119 (April 29). Full leaf expansion was reached first by the regeneration (on JD 122-May 2), then the lower and upper canopies on JD 133 (May 13).

Individual tree differences in developmental rate are shown in Figures 2-6, and can be used as a baseline for monitoring changes in developmental rates over time.

Table 1. Stages of sugar maple bud development, as identified by Skinner & Parker (1991)[see guide for more detailed description of each stage].

Vegetative bud stage	Developmental event
V0	Dormant
V1	Initial bud swell
V2	Bud elongation
V3	Green tip stage
V4	Bud break
V5	Extended bud break
V6	Initial leaf development
V7	Initial leaf expansion
V8	Full leaf expansion

Flower bud stage	Developmental event
F0	Dormant
F1	Initial bud swell
F2	Bud elongation
F3	Green tip stage
F4	Bud break
F5	Initial flower expansion
F6	Full flower expansion
F7	Flower senescence and drop

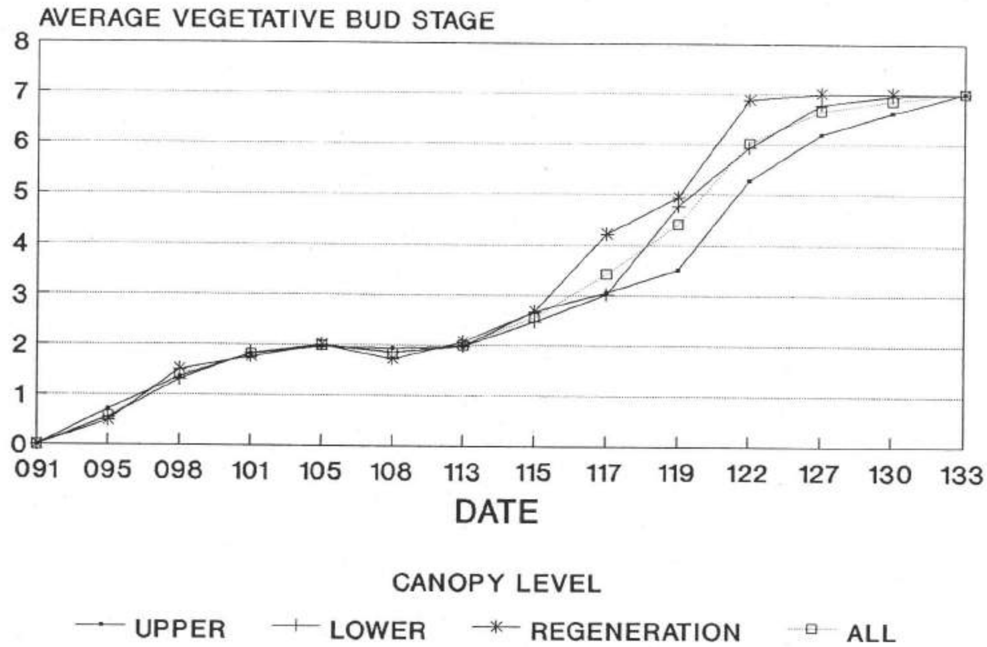


Figure 1. Sugar maple bud phenology. Average developmental rate for sugar maple buds at different levels in the canopy: upper canopy, lower canopy and regeneration. Proctor Maple Research Center, Mount Mansfield [1360 ft (415 m)], Vermont, 1991.

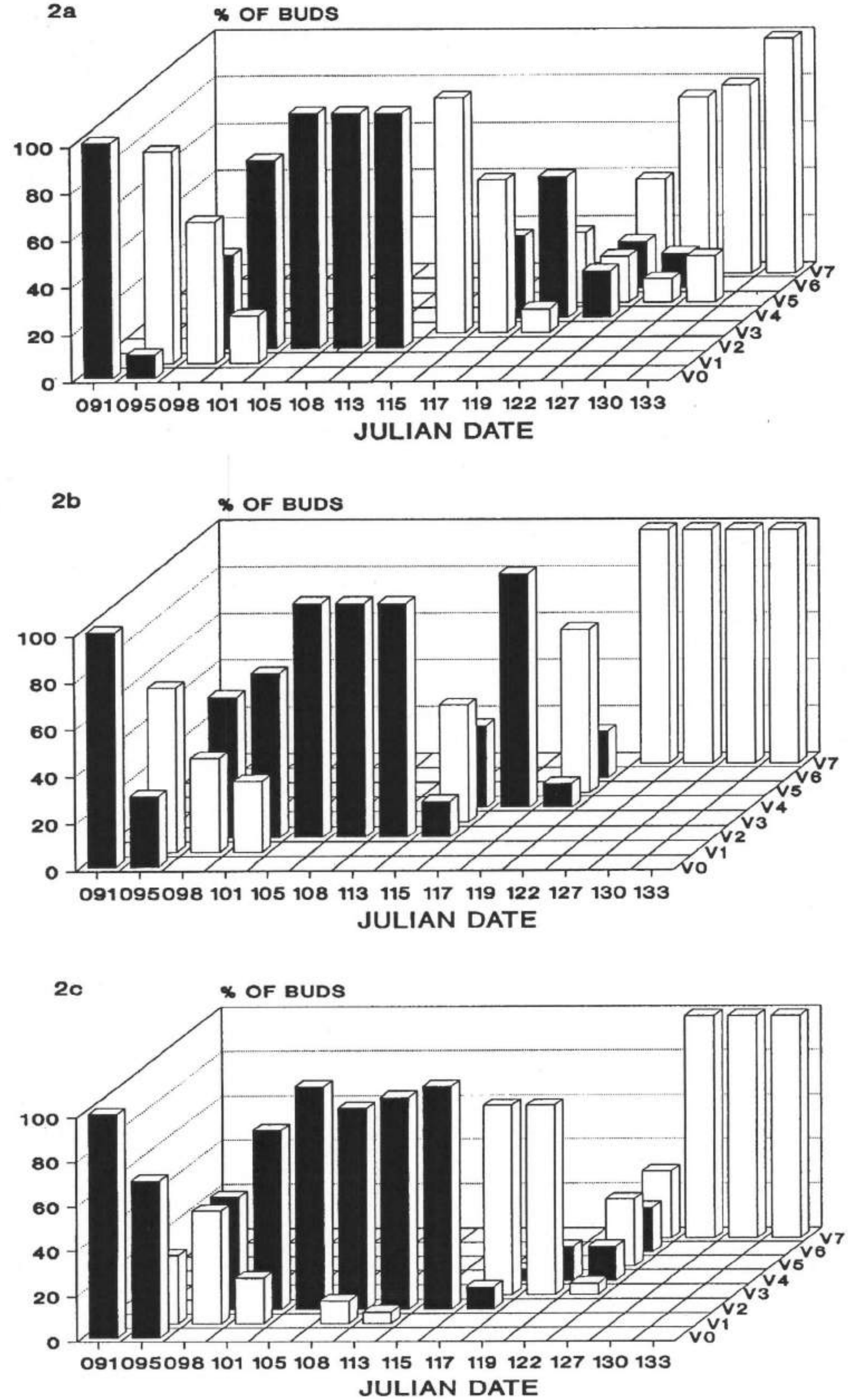


Figure 2a-c. Sugar maple tree 1, bud phenology. Developmental rate of upper canopy (2a), lower canopy (2b), and regeneration (2c) of tree 1, Proctor Maple Research Center, Mount Mansfield [1360 ft (415 m)], Vermont, 1991.

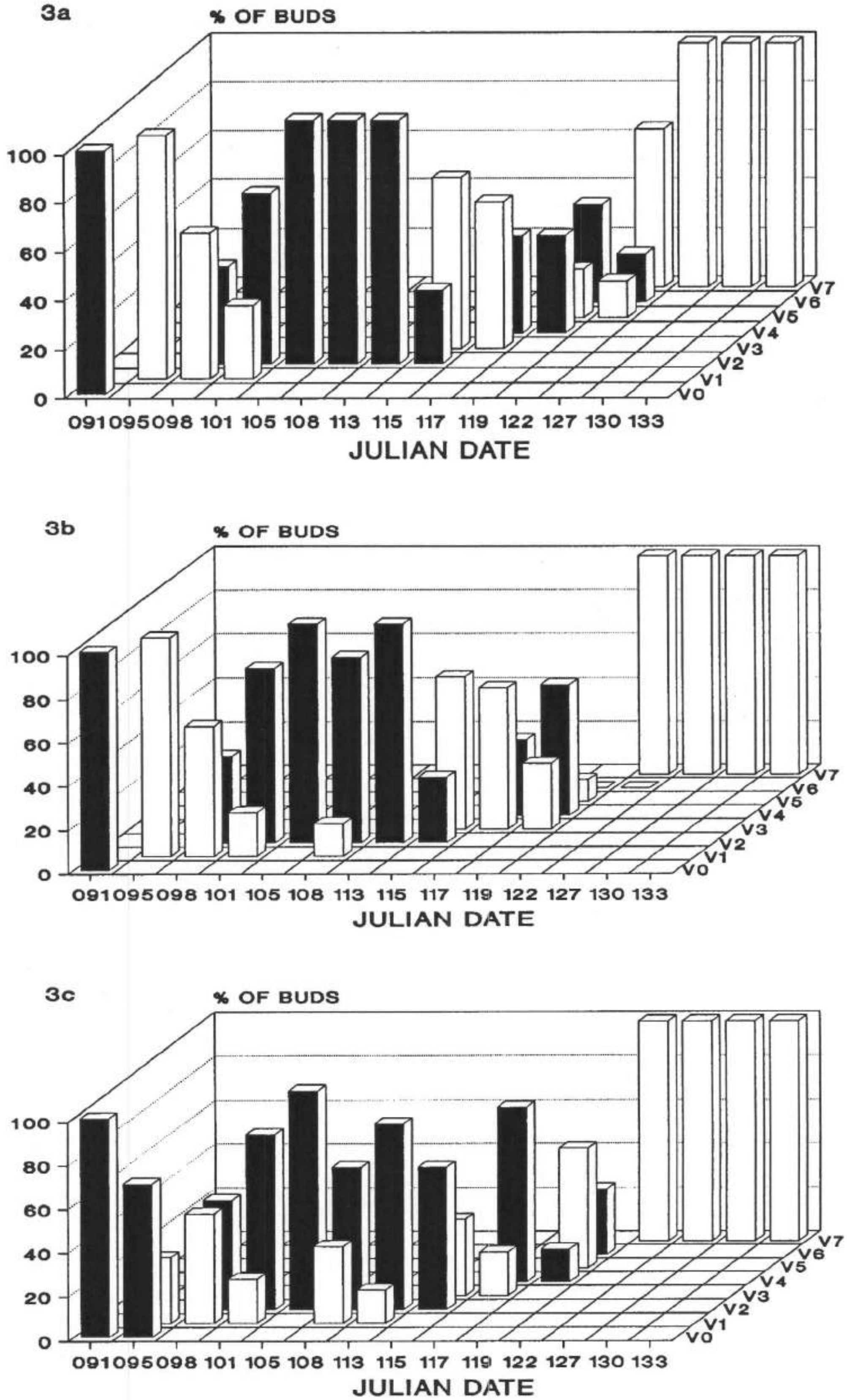
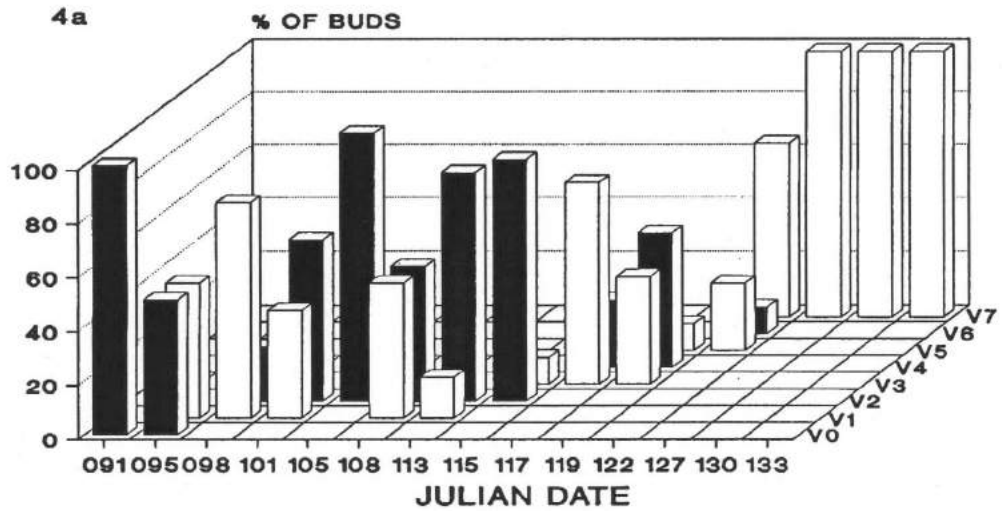
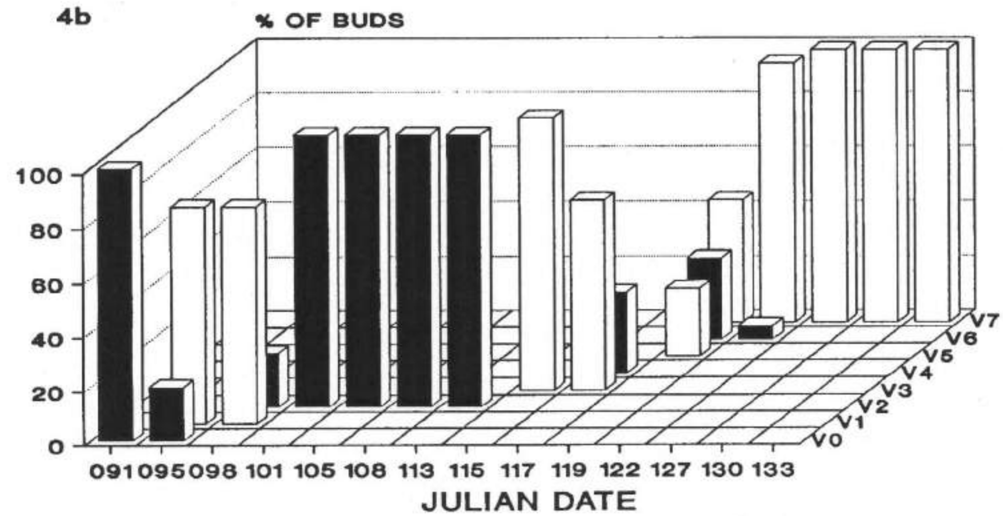


Figure 3a-c. Sugar maple tree 2, bud phenology. Developmental rate of upper canopy (3a), lower canopy (3b), and regeneration (3c) of tree 2, Proctor Maple Research Center, Mount Mansfield [1360 ft (415 m)], Vermont, 1991.





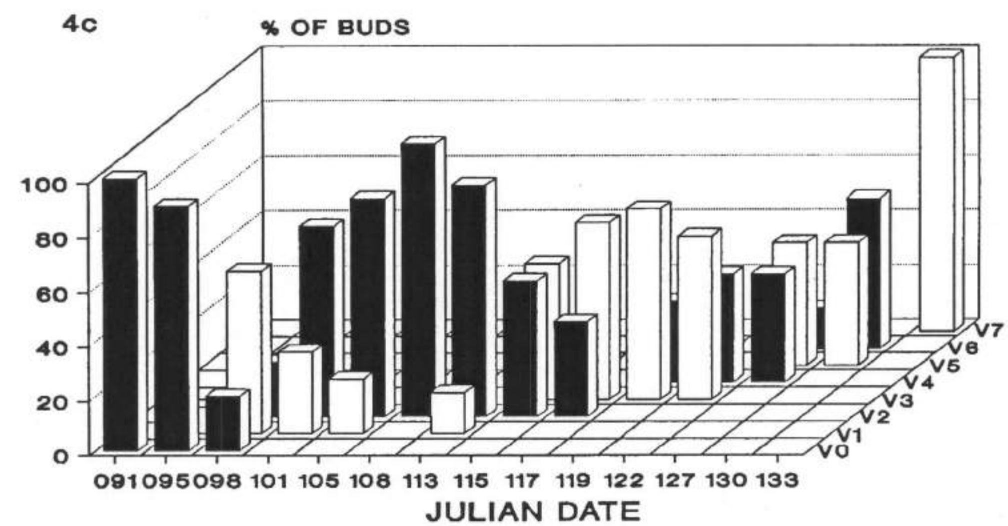
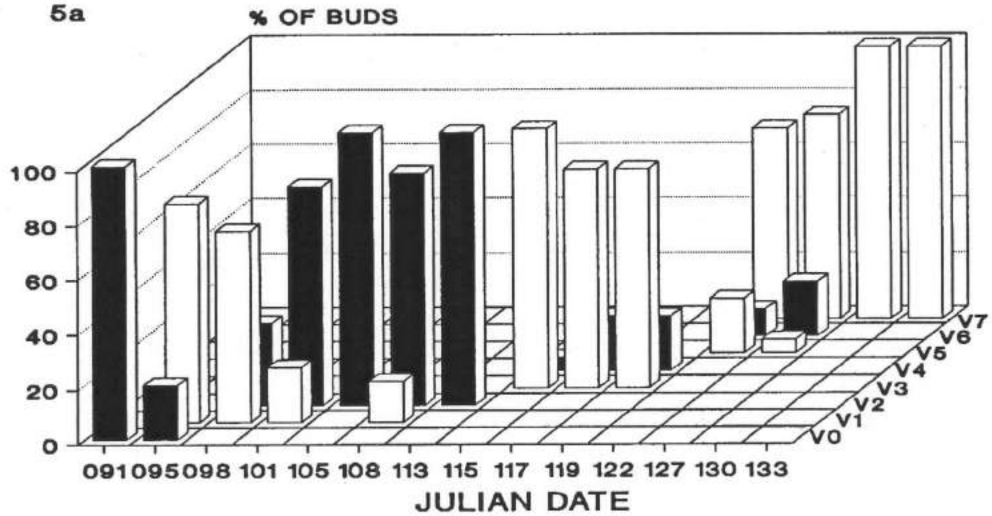
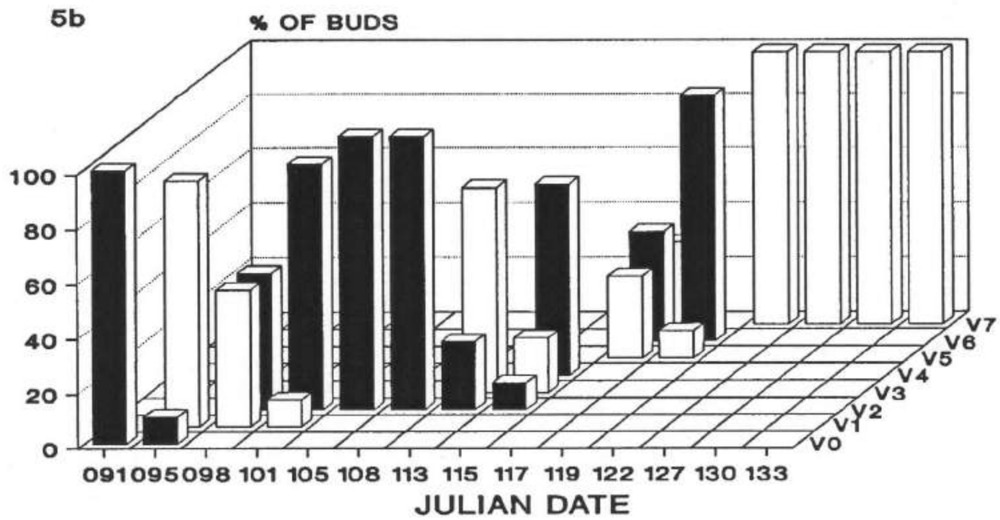


Figure 4a-c. Sugar maple tree 3, bud phenology. Developmental rate of upper canopy (4a), lower canopy (4b), and regeneration (4c) of tree 3, Proctor Maple Research Center, Mount Mansfield [1360 ft (415 m)], Vermont, 1991.





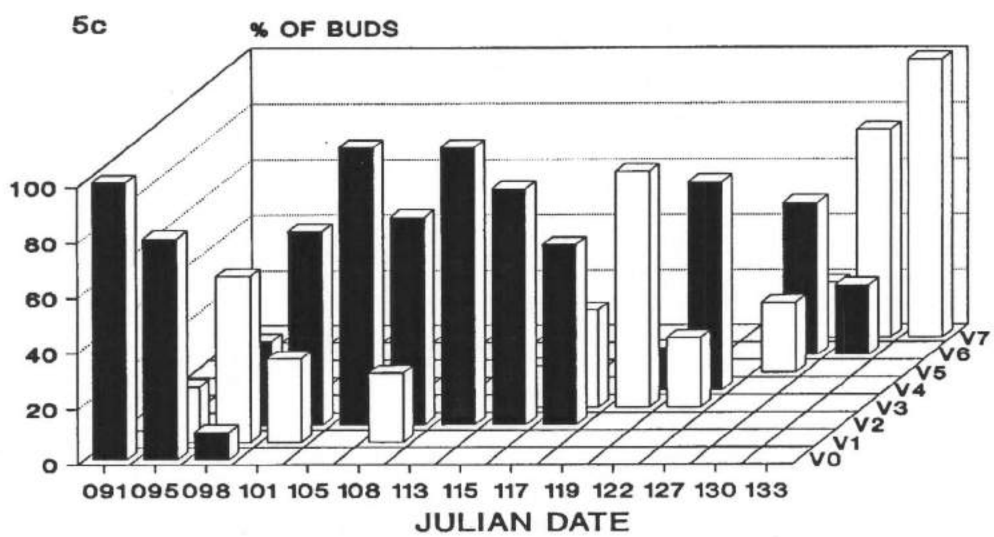
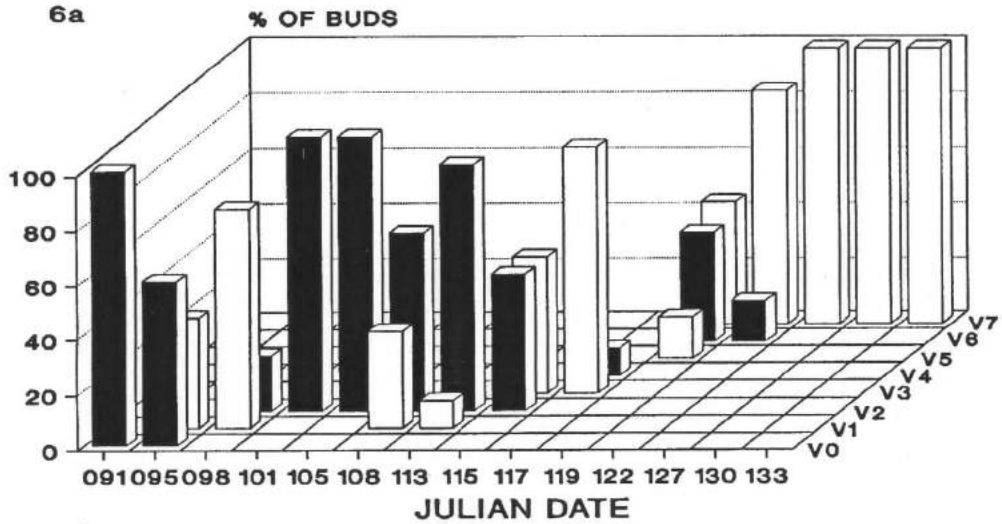
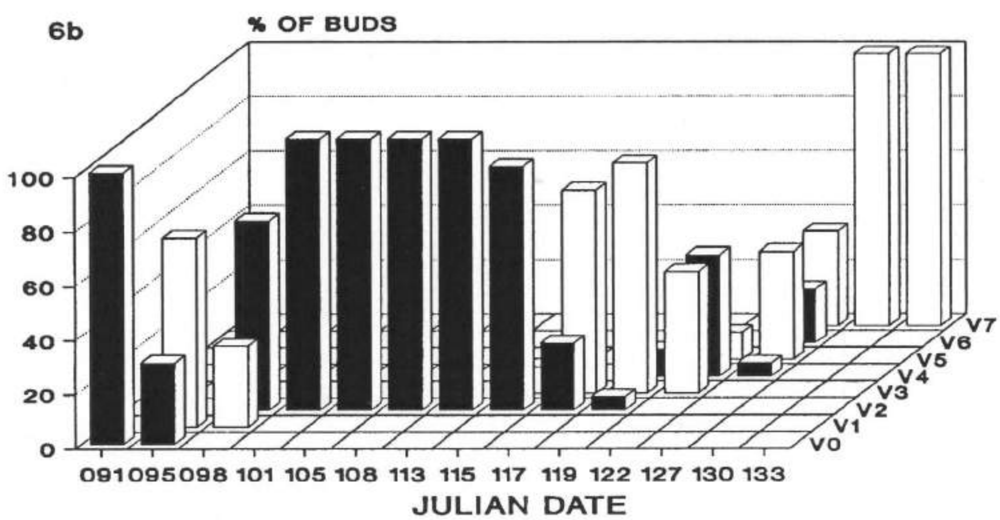


Figure 5a-c. Sugar maple tree 4, bud phenology. Developmental rate of upper canopy (5a), lower canopy (5b), and regeneration (5c) of tree 4, Proctor Maple Research Center, Mount Mansfield [1360 ft (415 m)], Vermont, 1991.





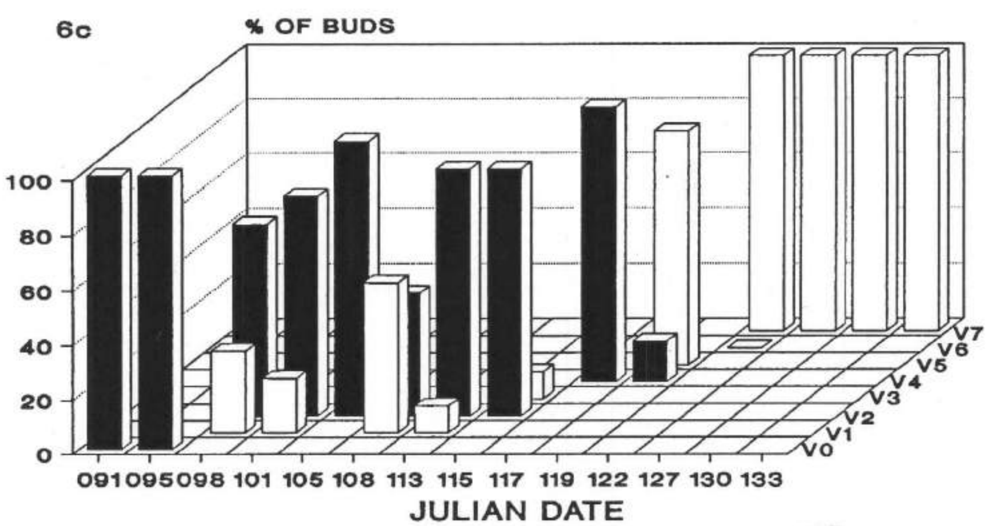


Figure 6a-c. Sugar maple tree 5, bud phenology. Developmental rate of upper canopy (6a), lower canopy (6b), and regeneration (6c) of tree 5, Proctor Maple Research Center, Mount Mansfield [1360 ft (415 m)], Vermont, 1991.

Discussion

Since budbreak is an important event in terms of insect pest activity, among others, it is interesting to note that although the average vegetative stage on JD 119 was V4, only the regeneration and lower canopy buds were at this stage. The upper canopy did not reach budbreak until 3 days later when the average bud stage had actually moved beyond this to the extended bud break stage (V5). In general, the upper canopy lagged behind the regeneration and lower canopy in timing of development.

Context

Bud phenology of sugar maple trees is being conducted at other locations in Vermont by the UVM Entomology Laboratory (B.L. Parker et al) in the context of understanding the relationship between insect populations (pear thrips) and bud phenology.

LEAF SIZE

Methods

Mid-canopy leaf samples were taken from the same 5 sugar maple trees used for bud phenology monitoring, 5 times throughout the growing season. Each sample consisted of 20 leaves collected from 4 sides of each tree. Leaves were pressed, dried and leaf surface area measured using both a leaf area meter and a modified swath kit (a computerized system developed for measurement of spray droplets used in insect pest suppression projects).

Results

Both the leaf area meter and the swath kit yielded the same results for each leaf measured, so results reflect both measurement types (Figure 7). Maximum leaf size was obtained on Julian date (JD) 165 (June 14), and was 44.21 cm^2. A decrease in leaf size occurred on the subsequent collections, probably due to defoliation from the maple leaf cutter, which was present at the site.

Discussion

This year was a good year for gaining baseline information on leaf size, since field observations found growing conditions to be favorable for early season leaf growth, generally low seed production and light insect activity.

Variation between collection dates could also have be affected by the presence of small, immature leaves, that persisted throughout the field season. As much as possible, leaves were collected in an unbiased manner, taking all leaves from a cluster of 3-5 leaves. But it is easy to see how these small leaves, ca. one-quarter the size of other leaves, could have changed average leaf

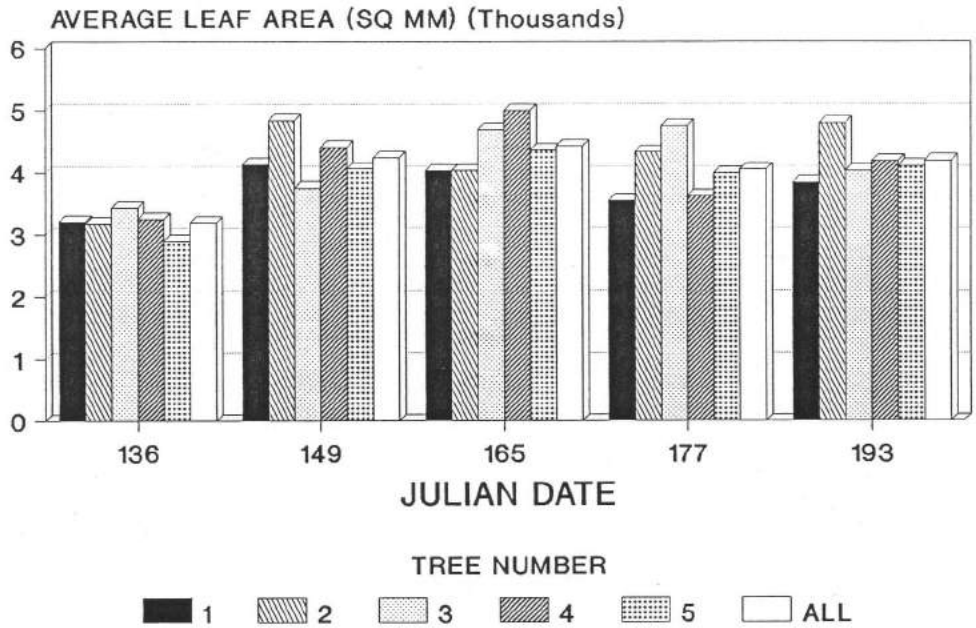


Figure 7. Sugar maple leaf size. Timing of full leaf expansion and average leaf surface area (mm^2), expressed in thousands, of sugar maple leaves collected from 5 mature trees at the Proctor Maple Research Center, Mount Mansfield [1360 ft (415 m)], Vermont, 1991.

size. The range of variation in calculating size was 7.85 to 13.57 %.

FALL PHENOLOGY

Methods

Leaf senescence and drop was measured on the same 5 sugar maple trees as bud phenology and leaf size studies. Visual crown ratings were taken from JD 207 (July 26) through JD 289 (October 16) [the time when all leaves on all trees had turned color] once every two weeks, with weekly ratings done when the rate of color change and leaf drop increased (JD 276-289, October 3-16). The visual crown rating system used is that used by the National Forest Health Monitoring Program (Conkling and Byers, 1992), where leaf discoloration (DS) measurement was used to measure change in coloration, and foliage transparency (TR) and crown dieback (DK) were used to measure change in leaf drop. All ratings were taken in 5 % classes.

Results

Data were analyzed as percent of leaves turning color or dropping (Figures 8-13). Initial ratings show the baseline ratings of each tree for this year. Significant coloration did not begin until JD 276 (October 3), when the average coloration was 62 %. There was a slight increase in leaf drop on this date, but leaf drop did not exceed 50 % until JD 289 (October 16).

Discussion

Although this crown rating system was not developed for this use, it worked well for this application. At the onset, we did not know whether to use TR or DK as an indication of leaf drop. Since some trees lost leaves from twig tips first, the DK rating served to indicated leaf drop. Other trees leaf loss was evenly distributed throughout the crown, and the TR rating better represented these individuals. For future applications, we will continue to take both measurements as an indication of the timing of leaf drop.

Future Plans

In 1992, we plan to add 2 additional species to this tree phenology study. In addition, the 3 species would be monitored at both the Proctor Maple Research Center and an additional site at a higher elevation on Mount Mansfield.

Funding Sources

This project was partially funded through the VMC grant from the USDA Forest Service. Additional support for leaf area measurements was provided by the UVM Entomology and the St. Albans Correctional Facility.

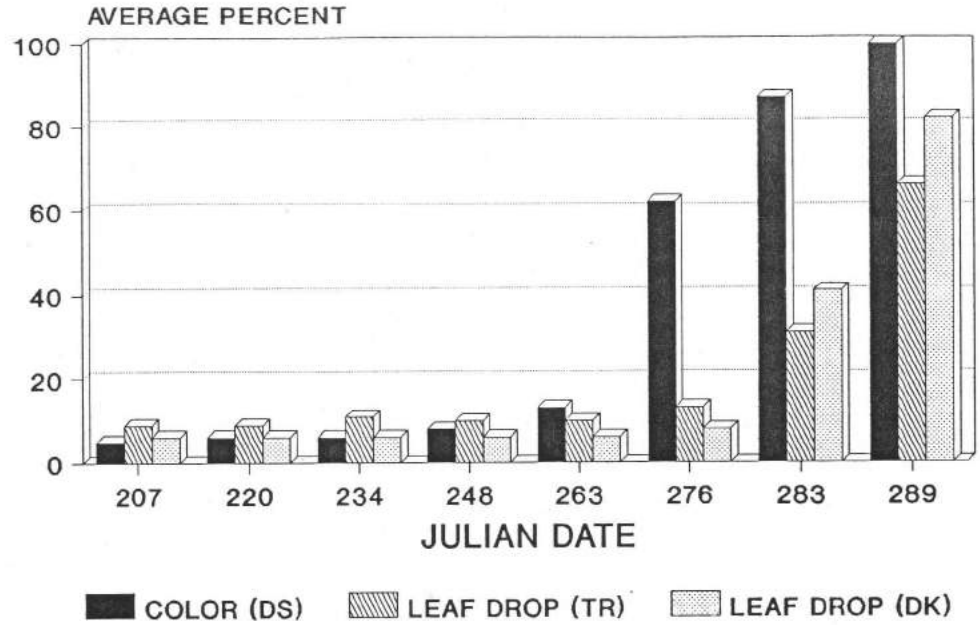


Figure 8. Sugar maple fall phenology. Average rate of fall leaf coloration and drop for 5 mature sugar maple trees, Proctor Maple Research Center, Mount Mansfield [1360 ft (415 m)], Vermont, 1991. Rating system is according to North American Maple Project protocols for foliage discoloration (DS), dieback (DK) and transparency (TR), expressed in a 12-class percentage rating system (Millers et al).

9a

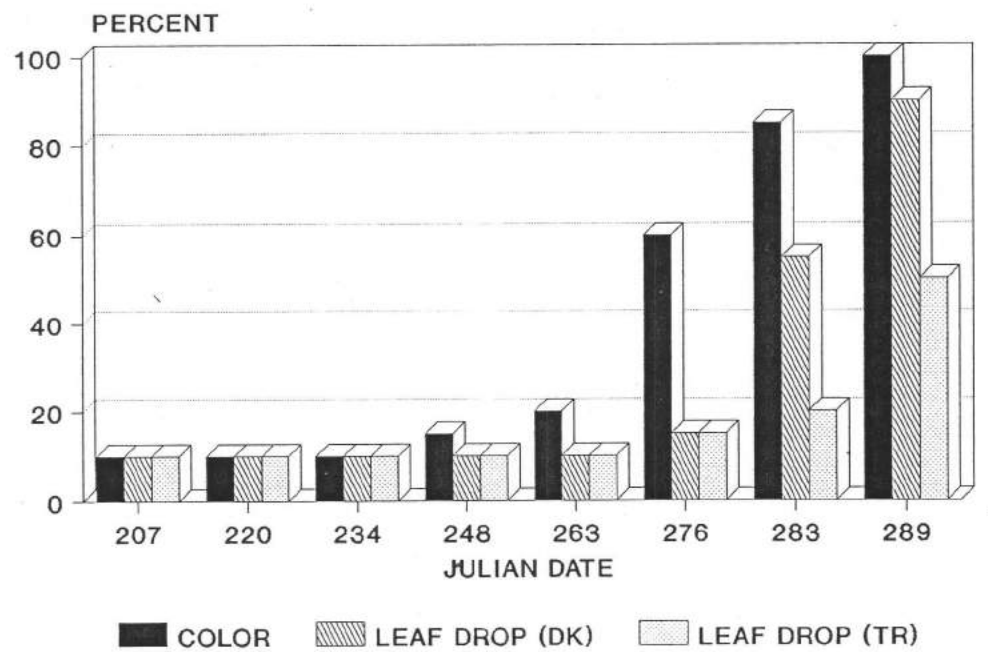
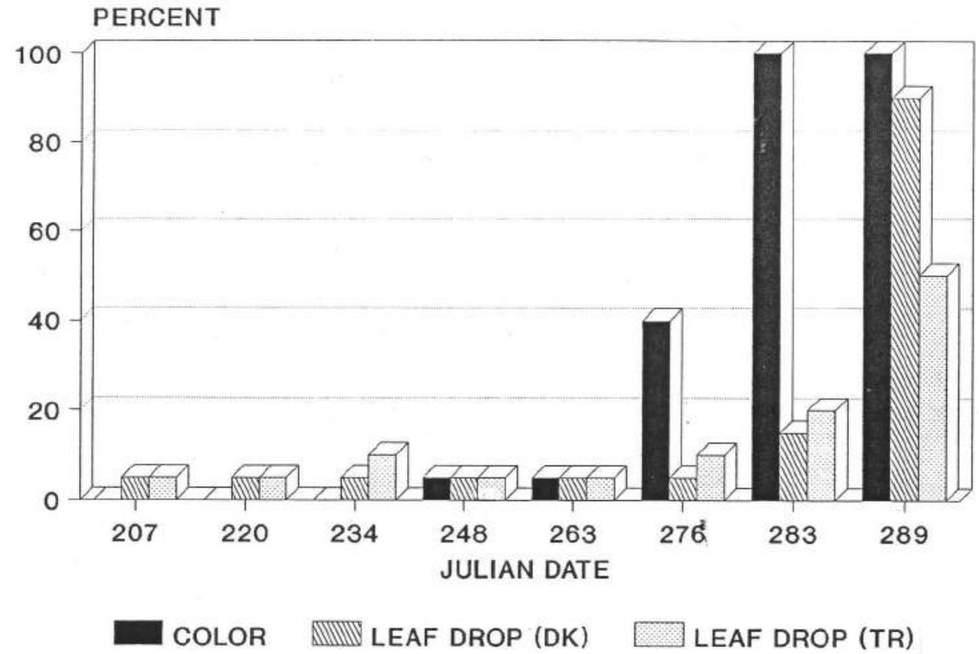


Figure 9a-e. Sugar maple fall phenology. Rate of fall leaf coloration and drop for 5 mature sugar maple trees [Tree 1 (9a), Tree 2 (9b), Tree 3 (9c), Tree 4 (9d) and Tree 5 (9e)], Proctor Maple Research Center, Mount Mansfield [1360 ft (415 m)], Vermont, 1991. Rating system is according to North American Maple Project protocols for foliage discoloration (DS), dieback (DK) and transparency (TR), expressed in a 12-class percentage rating system (Millers et al).

9b


PERCENT
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283
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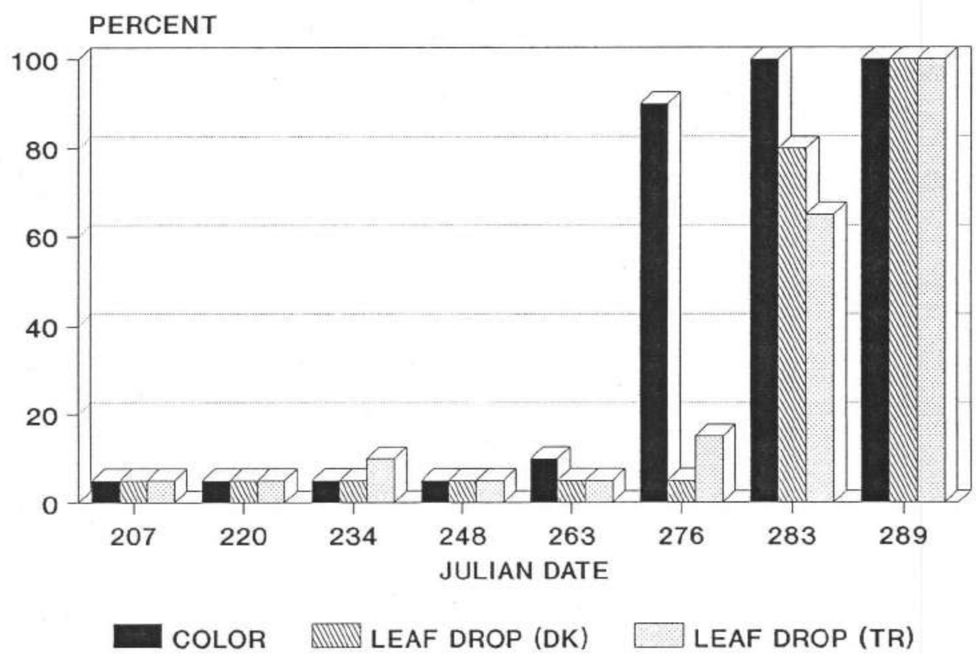
JULIAN DATE
COLOR
LEAF DROP (DK)
LEAF DROP (TR)

9c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LEAF DROP (TR)

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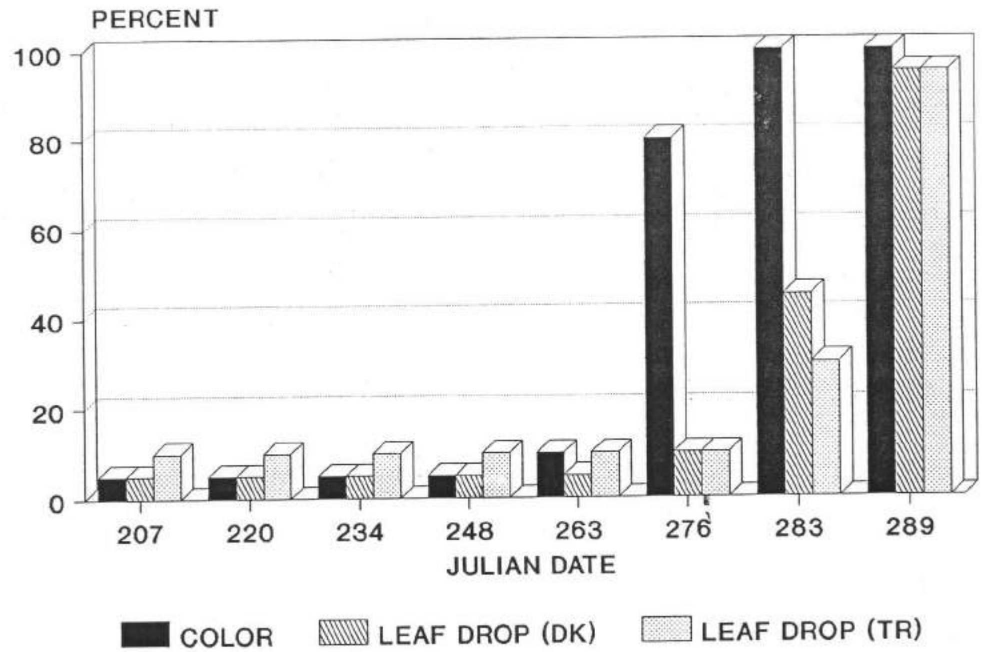
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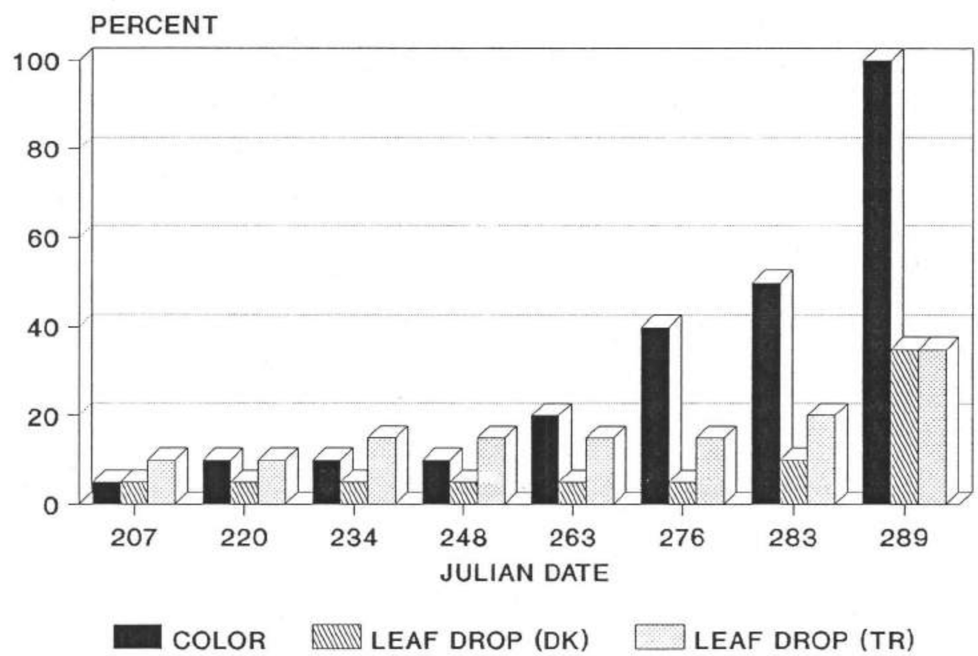
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LEAF DROP (TR)

References

Conkling, B. B. and G. E. Byers (eds.). 1992. Forest Health Monitoring Field Methods Guide. Internal Report. U. S. Environmental Protection Agency, Las Vegas, NV.

Millers, I., D. Lachance, W. Burkman & D. Allen. 1991. North American Sugar Maple Decline Project: organization and field methods. Gen. Tech. Rep NE-154. Radnor, PA: U.S. Dept. of Agr., Forest Service, Northeastern Forest Experiment Sta. 26 p.

Skinner, M. and B. L. Parker. 1991. Sugar Maple Bud Phenology Ground Monitoring Protocol (April 1991 draft). Entomology Research Lab, 655B Spear St., So. Burlington, VT 05403.

FOREST PEST SURVEYS

by Sandra H. Wilmot, Vermont Dept. Forests, Parks and Recreation

Cooperators: H. Brenton Teillon, Thomas Simmons, Cecilia Polansky, and Patricia Hanson, VT Dept. Forests, Parks and Recreation (FPR); Bruce L. Parker, UVM Entomology Laboratory; Jon Turmel, VT Dept. of Agriculture.

Introduction

Historically, damage from forest insects has played a major role in widespread tree declines. Monitoring pest population trends and resulting tree damage is therefore vital in understanding trends in the health of forests and how forest management exacerbates or moderates the impacts from pests.

The objective of conducting forest pest surveys is to track trends in major insect pest populations as potential stressors to the forest.

Methods

There exists numerous different methods for measuring forest pest populations, and the effectiveness of each method is pest specific. Some forest pests do not yet have reliable, meaningful survey methods developed. At present, the forest pests monitored at the Proctor Maple Research Center (PMRC) include: pear thrips (PT), gypsy moth (GM), forest tent caterpillar (FTC), and spruce budworm (SBW).

SPRUCE BUDWORM AND FOREST TENT CATERPILLAR

These pests are monitored using pheromone traps [multipher traps with a biolure and a vaportape insecticide], which attract male moths during their flight period, indicating relative population levels in the area. FTC trapping is done using a 5 trap cluster, which was placed in the vicinity of NAMP (North American Maple Project) plots. SBW trapping is done using a 3 trap cluster, which was placed west of the PMRC Lab in a dense spruce habitat. Protocols for these surveys is accordance with that of other statewide surveys for these pests.

FTC traps were set out on Julian Date (JD) 177 (June 26) and collected on JD 227 (August 15). SBW traps were set out on JD 170 (June 19) and collected on JD 248 (September 5). Trap catches were returned to the VT FPR Laboratory in Waterbury for counting and moth verifications.

PEAR THRIPS

PT are a relatively new pest to Vermont sugar maple trees, and therefore lack the depth of understanding in relating trap catches to population densities and subsequent damage. At present 3 different population assessment methods are in operational for monitoring this pest: soil samples for immature population estimates, emergence traps for adult population estimates and timing of emergence, and yellow sticky traps for adult population estimates. All 3 methods were employed at the PMRC [1360 ft. (415 m) elevation].

Soil samples were collected in the fall of 1990 to estimate the overwintering pear thrips population, using field and laboratory protocols previously established for statewide and regional PT surveys (Parker et al, 1990). Basically, 5 sugar maple trees were identified in 1988 as reference points for soil sampling, using a bulb planter collecting tool. Resultant damage assessments are taken on these 5 trees in mid-June.

Emergence traps were used in the spring of the year to monitor PT adult emergence from the soil and to estimate the surviving adult population size, using standard protocols (Parker et al, 1990). Again, the same 5 sugar maple trees are used as reference points for emergence trap placement and comparisons between emergence population size and damage.

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

Gypsy moth burlap banded plot was used to monitor GM egg masses present on preferred host tree species. At the PMRC, most of the forest is non-preferred host trees (like sugar maple). A small cluster of poplar trees was therefore used to detect the presence/absence of this pest on-site, and monitor trends in population over time. Protocols for this survey follow standards used in other Vermont GM focal areas. Burlap bands placed at DBH on live trees within the plot attract egg bearing females, who tend to lay their egg masses under or near the burlap. Counts of egg masses in the fall are used to estimate the resident population.

Results

Results of trap catches showed the presence of 3 out of the 4 target pest species, spruce budworm, pear thrips and gypsy moth (Tables 1-2). In addition, hemlock looper (HL), a new forest pest threat in Vermont, was present and captured in both types of pheromone traps. PT soil population and resulting damage for 1988 through 1991 shows a steady decrease in the population, with resulting damage lessened on saplings.

Discussion

Contamination of pheromone trap lures is common. The large GM catches in both the FTC and SBW traps suggest that past handling of gypsy moth pheromone traps resulted in contamination at some point in the distribution of these traps.

The presence of HL in our traps may be a result of the behavior of this insect, which likes the concealment offered by the traps. But this did allow us to detect the presence of this new forest pest on Mount Mansfield.

The presence of GM at this site was not expected, since there is but a small area with preferred host species. But GM do feed on non-preferred hosts, which may be the case at this site.

No sugar maple seedlings were found in 1988, but it is unknown whether this is due to low reproduction or low survival. Other sites in Vermont and the Northeastern region have documented seedling mortality from PT feeding, so this possibility can not be ruled out.

More specific PT damage assessments began in 1991 using NAMP crown ratings for foliage transparency (measurement of defoliation) and dieback (stress impact manifested). Trees with dieback $\leq$ 15 % are considered healthy. Since the average dieback on these trees was 17 %, this would indicate that the trees are in a state of light decline. General observations suggest that over the past 3 years the amount of damage from PT to the overstory has lessened, but this is not represented in the gross damage assessments used here (light, moderate and heavy damage).

Context of this study

Statewide surveys presently exist to monitor these 4 pests (Teillon et al, 1991). FTC and SBW are monitored at 8 and 21 sites in Vermont, respectively. FTC populations were low in 1991, with the average trap catch at 0.4 moths/trap. SBW populations were higher that in recent past, an average of 12 moths/trap, but still at low levels with not visible defoliation occurring. Numbers at the Mount Mansfield site, however, were the highest in the state with no obvious explanation.

GM populations in focal areas are monitored at 11 sites in Vermont. In 1991, average populations from these sites was 3 egg masses, the same as that found at Mount Mansfield.

PT soil populations are monitored at ca. 100 sites in Vermont (Teillon et al, 1991). The overwintering population for this year was lower than previous years with resulting damage at low for recent years, as was the case at Mount Mansfield.

Future plans

As survey methods for other forest pests become available they will be implemented at this site. In addition to surveys at the 1360 ft [415 m] elevation, we anticipate expanding elevationally to monitor these pests at other sites on the mountain.

Funding sources

Insect pest surveys are funded in part through a cooperative agreement with the USDA Forest Service State and Private Forestry, Forest Health Protection grants program, with matching funds from the State.

References

Millers, I., D. Lachance, W. Burkman & D. Allen. 1991. North American Sugar Maple Decline Project: organization and field methods. Gen. Tech. Rep NE-154. Radnor, PA: U.S. Dept. of Agr., Forest Service, Northeastern Forest Experiment Sta. 26 p.

Parker, B. L., M. Skinner, S. H. Wilmot and D. Souto. 1990. Proceedings, Regional Meeting: "Pear Thrips Research and Management: Current Methods and Future Plans." South Burlington, VT, November 15-16. Vt. Agr. Exp. Sta. Bull. 697, Univ. Vt., Burlington. 151 pp.

Teillon, H.B., B.S. Burns and R.S. Kelley. 1991. Forest Insect and Disease Conditions in Vermont - 1991. Agency of Natural Resources, Dept. of Forests, Parks and Recreation, 103 So. Main St., Waterbury, VT 05671-0602. 70 pp.

Table 1. Pest survey results from Proctor Maple Research Center, Mount Mansfield, Vermont, 1991. Four pest surveys are presented: spruce budworm and forest tent caterpillar adult collections from pheromone traps, pear thrips adult collections from yellow sticky traps, and gypsy moth egg mass survey from burlap banded trees.

TARGET PEST	SURVEY TYPE SURVEYED	JULIAN DATES PEST OBSERVED	TOTAL NO. COLLECTED	OTHER PESTS COLLECTED
Spruce budworm (SBW)	Pheromone traps	170-248	59	GM=95 HL= 9
Forest tent caterpillar (FTC)	Pheromone traps	177-227	0	GM=181 HL= 1
Pear thrips (PT)	Sticky traps	091-133	8	-----
Gypsy moth (GM)	Burlap banded trees	289	3	-----

HL=Hemlock looper

Table 2. Pear thrips soil population and associated sugar maple damage assessments for 1988 through 1991, Proctor Maple Research Center, Mount Mansfield, Vermont. Soil population figures are recorded in units of pear thrips per bulb planter of soil to allow for comparisons with other Vermont sites.

YEAR*	PT SOIL POPULATION (AVE. NO./ BULB PLANTER)	RESULTING DAMAGE TO:				
		TREES	DK	TR	SAPLINGS	SEEDLINGS
88-89	17.5	LIGHT			MODERATE	----
89-90	10.6	LIGHT			LIGHT	LIGHT
90-91	0.6	LIGHT	17	15	LIGHT	LIGHT

* = first year listed indicates year of fall soil sample for population assessment, second year of each combination indicates year of spring damage assessment.

PT = pear thrips
LIGHT DAMAGE = 1-30 % of leaves damaged
MODERATE DAMAGE = 31-60 % of leaves damaged
DK = dieback (ave. %) [North American Maple Project protocol]
TR = transparency (ave. %) ["]

SUGAR MAPLE LEAF SURVEY

by Sandra H. Wilmot and Patricia Hanson,
Vermont Dept. Forests, Parks and Recreation

Cooperators: H. Brenton Teillon, Thomas Simmons, Cecilia Polansky, and Ted Walker, VT Dept. Forests, Parks and Recreation; Scott Pfister and Jon Turmel, VT Dept. of Agriculture.

Introduction

The purpose of this survey is to obtain site-specific, baseline information on the variety of insects, diseases and weather phenomena manifest on sugar maple leaves. Little information is available on minor damage to leaves caused by numerous factors. It is our goal to establish a long-term database of temporal information on organisms and symptoms present on canopy leaves.

Methods

Five codominant, mature sugar maples located at the Proctor Maple Research Center [1360 ft (415 m)] were sampled 5 times during the growing season to collect leaves for evaluations. Twenty leaves per tree and collection period were taken from each of the 5 sample trees for a total of 100 leaves per collection period. A 20-gauge shot gun with steel shot was used to collect leaves from mid-canopy. Five leaves from each of 4 sides of each tree were sampled to obtain maximum diversity of growing conditions. Leaves were refrigerated until examinations could be made.

Laboratory evaluations included macro- and micro-scopic examinations of each leaf by entomologists and pathologists. Records were made of the presence of any symptom and organism on each leaf. Most leaves had numerous symptoms or organisms present, and each separate one was noted.

Photographs, specimens and Riker mounts of common symptoms and organisms were taken for use in identifying subsequent specimens.

In addition, pear thrips egg deposition sites were counted to establish baseline information on incidence and timing of deposition at this site.

Results

A total of 25 different symptoms and organisms were identified from the maple leaves throughout the growing season. Fifteen symptoms and 10 different organisms were observed.

In general, the number of leaves with symptoms and organisms increased over the growing season (Table 1). The six most common types of damage to leaves were from: pear thrips oviposition scars, maple leaf cutter defoliation, leaf hopper feeding, tattering of leaves from wind, mining associated with webbing from an unrecovered insect, and feeding at internodes (Figure 1).

On a tree by tree basis, tree number 3 had more symptoms and organisms on leaves than the other trees (Table 2). Pear thrips oviposition scars were present on more leaves than any other symptom or organism, and by later collections, high numbers of oviposition sites were recorded (Table 3).

The other most frequent symptoms or organisms present were: maple leaf cutter feeding, leaf hopper feeding, necrotic feeding at internodes and purple mottling apparently caused from hot, dry weather. One unique occurrence was that leathery leaves occurred on the 3 last collection periods on tree 5, only. Tree 5 also was the only tree to have single occurrences of Aceria regulus, eyespot (Phyllosticta minima) and a birch leaf miner larva.

Although this study is not designed to determine the impact on leaves from the different damage agents, general comments on the condition of leaves in 1991 may assist in comparing years. The leaves collected in 1991 were generally healthy. Little major defoliation was present. Light defoliation from maple leaf cutter was present on lower foliage of the sample trees, but this did not extend up into the mid-canopy leaves. Overall damage from pear thrips was considered very light to none.

Our initial intent in this study was to survey sugar maple leaf diseases. Due to unusually dry conditions early in the growing season, few diseases were present, but many other damage agents were. We therefore expanded our survey to better represent true leaf conditions, including all symptoms and organisms present.

Funding Sources

Funding was provided, in part, from a USDA Forest Service grant for Vermont Monitoring Cooperative activities and USDA Forest Service Forest Health Protection funds for accelerated forest pest detection activities.

Future Plans

In 1992, we plan to expand this study to include 2 additional tree species and one additional site at a higher elevation (2200 ft) on Mt. Mansfield.

Figure 1. Disease symptom present on sugar maple leaves collected from Proctor Maple Research Center, 1360 ft.(415 m), on Mount Mansfield, Vermont.

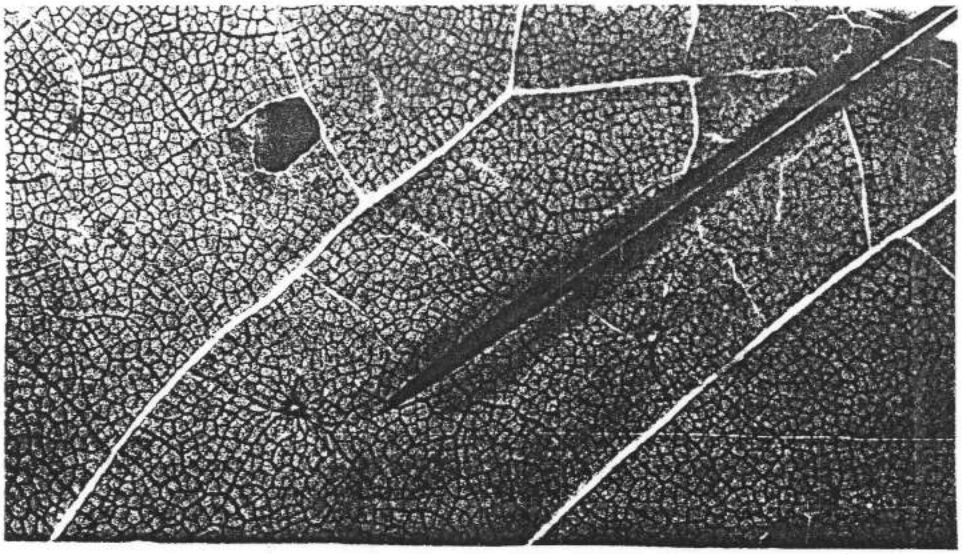


Figure 2. Internodal insect feeding present on sugar maple leaves collected from Proctor Maple Research Center, 1360 ft. (415 m), on Mount Mansfield, Vermont. No causal agent was recovered.

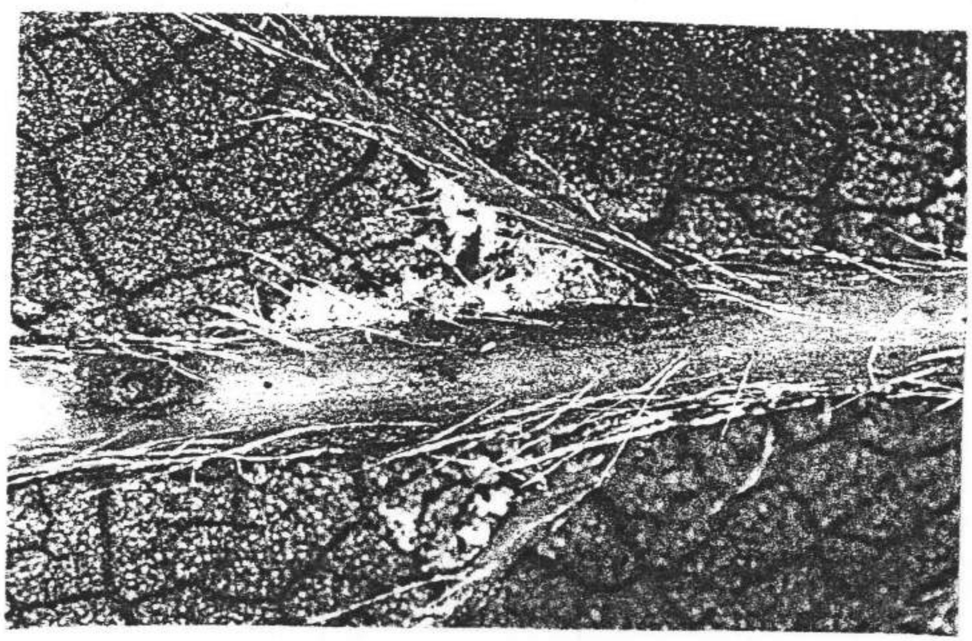


Table 1. Symptoms and organisms present on sugar maple leaves collected on five dates in 1991 from mature, codominant sugar maple trees at the Proctor Maple Research Center [1360 ft (415 m)], Mt. Mansfield, VT.

DATE	THREE MOST COMMON SYMPTOMS AND ORGANISMS	% OF LEAVES WITH DAMAGE OR ORGANISM
149	MAPLE LEAF CUTTER	55
	PEAR THRIPS EGG SCARS	48
	WIND TATTERING	31
165	MAPLE LEAF CUTTER	75
	PEAR THRIPS EGG SCARS	72
	WEBBING INSECT FEEDING	65
177	PEAR THRIPS EGG SCARS	91
	LEAF HOPPER FEEDING	68
	MAPLE LEAF CUTTER	58
193	PEAR THRIPS EGG SCARS	93
	LEAF HOPPER FEEDING	71
	NECROTIC INTERNODES	57
220	PEAR THRIPS EGG SCARS	94
	NECROTIC INTERNODES	88
	LEAF HOPPER FEEDING	84

Table 2. Symptoms and organisms present on sugar maple leaves collected from 5 different sugar maple trees growing at the Proctor Maple Research Center [1360 ft (415 m)], Mt. Mansfield, VT.

TREE NO.	5 MOST COMMON SYMPTOMS OR ORGANISMS PRESENT	% OF LEAVES WITH DAMAGE OR ORGANISM
1	PEAR THRIPS EGG SCARS	66
	MAPLE LEAF CUTTER	56
	LEAF HOPPER FEEDING	51
	DISEASE SYMPTOM (Figure 2)	41
	WIND TATTERING	35
2	PEAR THRIPS EGG SCARS	75
	LEAF HOPPER FEEDING	71
	MAPLE LEAF CUTTER	69
	DISEASE SYMPTOM (Figure 2)	42
	INTERNODAL INSECT FEEDING (Figure 1)	40
3	PEAR THRIPS EGG SCARS	87
	LEAF HOPPER FEEDING	71
	PURPLE MOTTLING	58
	MAPLE LEAF CUTTER	47
	INTERNODAL INSECT FEEDING (Figure 1)	43
4	PEAR THRIPS EGG SCARS	82
	MAPLE LEAF CUTTER	75
	INTERNODAL INSECT FEEDING (Figure 1)	66
	LEAF HOPPER FEEDING	63
	RASPING INSECT FEEDING	34
5	PEAR THRIPS EGG SCARS	88
	INTERNODAL INSECT FEEDING (Figure 1)	73
	MAPLE LEAF CUTTER	69
	LEATHERY LEAVES	60
	LEAF HOPPER FEEDING	54

Table 3. Frequency of pear thrips oviposition on sugar maple leaves collected over the spring and summer, 1991, Proctor Maple Research Center [1360 ft (415 m)], Mount Mansfield, Vermont.

Julian date	Ave. No. Egg Scars/Leaf
149	1.48
165	3.88
177	5.33
193	6.64
220	5.68

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

by
Luke Curtis, University of Vermont
Ronald Kelley, Vermont Department of Forests, Parks & Recreation

OBJECTIVES

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. The purpose of this project is to develop a method to quantify forest canopy cover for short-term assessments, as well as long-term objective documentation of changes within permanent plots.

METHODS

Using a 35mm camera with a 17mm wide angle lens, Ektachrome slides (IS0200) were taken beneath tree crowns by orienting the camera vertically over 107 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.

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 order to evaluate the performance of this system for characterizing softwood canopies, a series of nine photo-points, 10 m apart, was surveyed on a transect in a red pine plantation in Salisbury, VT.

Photography:

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 was mounted on the tripod with the lens oriented toward the zenith. For consistency of orientation, the base of the camera always faced true east. This arrangement, with the long axis of the film parallel to the true north-south axis, minimized the period at midday during which the sun might appear in the image.

The camera tripod was erected over each photopoint 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 be magnified in portions of the image from the upper canopy.

The camera was equipped with a right-angle viewfinder and a cable release.

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 close foliage to be removed.

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, Ektachrome has enough latitude to make all three exposures useful. 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.

<u>Video:</u>

To compare computer analyses of photographic and video images, video images were taped in August at 18 NAMP photo points on the same day that slides were taken. Video images were taken using a regular VHS video camera (Panasonic WDV 5000), equipped with an 8x autofocus lens with a focal length of 10.5-84mm. The field of view with video cameras is actually four to five times as narrow as that of a 35mm camera lens of the same focal length. This video camera has a field of view that is four times as narrow, making the lens at 10.5mm the equivalent of a 42mm lens on a 35mm camera. Wide angle lenses that screw onto the front of video lenses are available that would more closely approximate the field of view of the 17mm lens and could be tried in the future.

Techniques described for setup and placement of the 35mm camera above each point were also followed for the video camera, with its optical center at the same height. Understory foliage within 1 meter of the camera lens was also removed. The video camera was operated using automatic exposure, taping for about 15 seconds at the wide-angle setting, and then slowly zooming up to the telephoto (84mm) setting to capture closeup images of foliage and any visible foliar damage.

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. The term canopy cover is used here to refer to the percent of sky obstructed by vegetation, including woody tree parts.

Slide Grid Projection:

A radial grid was drawn on white paper to include 144 intersections formed by 12 concentric circles and 12 equally spaced radial lines. The concentric circles were spaced to sample 12 concentric bands, equal in arc degrees, partitioning the field of view from the zenith to 30 degrees from the zenith. This samples an area equal to a circle of approximately 20 mm diameter on the slide. At a height of 25 m, this circle represents an area of canopy 48 m in diameter. The frame of the grid was proportional to a slide and has dimensions of 75 x 50 cm. Grid lines were drawn as fine as possible, so as not to obscure detail, while permitting easy viewing from a distance of about .5 m.

This custom screen was hung on a wall and the projector positioned 2.84 m from lens front to screen. While this relatively short distance resulted in only fair focus at the edges of the image, it was good within the target region. Careful adjustment was made to ensure that the slide fit the screen borders. If, because of variation in mount size in different brands, slides did not register consistently on grid borders, all slides were projected so that left-hand corners were filled and even.

Each slide was read with a set routine, scoring intersections on successive circles beginning with the innermost. The number of grid intersections falling on visible sky were tallied to obtain raw scores, since in plots of normal canopy density it is much faster to count sky than tree. Processed data, however, were expressed as percent canopy cover.

For scoring, we consistently used the slide least exposed of the three taken for each photo point on each occasion, as contrast was best in this case.

Scoring time with the manual/visual system varies according to crown density, with the less dense images taking longer. We estimate about 3-4 minutes turnaround time with the 144 intersection grid.

Swathkit:

The Swathkit is an image analysis/weather monitoring system used in 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.

Photography: 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 illuminate properly 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 in the camera, light from the light table surrounding the slide was masked out.

Using the striped test pattern, which is slightly less than 50 percent black on white, the threshold was set at 120. The area measurement is given as a percent of the total area which the Swathkit scans. A solid black piece of paper was placed behind the mask to yield a percent representing the total area within the mask. The percent crown cover is derived as a ratio of the image reading to the total possible within the mask.

A series of 25 images taken over two days from one photo point was run at threshold 120, and then with a blue/purple filter at threshold 53. The filter reduced the variance in crown canopy readings, it was used with all 1991 slides measured with the Swathkit. The threshold was not changed during this process. Scoring time with the Swathkit was about 1 minute/slide when a series of slides was run at a single threshold.

Video: Because the Swathkit was designed to read spray droplets on white cards, the software was programmed to eliminate any images that are contiguous with the edge of the screen and, therefore, of unknown dimension. This prevented accurate processing of video frames with crown, or sky contiguous with the edge. For that reason, video frames were modified by use of a MIPS (Map and Image Processing System, Microimages, Inc.) program at the U.S. Forest Service Methods Application Group Office in Fort Collins, Colorado. One wide-angle frame was grabbed for each point and reduced in size a little so that it was surrounded by a black mask. It was then copied back onto videotape, allowing about 30 seconds per frame. To process the video frames, the modified videotape was played on a video cassette recorder, the signal was fed directly into the frame-grabber of the Swathkit, and each frame was grabbed while viewing the tape on a monitor.

Largely due to the narrower field of view for video, the size of the image captured was only 45 percent as large as the area analyzed for 35mm slides, although the images shared a common center. The black and white image as seen by the Swathkit was reversed during analysis to give a white border around each frame. Future video images could be mechanically masked during the recording process by use of a reducing ring or similar attachment screwed on to the front of the video camera lens.

RESULTS AND DISCUSSION

Photography:

Preliminary data suggest that grid projection and Swathkit scoring methods agreed rather well in these hardwood stands (Figures 1,2 and 3). Swathkit results produce more stable plot canopy density averages between months than grid projection.

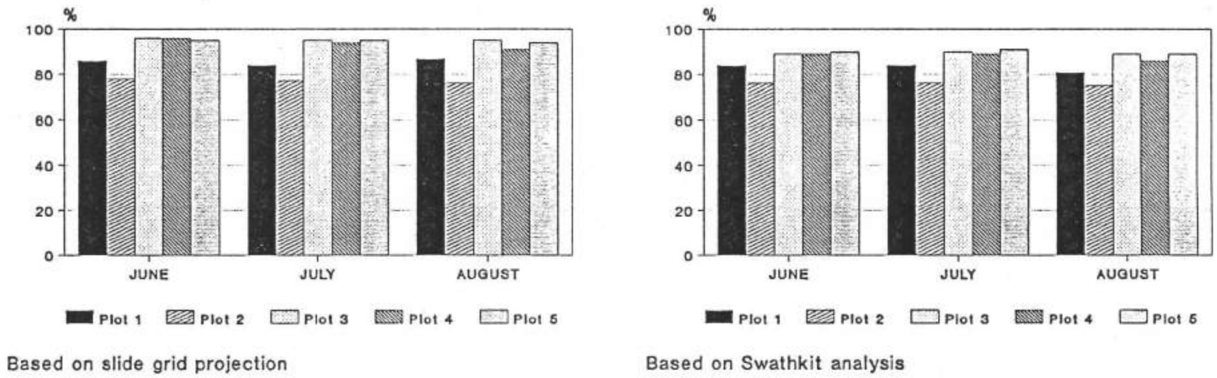


Figure 1. Percent Canopy Cover in 1991 for the NAMP Plot at Proctor Maple Research Center Based on Two Analysis Methods.

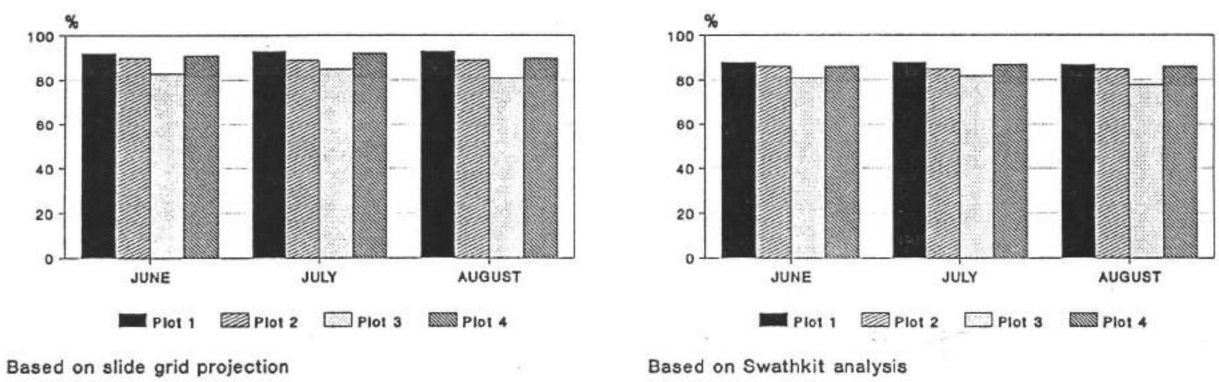
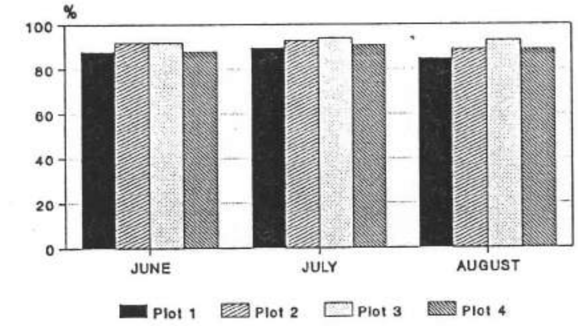
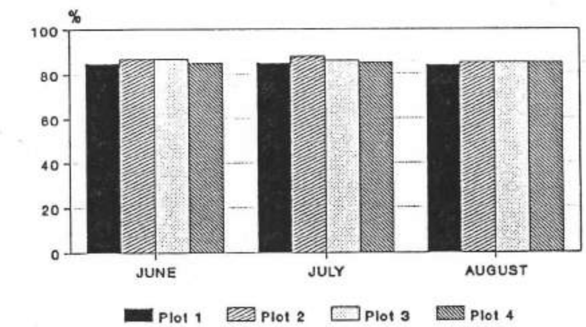


Figure 2. Percent Canopy Cover in 1991 for the FHM Plot at Proctor Maple Research Center Based on Two Analysis Methods.



Based on slide grid projection



Based on Swathkit analysis

Figure 3. Percent Canopy Cover in 1991 for the FHM Plot at Underhill State Park Based on Two Analysis Methods.

The trial in the red pine plantation, in which the nine photo-point transect was traversed four times on an overcast morning, again showed good agreement between the two scoring methods (Figure 4). Although the stand was of uniform composition and thus displayed less variation than we would have liked for a good comparison, we believe that those needing evaluations in softwood forests will find hope in this procedure.

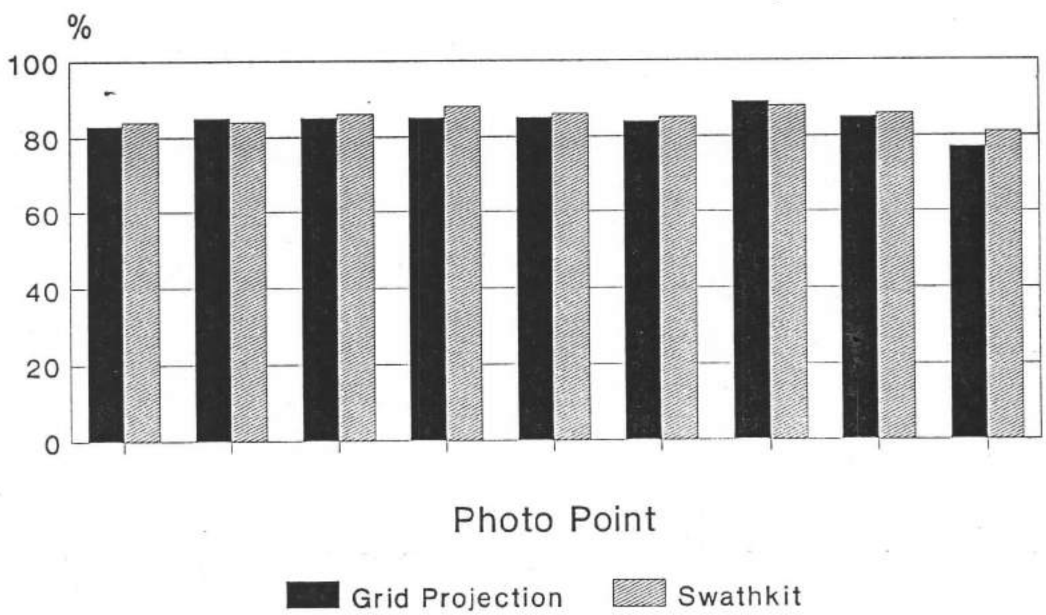


Figure 4. Percent Canopy Cover for Individual Photo Points in a Red Pine Plantation Based on Two Analysis Methods.

One advantage of the grid projection system over image analysis is the ability to compare density at different angles with sensors like the LiCor, which reads in five concentric rings. A comparison of this sort is projected for 1992.

Video:

Swathkit analysis of the video images resulted in plot averages for percent canopy cover that were similar to photography, despite the fact that the video images were of a much reduced area of view. Video images for Plots 2 and 5 averaged 75.3 and 93.7 percent canopy cover, respectively, compared to 75.7 and 89.1 percent for color slides taken from the same points.

From this limited test, video appears to offer a low cost alternative to photography for capturing similar information. The separate video camera and recorder used in this project to capture the original canopy images was cumbersome compared to photography, but the variety of small camcorders and still video cameras available today offer light-weight alternatives. The short life of most video recorder batteries must be considered if images from many points need to be captured in a single day.

Photographic transparencies can be easily modified with filters, masks, etc. in the analysis process whereas video images are difficult to manipulate without complex, expensive computer systems.

FUTURE PLANS

Photography for June, July and August will be repeated in 1992 using the same photopoints and methods. Slides obtained will be processed with the Swathkit and will be used for year to year, as well as seasonal comparisons. Additional ground information on tree transparency ratings will be obtained to help explain any changes in canopy cover expected from defoliation by maple leaf cutter, or other insects. Processing of the data will be fine-tuned, and cost and efficiency information will be obtained, including determination of the minimum number of points needed for reasonable precision.

Light sensors such as the LiCor Plant Canopy Analyzer and Sunfleck PAR Ceptometer are now available for measuring light, or photosynthetically active radiation beneath tree canopies. We hope to compare the utility of one of these methods to the photographic method.

FUNDING SOURCE

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

REFERENCES

Fargione, Michael J., 1985, an estimation procedure for determining canopy densities from hemispherical photographs. Unpublished Rept. Institute of Ecosystem Studies, Milbrook, N.Y.

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

by the
Vermont Department of Environmental Conservation

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 will be integrated into the Statewide long-term biological monitoring program.

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.

METHODS

Duplicate samples of aquatic macroinvertebrates were collected from riffle areas using a standardized "kick-net" procedure used by DEC at all ABN sites. The use of standardized sampling methods results in an equal sampling effort applied to all sites sampled, providing a quantitative basis for making comparisons between sites. The sampler holds a 500u mesh D-frame net in the stream and vigorously disturbs the substrate immediately above the net, dislodging macroinvertebrates associated with the substrate and allowing them to be carried into the net by the current. A sample consists of all the organisms and detritus that are dislodged from the substrate during two minutes (as timed by a stopwatch) of active substrate disturbance. 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 PC systems. Data can be outloaded in a variety of formats, including ASCII, dBase, and Lotus.

RESULTS

36 and 35 taxa of aquatic invertebrates were identified from Browns River and Stevensville Brook respectively (Tables 1 and 2). 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.

Stevensville Brook had lower pH and alkalinity than Browns River and had fewer organisms per unit sampling effort. Distribution of species among the mayflies, stoneflies, and caddisflies was much more even in Browns River, with Stevensville Brook being dominated (76%) by filipalpian stoneflies. The mayflies _Baetis tricaudatis_ and _Epeorus sp._ and the caddisfly _Dolophiloides sp._ were present in both streams but were much more dominant in the Browns River community then in Stevensville Brook. Stevensville Brook was dominated by organisms dependent upon course organic material as an energy (food) source while Browns River was dominated by organisms dependent upon fine organic particulate material as a source of energy.

DISCUSSION

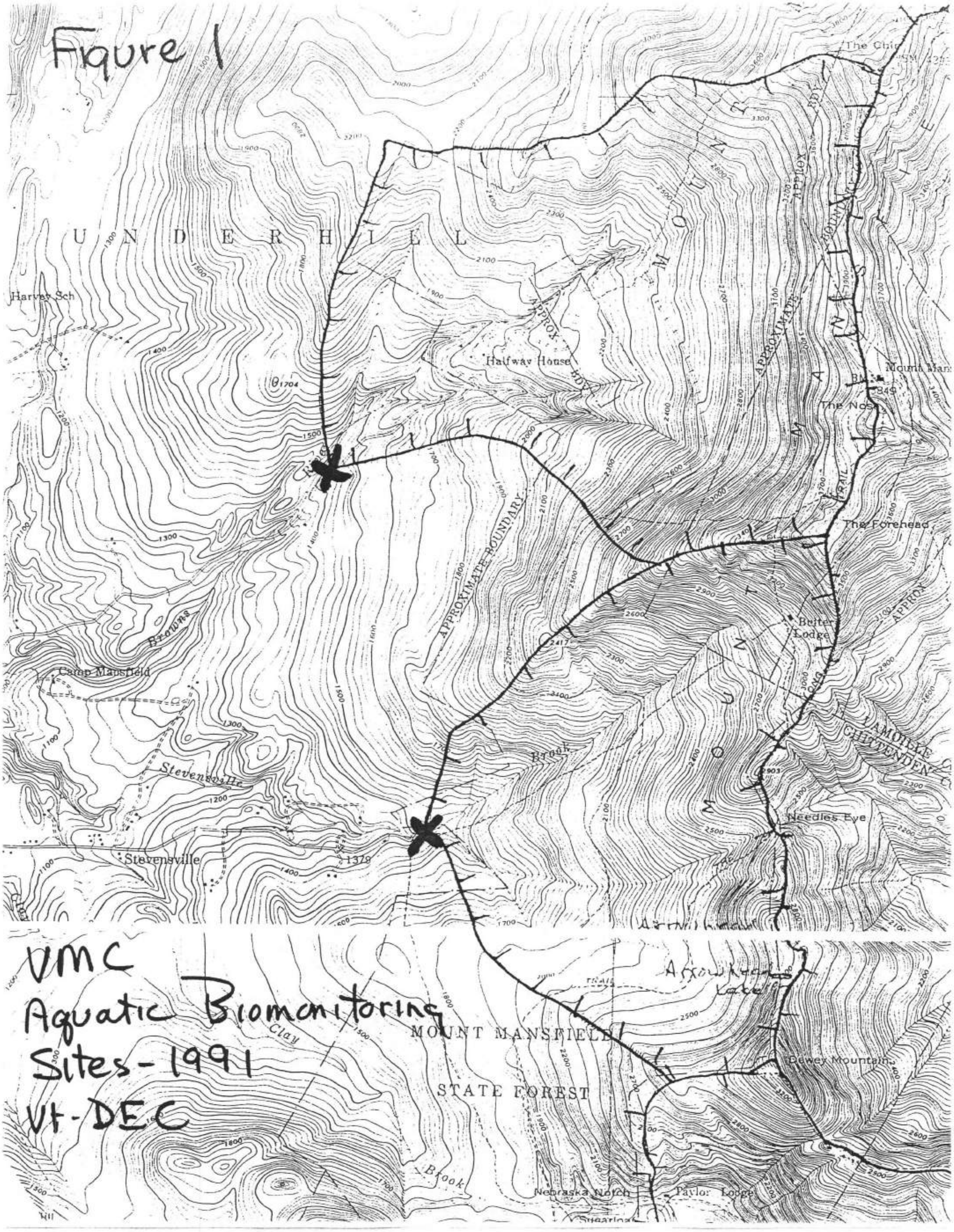
The aquatic macroinvertebrate communities in these two adjacent watersheds show some compositional differences that may reflect differences in water quality/watershed character. While both communities reflect generally high quality conditions, the distribution of species within the communities suggests that Stevensville Brook may be subjected to more acidic conditions than Browns River. The overwhelming dominance of filipalpian stoneflies, which are relatively tolerant of acidic conditions, in Stevensville Brook is unique among the more than 300 sites in the DEC database. Differences in the functional structure of the two communities suggest that energy dynamics in the two streams may be different. These differences may be due to differences in acidity or perhaps land use/riparian vegetation differences in the two watersheds.

DEC will continue monitoring these sites on an annual basis. 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. However, DEC has no plans at this time to intensify its effort at this site.

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.

Figure 1



VMC
Aquatic Biomonitoring
Sites - 1991
VT-DEC

Table 1

Location: Stevensville Brook # 2.1
Device: Kick Net

Town: Underhill

Site Id: 461143000021
Composites/Rep: 1

Lab Id: 91.087
Date: 10/30/91
Area: 1.00 m2
Number of Reps: 2
Comments:

Physical/Chemical Habitat Conditions:

pH: 6.05 Alk (mg/l): 1.01 Conductivity: 25.0

Embeddedness: 5 (5->1: Excellent->Poor) Canopy % 90.0 Velocity (fps): 1.0 Depth (m): .2

Bedrock % 5.0 Cobble % 40.0 Gravel % 10.0 Silt:
Boulder % 30.0 Course Gravel % 15.0 Sand % Clay:

Biometrics by Replicate

Rep #	Abunda.	EPT Abun.	Rich.	EPT Rich.	Diversity	Old BI	New BI	EPT/ Chiro	Spec/ Gen	Scrap/ Sc&Fi	Coll Gath	Coll Filt	Pred	Plank	Shred detri	Shred herbi	Scrap	Pierc Carni	Pierc Herbi	Un-Class
1	182.0	169.0	23.0	16.0	3.21	.53	.70	24.14	12.00	.11	3.3	4.4	18.7	0.0	71.4	1.6	.5	0.0	0.0	0.0
2	356.0	316.0	33.0	21.0	3.42	.52	1.01	10.19	5.25	.19	10.1	5.9	18.0	0.0	64.6	0.0	1.4	0.0	0.0	0.0

Community Metrics

Relative Abundance	=	269.0
Total Richness	=	37.0
Mean Richness	=	28.0
Total EPT Richness	=	23.0
Mean EPT Richness	=	18.5
Mean EPT/Mean Rich.	=	.66
Diversity	=	3.32
Old Bio-Index (0-5)	=	.52
New Bio-Index (0-10)	=	.85
(# EPT)/(# Chiro)	=	12.76
Dominant Taxa %	=	38.48
# Ephemeroptera	=	3
# Plecoptera	=	7
# Trichoptera	=	11

Percent Composition Major Groups

Coleoptera %	=	.4
Diptera %	=	9.5
Ephemeroptera %	=	2.0
Plecoptera %	=	76.2
Trichoptera %	=	11.9
Oligocheata %	=	0.0
Other %	=	0.0

Percent Composition by Functional Groups

Collector Gatherer	=	7.8
Collector Filterer	=	5.4
Predator	=	18.2
Shredder - Detritus	=	66.9
Shredder - Herbivore	=	.6
Scraper	=	1.1

Table 1 (cont)

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

Lab Id: 91.087 Date: 10/30/91 Area: 1.00 m2 Number of Reps: 2

Order	Genera	Species	Density	% Comp	Std Err	Minimum	Maximum
COLEOPTERA			1.0	.37	1.00	0.0	2.0
	OULIMNIUS	latiusculus	1.0	.37			
DIPTERA			25.5	9.48	12.50	13.0	38.0
	BRILLIA	sp	1.5	.56			
	EUKIEFFERIELLA	brehmi	1.5	.56			
	PARACHAETOCLADIUS	sp	2.5	.93			
	POLYPEDILUM	illionoense	.5	.19			
	POLYPEDILUM	aviceps	2.5	.93			
	THIENEMANNEMYIA	sp	.5	.19			
	TVETENIA	bavarica	1.5	.56			
	MICROPSECTRA	sp	8.5	3.16			
	EMPIDIDAE	unid	.5	.19			
	PROSIMULIUM	mixtum	1.5	.56			
	DICRANOTA	sp	3.5	1.30			
	HEXATOMA	sp	.5	.19			
	TIPULA	sp	.5	.19			
EPHEMEROPTERA			5.5	2.04	2.50	3.0	8.0
	BAETIS	tricaudatus	1.0	.37			
	EPEORUS	sp	3.0	1.12			
	STENONEMA	sp	.5	.19			
	STENONEMA	luteum	1.0	.37			
TRICHOPTERA			32.0	11.90	16.00	16.0	48.0
	PARAPSYCHE	apicalis	4.5	1.67			
	SYMPHITOPSYCHE	alhedra	2.0	.74			
	SYMPHITOPSYCHE	macleodi	2.5	.93			
	LEPIDOSTOMA	sp	3.0	1.12			
	HYDATOPHYLAX	sp	4.5	1.67			
	NEOPHYLAX	nacatus	.5	.19			
	DOLOPHILODES	sp	4.0	1.49			
	RHYACOPHILA	fuscula	3.5	1.30			
	RHYACOPHILA	manistee	4.0	1.49			
	RHYACOPHILA	vibox	.5	.19			
	RHYACOPHILA	carpenteri	3.0	1.12			
PLECOPTERA			205.0	76.21	55.00	150.0	260.0
	CAPNIIDAE	unid	17.0	6.32	2.00	15.0	19.0
	CHLOROPERLIDAE	unid	32.0	11.90	8.00	24.0	40.0
	LEUCTRIDAE	unid	103.5	38.48	43.50	60.0	147.0
	AMPHINEMURA	sp	6.5	2.42			
	PELTOPERLA	sp	26.0	9.67	4.00	22.0	30.0
	ACRONEURIA	sp	.5	.19			
	ACRONEURIA	carolinesis	.5	.19			
	TAENIONEMA	sp	19.0	7.06	3.00	16.0	22.0
TOTAL			269.0	100.00	87.00	182.0	356.0

Table 2

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

Lab Id: 91.086 Date: 10/30/91 Area: 1.00 m2 Number of Reps: 2
Comments:

Physical/Chemical Habitat Conditions:

pH: 7.05 Alk (mg/l): 6.41 Conductivity: 36.0

Embeddedness: 5 Canopy % 90.0 Velocity (fps): 1.0 Depth (m): .2
(5->1: Excellent->Poor)

Bedrock %	10.0	Cobble %	30.0	Gravel %	5.0	Silt:
Boulder %	35.0	Course Gravel %	20.0	Sand %		Clay:

Biometrics by Replicate

Rep #	Abunda.	EPT Abun.	Rich.	EPT Rich.	Diver sity	Old BI	New BI	EPT/ Chiro	Spec/ Gen	Scrap/ Sc&Fi	Coll Gath	Coll Filt	Pred	Plank	Shred detri	Shred herbi	Scrap	Pierc Carni	Pierc Herbi	Un-Class
1	1372.0	1128.0	30.0	21.0	3.96	.74	1.80	5.53	1.22	.09	35.6	9.3	15.2	0.0	38.5	.3	.9	0.0	0.0	.3
2	764.0	658.0	32.0	21.0	3.83	.67	2.20	7.48	.97	.13	45.3	5.5	16.0	0.0	31.4	1.0	.8	0.0	0.0	0.0

Community Metrics

Relative Abundance	=	1068.0
Total Richness	=	37.0
Mean Richness	=	31.0
Total EPT Richness	=	24.0
Mean EPT Richness	=	21.0
Mean EPT/Mean Rich.	=	.68
Diversity	=	3.89
Old Bio-Index (0-5)	=	.71
New Bio-Index (0-10)	=	2.00
(# EPT)/(# Chiro)	=	6.12
Dominant Taxa %	=	22.57
# Ephemeroptera	=	5
# Plecoptera	=	8
# Trichoptera	=	9

Percent Composition Major Groups

Coleoptera %	=	.8
Diptera %	=	15.5
Ephemeroptera %	=	26.2
Plecoptera %	=	42.9
Trichoptera %	=	14.5
Oligocheata %	=	0.0
Other %	=	0.0

Percent Composition by Functional Groups

Collector Gatherer	=	39.0
Collector Filterer	=	8.0
Predator	=	15.4
Shredder - Detritus	=	36.0
Shredder - Herbivore	=	.6
Scraper	=	.8

Table 2 (cont)

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

Lab Id: 91.086 Date: 10/30/91 Area: 1.00 m2 Number of Reps: 2

Order	Genera	Species	Density	% Comp	Std Err	Minimum	Maximum
COLEOPTERA			9.0	.84	3.00	6.0	12.0
	OULIMNIUS	latiusculus	9.0	.84			
DIPTERA			166.0	15.54	66.00	100.0	232.0
	BRILLIA	sp	6.0	.56			
	EUKIEFFERIELLA	brehmi	1.0	.09			
	PARACHAETOCLADIUS	sp	14.0	1.31			
	PARAMETRIOCNEMUS	sp	8.0	.75			
	POLYPEDILUM	aviceps	42.0	3.93	22.00	20.0	64.0
	SYNORTHOCLADIUS	sp	2.0	.19			
	ZAVRELIMYIA	sp	1.0	.09			
	MICROPSECTRA	sp	72.0	6.74	32.00	40.0	104.0
	EMPIDIDAE	unid	2.0	.19			
	PROSIMULIUM	mixtum	1.0	.09			
	DICRANOTA	sp	15.0	1.40			
	HEXATOMA	sp	2.0	.19			
EPHEMEROPTERA			280.0	26.22	12.00	268.0	292.0
	BAETIDAE	unid	72.0	6.74	32.00	40.0	104.0
	BAETIS	tricaudatus	75.0	7.02	21.00	54.0	96.0
	EPHEMERELLA	sp	1.0	.09			
	HEPTAGENIIDAE	unid	2.0	.19			
	EPEORUS	sp	112.0	10.49	8.00	104.0	120.0
	PARALEPTOPHLEBIA	sp	15.0	1.40			
	AMELETUS	sp	3.0	.28			
TRICHOPTERA			155.0	14.51	77.00	78.0	232.0
	PARAPSYCHE	apicalis	1.0	.09			
	SYMPHITOPSYCHE	slossonae	5.0	.47			
	LEPIDOSTOMA	sp	14.0	1.31			
	HYDATOPHYLAX	sp	7.0	.66			
	PYCNOPSYCHE	sp	2.0	.19			
	DOLOPHILODES	sp	78.0	7.30	42.00	36.0	120.0
	RHYACOPHILA	fuscula	34.0	3.18			
	RHYACOPHILA	fenestra	1.0	.09			
	RHYACOPHILA	carpenteri	13.0	1.22			
PLECOPTERA			458.0	42.88	146.00	312.0	604.0
	CAPNIIDAE	unid	23.0	2.15			
	CHLOROPERLIDAE	unid	76.0	7.12	4.00	72.0	80.0
	LEUCTRIDAE	unid	241.0	22.57	99.00	142.0	340.0
	AMPHINEMURA	sp	12.0	1.12			
	PELTOPERLA	sp	20.0	1.87			
	ISOPERLA	sp	4.0	.37			
	MALIREKUS	hastatus	17.0	1.59			
	TAENIONEMA	sp	65.0	6.09	3.00	62.0	68.0
TOTAL			1068.0	100.00	304.00	764.0	1372.0

Insect Diversity on Mount Mansfield

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June 15, 1992

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OBJECTIVES

(1) Record the insect biodiversity of Mount Mansfield with respect to taxonomic composition and abundance.

(2) Establish a long-term monitoring strategy for forest insects through permanent survey sites and traps.

(3) Compare and contrast insect biodiversity in three forest habitats on Mount Mansfield.

(4) Develop a fully curated and referenced voucher collection of Mount Mansfield forest insects.

(5) Provide a taxonomic foundation for future ecological classifications of insect diversity and associations with hosts and other ecosystem components.

METHODS

Sampling sites were established at three different elevations, 400 m in a sugar maple forest at the Proctor Maple Research Center (PMRC), 600 m in a mixed hardwood forest at Underhill State Park (USP), and at 1160 m near the summit of Mt. Mansfield (1348 m) in a sub-alpine balsam fir forest (MMS).

Five circular (20 m diameter) plots were established at each site. In each of the four outlying plots a canopy malaise trap was installed 10-15 m above ground in a dominant sugar maple or 2 m above ground in a balsam fir tree (sub-alpine habitat). A water pan trap was placed 60 cm above ground in the southwest sector of each plot and six pitfall traps were installed around the plots at 60° intervals. One light trap was placed in the center plot. Two one m^2 plant survey plots were established 10 m to the east and west of plot center. Samples were collected, pressed and identified (Table 1).

Killing agents in the field include a 0.05% formalin solution in the pitfall traps, an alcohol/glycerine/acetic acid (AGA) solution in malaise traps, a water/salt/detergent solution in the waterpan traps, and a plaster-of-paris block saturated with tetrachloroethane in each of the light traps. Specimens were collected twice a week for pitfall, malaise, and water pan traps, while the light traps were operated once a week from June 1 to October 30 1991. Pitfall trap specimens were sorted at the St. Albans Correctional Facility. Insects from the light traps and waterpan traps were sorted and stored at the Entomology Research Laboratory. Coleoptera and Lepidoptera were pinned and stored in Cornell drawers while other insects and non-insect invertebrates were stored in 80% alcohol. Insects collected from the malaise traps are currently being sorted and cataloged.

RESULTS

(a) Water pan Traps

The two main orders collected were Hymenoptera and Diptera. Occasional specimens were also collected from Mecoptera, Hemiptera, Plecoptera,

Table 1. Plant species and number of individuals found in sample plots within each of the three main research sites on Mount Mansfield. MMS = Mount Mansfield Summit, USP = Underhill State Park, PMRC = Proctor Maple Research Center.

Species:	Sites/No. Individuals		
	MMS	USP	PMRC
Abies balsamea	7	1	1
Acer saccharum	-	3	3
A. pensylvanica	-	2	-
A. spicatum	-	1	2
Anthyrium femina	-	1	3
Betuala cordifolia	3	-	-
Clintonia borealis	2	1	1
Coptis groenlandica	4	-	-
Cornus canadensis	4	2	-
C. cornuta	-	-	1
Dryopteris spinulosa	7	7	4
Graminae	1	3	-
Fagus grandifolia	-	1	1
Impatiens capensis		-	5
Lycopodium lucidum	3	4	-
Onoclea sensibilis	-	-	1
Osmunda cinnamomea	-	-	2
Oxalis montana	4	3	-
Picea rubens	1	-	1
Ribes glandulosum	2	3	-
Rubus idaeus	-	1	3
Solidago rugosa	-	1	5
Thelpteris noveborac	-	1	1
Trientalis borealis	2	-	-
Trillium grandiflorum	-	1	1
Vaccinum corymbosum	1	-	-
Viburnum alnifolium	-	3	-
Viola sp.	-	-	2

Coleoptera, and Lepidoptera, but were not collated in the present study. Sample comparisons were confined to Diptera which was the only group present in large numbers. Taxa difficult to identify and not collated include the Culicidae (mosquitoes), Chironomidae (midges), and Simuliidae (blackflies).

A total of 849 specimens of Diptera were collected from 14 families (Fig. 1). The Mt. Mansfield summit site has the largest number of families (13) and individuals (725). Tachinidae (parasitoids) were most abundant at all three sites, while Muscidae (detrital feeders) were second most abundant in the MMS and PMRC. Locally abundant groups include Bibionidae (detrital feeders) in USP, Heleomyzidae (detrital feeders) in MMS, and Rhagionidae (predacious) in PMRC (Fig. 2).

(b) Pitfall traps

A range of insects and other invertebrates were collected (Table 2). The non-insect macro-invertebrates were represented by six major groups with the Areneda and Philangida comprising 88% of all individuals (Fig. 3). Insects abundance was represented by two Coleoptera families, ants (Formicidae) and one species of camel cricket (Gryllacrididae) (Fig. 4).

Table 2. Insects and other invertebrates collected from pitfall traps on Mount Mansfield.

Taxon	Abundance
Insecta	
Carabidae	1741
Staphylindae	814
Formicidae	418
Elateridae	57
Gryllacrididae	618
Areneda	2201
Phalangida	1270
Chilopoda	22
Diplopoda	375
Gastropoda	
snails	25
slugs	34

The ground beetles (Carabidae) were identified and compared at the species

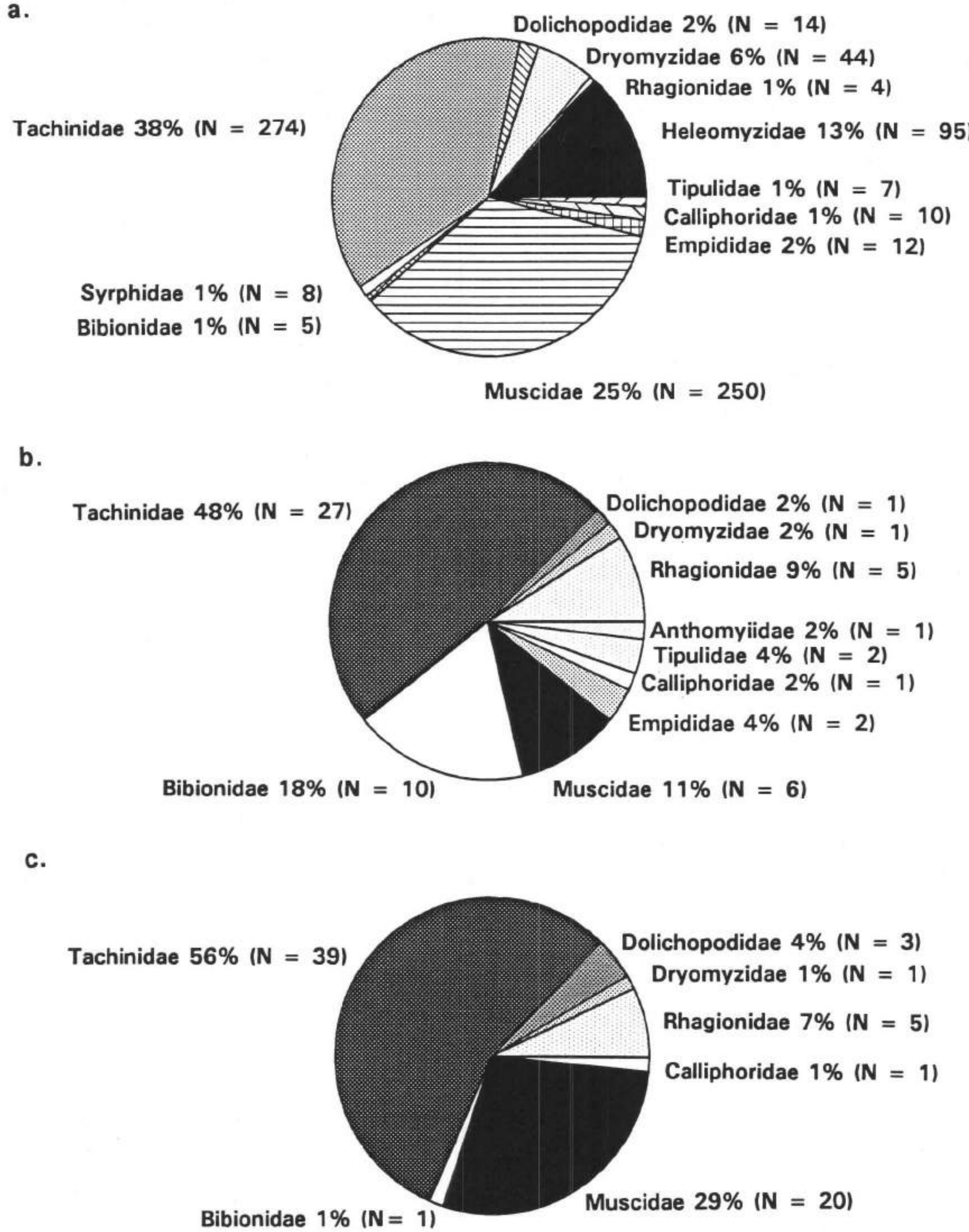


Figure 1. Abundance of Diptera families collected on Mount Mansfield in waterpan traps at: (a) the high elevation survey site (MMS) on Mount Mansfield, (b) the Underhill State Park survey site (USP) on Mount Mansfield, and (c) the Proctor Maple Research survey site (PMRS) on Mount Mansfield.

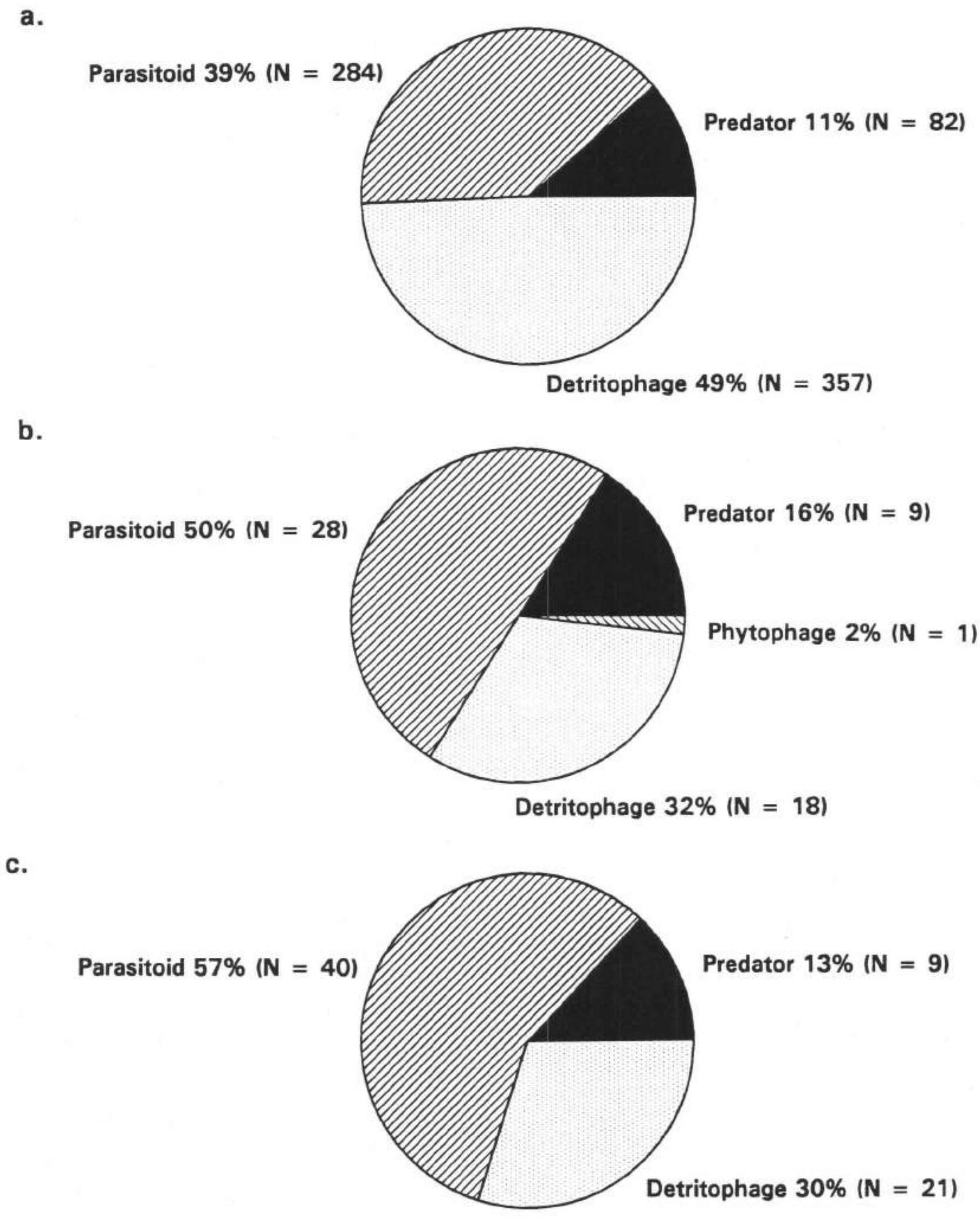


Figure 2. Abundance of Diptera feeding guilds (as represented by the larval stage) for families collected in waterpan traps on Mount Mansfield at: (a) the high elevation survey site (MMS) on Mount Mansfield, (b) the Underhill State Park survey site (USP) on Mount Mansfield, and (c) the Proctor Maple Research survey site (PMRS).

level. Out of the 32 species collected (Table 3) 12 were found at all three sites while a further 12 were each present at one site only. The four most abundant species (over 100 specimens) were present at all three sites. The total number of species in each habitat was similar (MMS 22, USP 22, and PMRC 20), but USP supported the highest total number of individuals with 1120 specimens, compared with 429 in PMRC, and 192 in MMS (Fig. 5).

Figure 3. Abundance of major non-insect macroinvertebrates (as % of total) combined for pitfall trap collections at all three survey sites on Mount Mansfield.

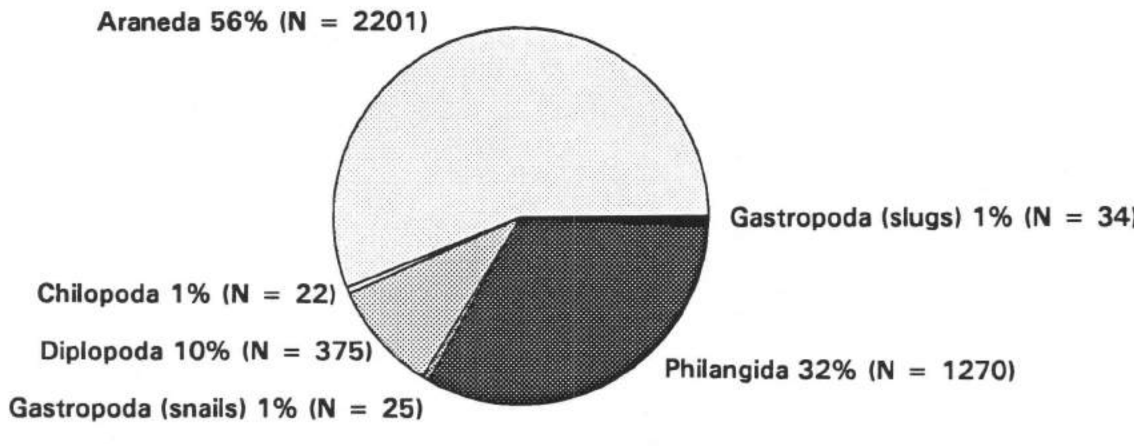
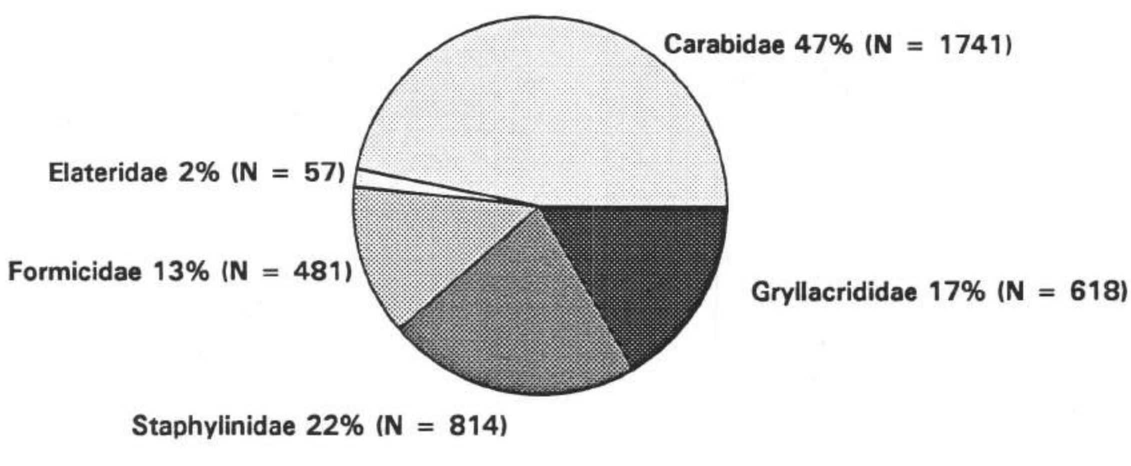


Figure 4. Abundance of the most common insect families (as as % of total) combined for pitfall trap collections at all three survey sites on Mount Mansfield.



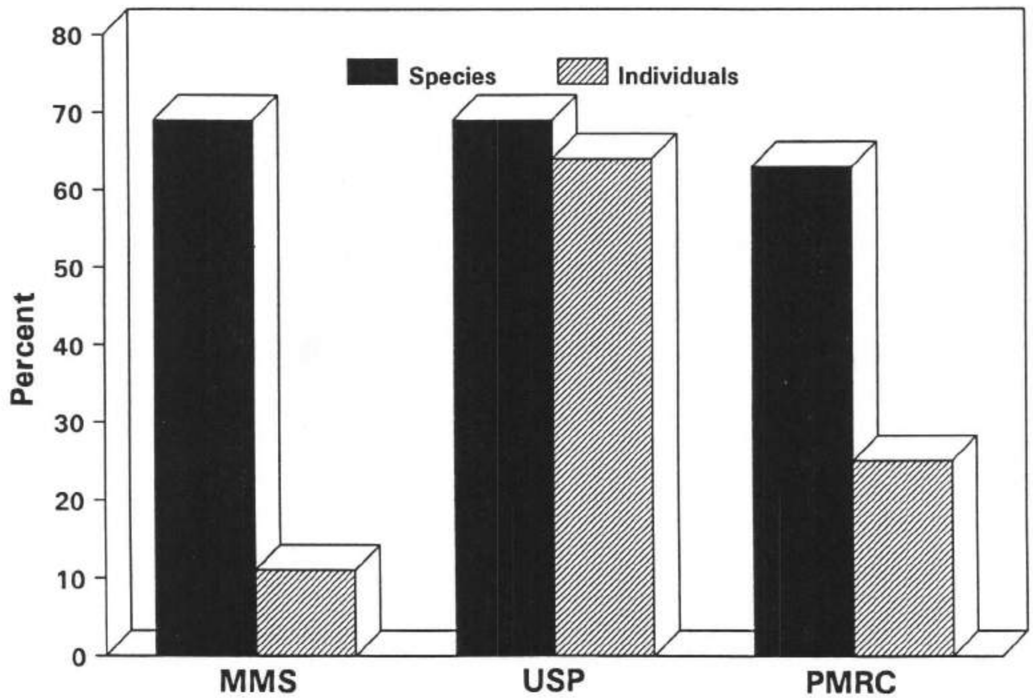


Figure 5. Percentage of species and individuals of Carabidae (Coleoptera) collected from pitfall traps for all three sites on Mount Mansfield.

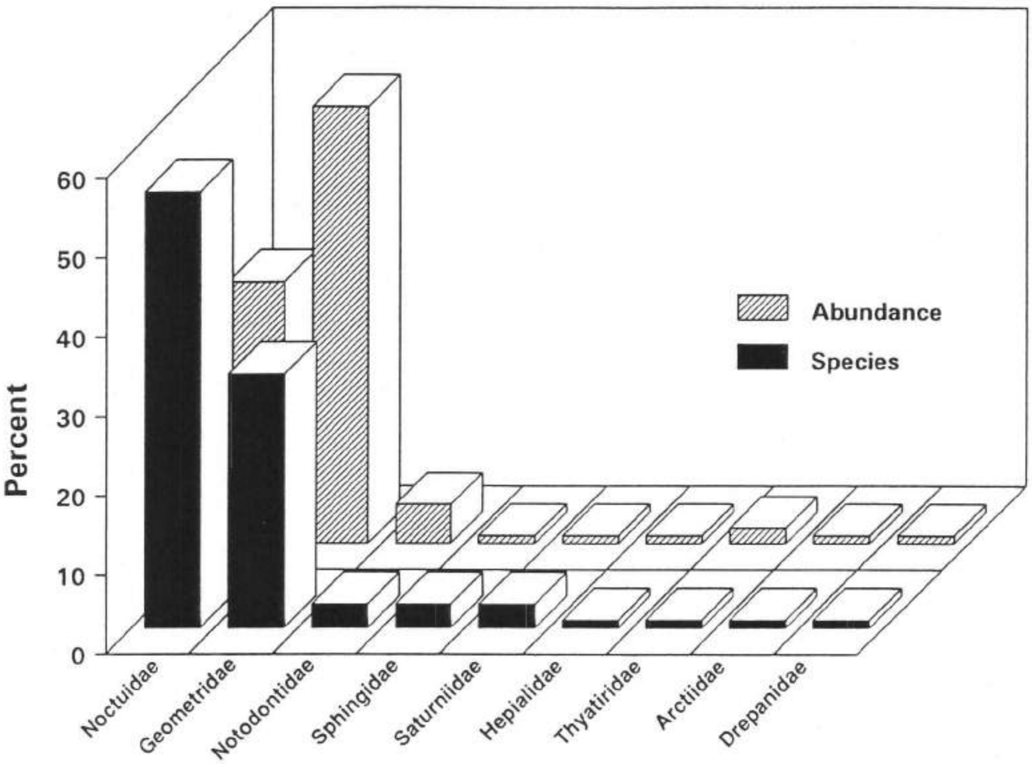
(c) Light Traps

About 227 species of moths (Lepidoptera) were collected and identified. Comparisons were confined to "macrolepidoptera" which represents an artificial grouping of families with relatively large and easily identifiable species. It leaves out a considerable number of species and taxonomic groups also of interest to forest entomology, but the selection was necessary because many "microlepidoptera" are difficult to identify without appropriate reference material or specialist knowledge and methods (such as microscopic examination or genitalic dissection). The 1992 Lepidoptera survey will be expanded to include the microlepidoptera.

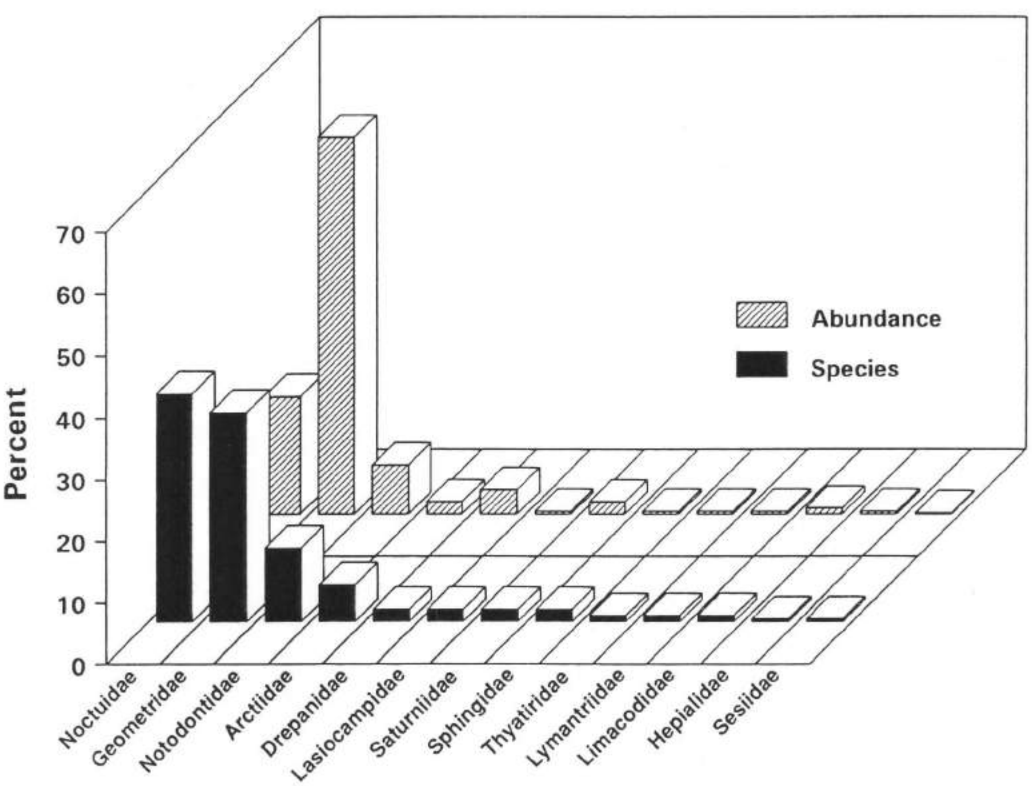
The results of the macrolepidoptera survey are presented as a summary of species diversity and abundance for different families (Fig. 6.). The families Noctuidae and Geometridae were dominant at all three sites in both species and numbers of individuals. The Notodontidae (closely related to Noctuidae) were the next dominant group. The remaining families were minor with respect to both species and abundance. Comparison of total species and abundance show that PMRC supported the highest numbers, while MMS supported very few (Fig. 7).

Figure 6. Species diversity and abundance of Lepidoptera families collected from Mount Mansfield light traps at: (a) the high elevation survey site (MMS), (b) the Underhill State Park survey site (USP), and (c) the Proctor Maple Research Center (PMRC).

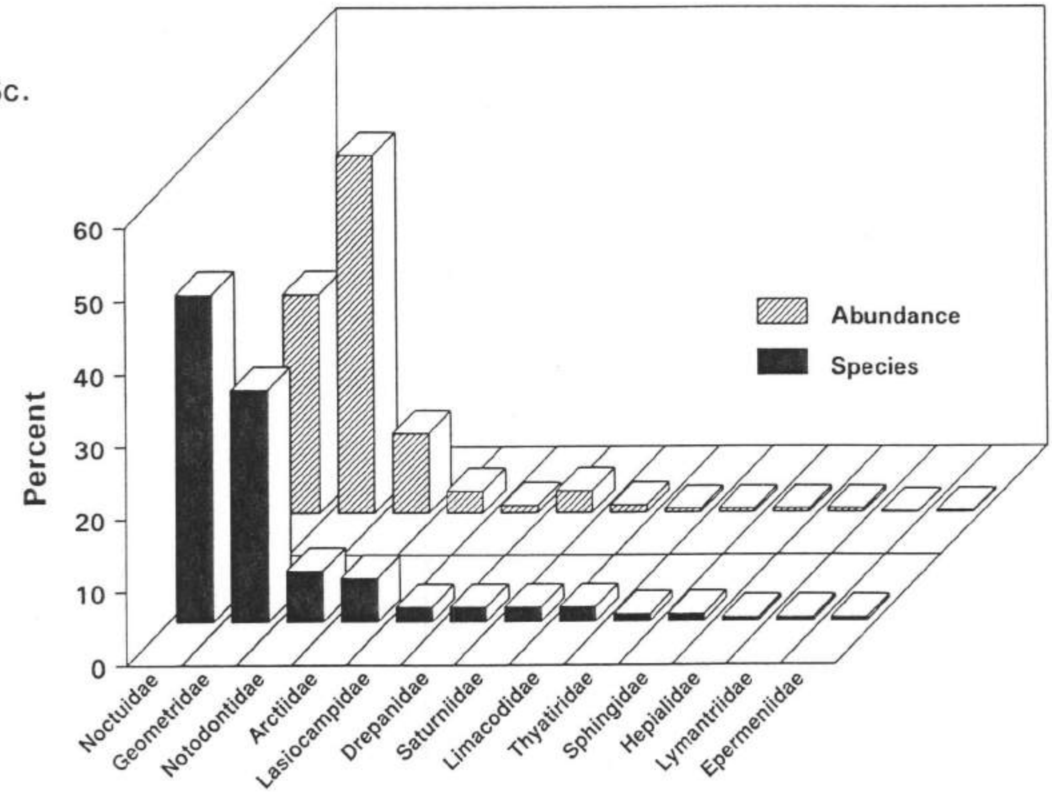
a.



b.



6c.



7.

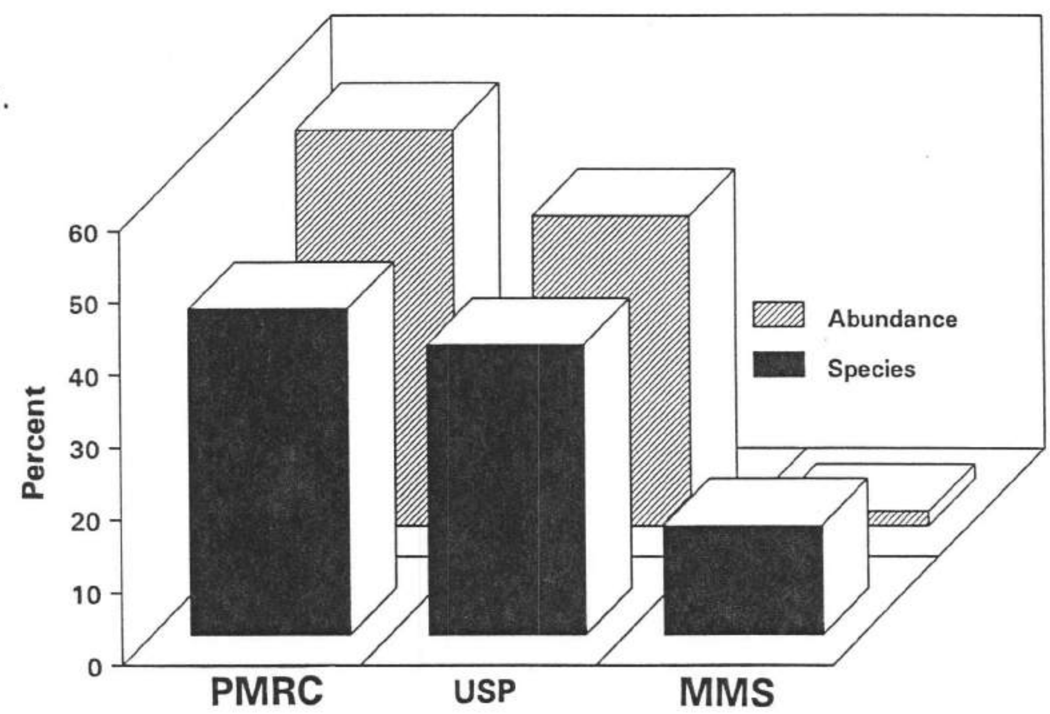


Figure 7. Percentage of species and individuals of Lepidoptera families collected from light traps for all three survey sites on Mount Mansfield.

SIGNIFICANT FINDINGS

The taxonomic focus on individual insect groups has the advantage of providing sufficient detail to recognize records of general ecological significance. In this respect several records from the 1991 season are noteworthy. Two Lepidoptera (Noctuidae) species - *Anomogyna rhaetica* Staudinger (MMS) and *Platypolia atricornis* Grote (PMRC) - qualified for inclusion in the special animal survey category in the Vermont Nongame and Natural Heritage Program (Department of Fish and Wildlife). Several species collected may represent new records for Vermont, but this designation is often uncertain because of the lack of comprehensive published records.

Four specimens of the high elevation species Sphaeroderus nitidicollis brevoorti Leconte (Carabidae) were collected from MMS. This beetle has a geographic range from Nova Scotia to the northeastern United States and New York, and west to Manitoba (Lindroth 1961). It is a "cold climate" species and may be sensitive to climate changes. It has been recorded in Vermont from Camel's Hump, but has not been sighted for several years (R. T. Bell, pers. comm.).

DISCUSSION

Mount Mansfield includes the only extensive sub-alpine/alpine habitat in Vermont. High elevation habitats have a fragile ecology susceptible to long-term environmental changes such as climate change and atmospheric pollution. The comparison of insect diversity and abundance between habitats may provide an important primary insight into long-term ecological trends affecting changes in the community structure of the forest habitat.

Taxonomy is critically important to the success of invertebrate ecosystem studies. Taxonomic detail is possible in the present study only for Carabidae and Lepidoptera. Several other groups may also be treated in similar detail within the present program, but the majority will require years of work. Available taxonomic expertise is limited and dispersed, while the published literature is often inadequate to meet the general identification requirements of a fauna survey. One partial solution is for the Vermont Monitoring Cooperative to develop its own taxonomic resource as is currently being prepared for the Carabidae, Lepidoptera, Diptera, and Hymenoptera. Even with this resource, utilization is dependant on the maintenance of staff with appropriate taxonomic skills and experience. Without this resource long-term invertebrate ecosystem studies are impossible.

CONTEXT

The Lepidoptera records are contributing to an inventory of the Vermont Lepidoptera fauna through a cooperative project between the Entomology Research Laboratory, the Extension Service, Lyndonville State College, and amateur lepidopterists. A comprehensive list of Vermont moths and butterflies is being prepared for publication, and is based on voucher specimens maintained in Vermont, including a State reference collection at the Entomology Research Laboratory comprising over 1,000 identified species. The carabid collection will contribute to a Vermont faunal list currently being prepared by R. T. Bell, Zoology Department, UVM.

FUTURE PLANS AND POTENTIAL OPTIONS

The present survey represents only the beginning of a research program that will need to address a range of questions if the taxonomic and ecological diversity of invertebrates is to be precisely characterized. It is expected that several years of collecting will be necessary to establish an accurate inventory of the fauna. The current study concentrates only on certain groups, but future work will need to expand the coverage to include the remaining invertebrate fauna, particularly the Myriopods (centipedes and millipedes), the Arachnida (spiders), and the Mollusca (snails and slugs). Many insects collected are recognized pests of recreational and commercial forestry. The composition and relative abundance of such pests should be identified in the future. The larval stages of many species are economically and ecologically significant, but they are often not well known compared to the adult stage. The adults surveys should be complemented by establishing an inventory of larval stages.

Complementary to the taxonomic work will be a precise documentation of feeding ecology for the invertebrates. In particular, feeding associations should be investigated for the groups currently under study. The biomass representation of invertebrates should be established relative to the total ecosystem. For example, the Sphingidae and Saturniidae are low in numbers and species, but include the largest bodied insects found in the Mt. Mansfield habitats. A regional context for the insects should be established through a total geographic record of the localities. These records will provide information on the local and regional significance of the mount Mansfield fauna.

The light-trap method is constrained by recording only those species attracted, and does not, therefore, provide a complete record of all groups and species. For example, the maple leaf cutter (a significant forest pest) is abundant in the two lower sites, but its diurnal habit excludes it almost entirely from the survey. Other species may be only infrequently attracted to the trap. An ideal long-term strategy for surveying the Lepidoptera would include a variety of methods. Possibilities include the use of different light sources (incandescent, mercury vapor), and other traps (bait, sticky traps). Future traps for other insects could include ground malaise traps and tree trunk traps.

REFERENCE

Lindroth, C. H. 1969. The ground beetles of Canada and Alaska. Entomologiska Sällskapet, Lund.

FUNDING SOURCES AND APPROXIMATE EXPENDITURE

The 1991 season was funded by a $9,112.00 grant from the Vermont Agency of Natural Resources: Department of Forests, Parks, and Recreation.

ACKNOWLEDGMENT

Our thanks to Ross T. Bell, University of Vermont; Bob Davidson, Carnage Museum of Natural History; Dale Sweitzer, Nature Conservancy; Mike Sabourin (Burlington); and the staff of the Canadian National Collections, for their time and expertise in determining and confirming many species identifications. Collecting and sorting insects and data entry was made possible through the help of Sumner Williams, David Barnes, Luis Yulfo, Peter Smythe, Kihoon Kim (University of Vermont Research Apprentice Program), Brian Verville, Dan Dillner, Jennifer Neat, Mike Sevigny, Dan Van der Vliet, and Richard Paradis (UVM Natural Areas Manger) for permission to collect near the summit of Mt. Mansfield. Special thanks to Judy Rosovsky for her help in the initial planning of this project.

Inventory and Monitoring of Amphibians on the west slope of Mt. Mansfield, Vermont. Dr. Stephen C. Trombulak, Department of Biology, Middlebury College, Middlebury, Vermont 05753.

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 my results for 1991 as well as the overall design for my continued monitoring activity.

The purpose of my study is to develop a baseline data set on what species are present in the Mt. Mansfield region, in what specific habitats, and with what abundances. Key indicator species will then be intensively monitored in the future in order to assess changes in their abundance over time.

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 Map 1.

Second, nighttime 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 Map 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.

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.

I have so far identified 12 species of amphibians from this area, from a total possible of 20 species known from Vermont (Table 1). Seven of these 12 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.
Green frog: 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.

Three 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 two-lined salamander: streams up to 3900 feet.

One species, the northern spring salamander, was seen only occasionally, although it is highly likely that it is more abundant than the surveys indicate. One species, the Bullfrog, was rare, being identified at only one site on one occasion. If it is indeed present it has probably been introduced to the area by humans.

Two species are suspected to be in the area but have not yet been observed:

Blue-spotted salamander complex (includes hybrids)
Pickerel frog

Six other species that are known in Vermont are unlikely to be present:

Mudpuppy: unlikely given the available habitat in the study area.

Jefferson salamander complex (includes hybrids): unlikely given the available habitat in the study area.

Four-toed salamander: 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 area.

Mink frog: unlikely given the available habitat in the study area.

Preliminary analysis of the data indicate that five of these species will merit long-term monitoring because of their current abundances, range of habitat types, and ease of investigation:

Spring peepers: small frogs that breed in most ponds; sensitive to changes in water quality and perhaps the introduction of bullfrogs (unpublished data); censused by sites during nighttime road searches.

Gray treefrogs: similar to peepers; likely to be sensitive to vegetational changes in ponds and water quality (DeGraaf and Rudis, 1983); less seasonally constrained for monitoring; censused by sites during nighttime road searches.

Redback salamanders: small salamanders that live and breed in moist soil, rotting logs, and leaf litter over most of the elevational range of Mt. Mansfield; sensitive to high levels of soil acidity and low abundance of soil insects (Wyman and Hawksley-Lescault, 1987) but not by forest clearing (Pough et al., 1987); censused by active searches and drift fences.

Spotted salamanders: medium-sized salamanders that breed in permanent and vernal pools and spend most of their non-breeding time underground; egg mortality influenced by pH (Pough 1976); censused by counts of egg masses in breeding pools and drift fences.

Wood frogs: medium-sized frogs that breed in ponds and are active as adults on the forest floor; likely to be sensitive to changes in water pH for breeding and forest clearing as adults (DeGraaf and Rudis, 1983); censused by counts of egg masses in breeding pools, nighttime road searches, and drift fences.

Two additional species, the Green frog and Eastern American toad, will be monitored because reliable data on their distributions and abundances will be obtained as a result of the studies of the five other species mentioned above, and because of some evidence that they may be particularly sensitive to pesticides (Lazell, 1976). I also plan to monitor closely the presence of the Bullfrog. Although it is currently rare in this area, it is commonly and easily introduced into permanent ponds, and has been implicated by research carried out by my lab at other sites in the decline of indigenous amphibian species.

This monitoring effort is part of a larger amphibian monitoring program co-ordinated by Mr. James Andrews, Middlebury College. Similar survey and monitoring activities are being conducted at a series of sites in Addison, Chittenden, and Franklin Counties with the goal of understanding the dynamics of amphibian populations throughout the Champlain Basin.

I plan to continue monitoring the key species in particular, and all species in general, to identify changes in their abundances and distributions that may indicate changes in the environmental health of the forest and its waters.

References

DeGraaf, R.M., and D.D. Rudis. 1983. Amphibians and Reptiles of New England: habitats and natural history. University of Massachusetts Press.

Lazell, J.D., Jr. 1976. This Broken Archipelago. Quadrangle/New York Times Book Co.

Pough, F.H. 1976. Acid precipitation and embryonic mortality of spotted salamanders, Ambystoma maculatum. Science 192: 68-70.

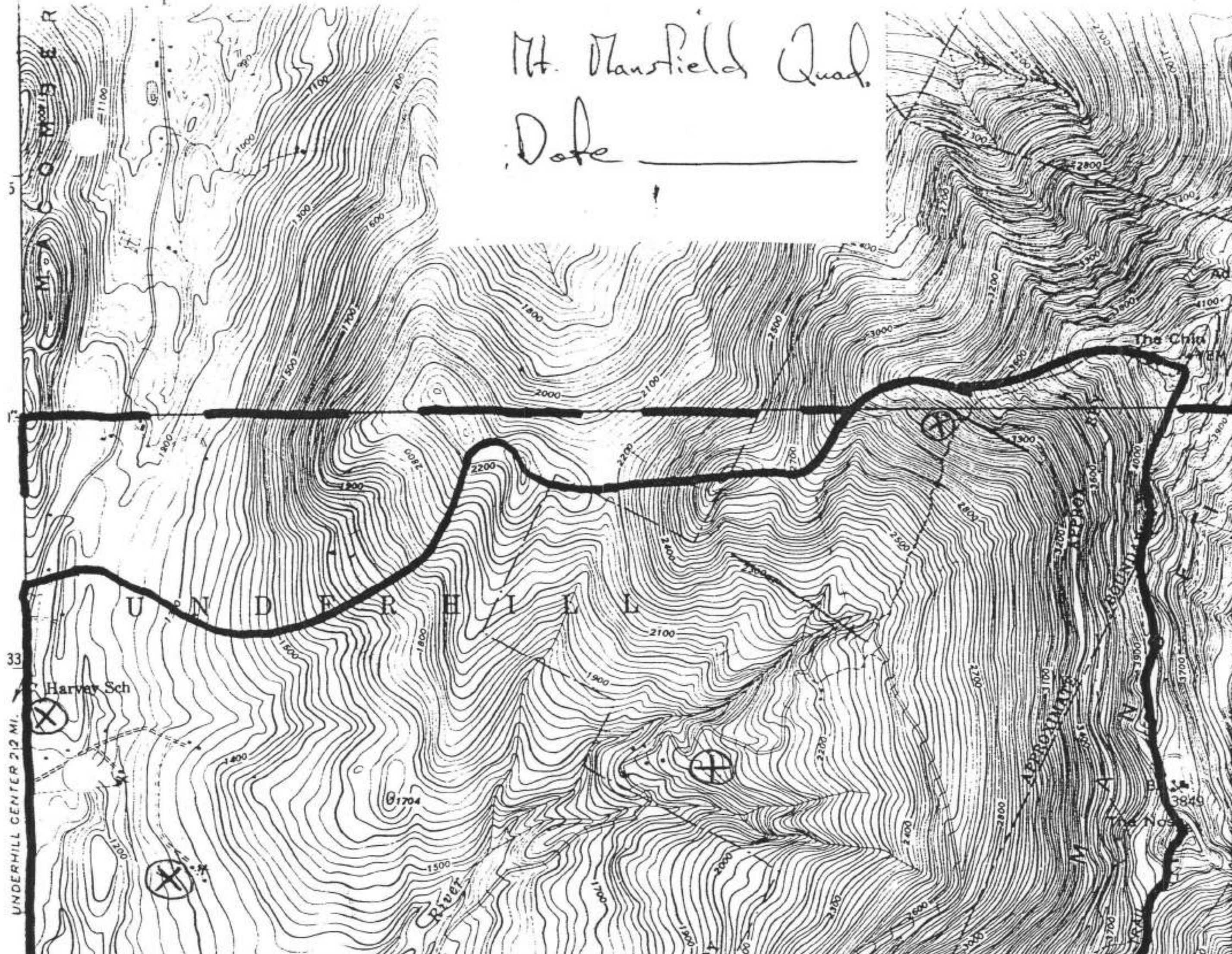
Pough, F.H., E.M. Smith, D.H. Rhodes, and A. Collazo. 1987. The abundance of salamanders in forest stands with different histories of disturbance. Forest Ecology and Management 20: 1-9.

Wyman, R.L., and D.S. Hawksley-Lescault. 1987. Soil acidity affects distribution, behavior, and physiology of the salamander Plethodon cinereus. Ecology 68: 1819-1827.

Funding sources

Vermont Monitoring Cooperative	$4125
Howard Hughes Medical Institute	$1800
Middlebury College	$1000
Lake Champlain Management Conference	$1428

Map 1. Location of drift fences (X)



Mapped by the Defense Mapping Agency

Map 2.

Mt. Mansfield Road Search Area

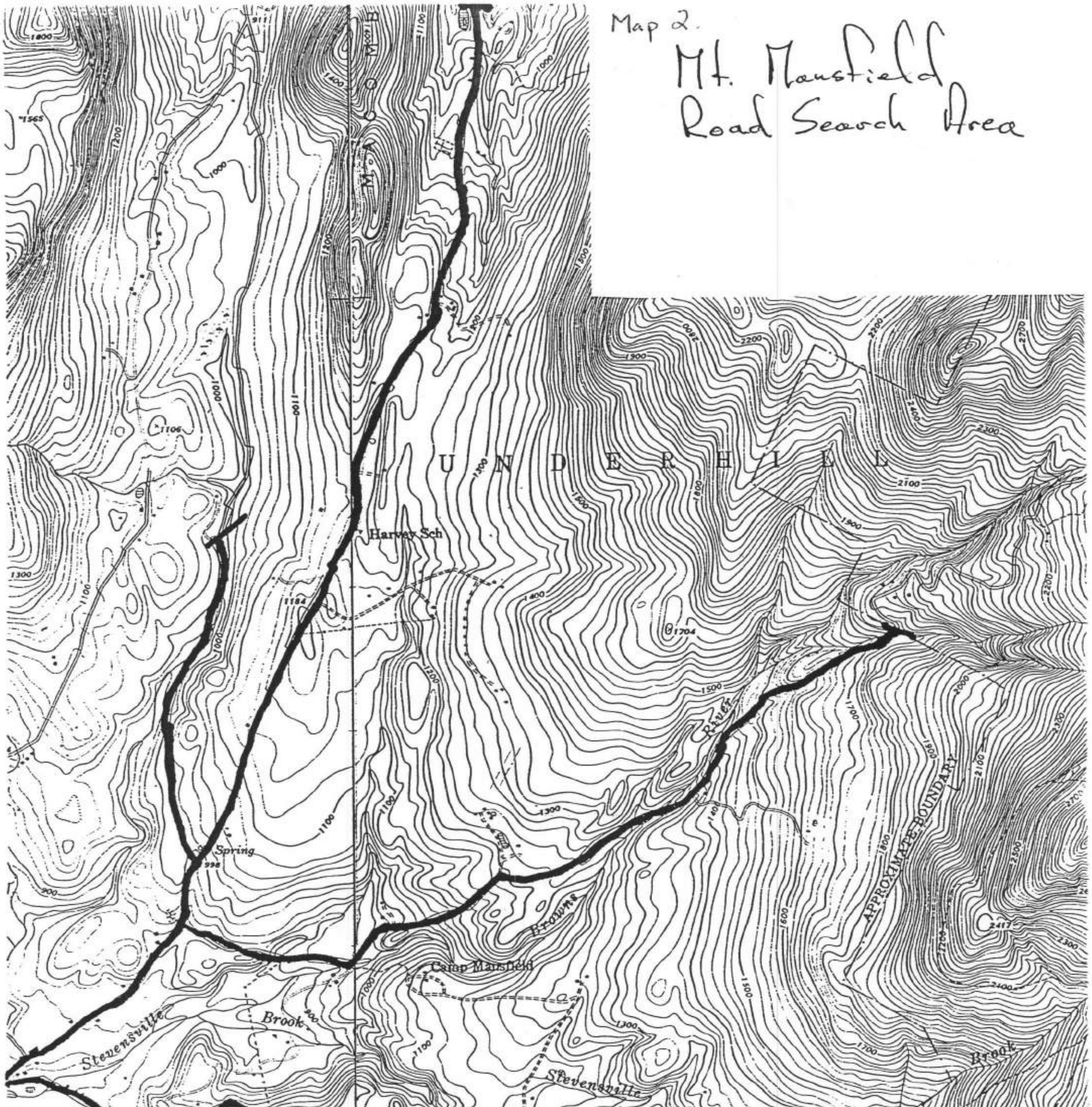


Table 1. Amphibians of Mt. Mansfield, Vermont, based on surveys from Spring 1991 to Spring 1992.

Species name	Common name	S^a	C^b
Necturus maculosus	Mudpuppy	U	
Ambystoma jeffersonianum	Jefferson salamander	U	
Ambystoma laterale complex	Blue-spotted salamander complex	S	
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	U	
Gyrinophilus porphyriticus	Northern spring salamander	K	O
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	A
Rana septentrionalis	Mink frog	U	
Rana sylvatica	Wood frog	K	A
Rana pipiens	Northern leopard frog	U	
Rana palustris	Pickerel frog	S	
Bufo americanus	Eastern American toad	K	A

Key

a: Status

U = unlikely
K = known
S = suspected, based on published range maps and occurence of appropriate habitat in the study area

b: Commonality

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

FOREST BIRD SURVEYS ON MT. MANSFIELD AND UNDERHILL STATE PARK

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Introduction and Objectives: In 1991, the Vermont Institute of Natural Science (VINS) established two permanent study sites on Mt. Mansfield, in conjunction with the Vermont Monitoring Cooperative (VMC) and as part of the Institute's long-term Vermont Forest Bird Monitoring Program. 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 1991, VINS had selected, marked and censused 16 permanently protected sites of mature forest habitat across Vermont (Fig. 1, Table 1). The specific objectives of extending this study to Mt. Mansfield included: 1) adding a bird monitoring component to the integrated ecological research being conducted under the VMC; 2) adding two permanently protected, mature forest study sites to VINS' statewide monitoring program; and 3) sampling bird populations in the geographically limited, high elevation spruce-fir zone.

Methods: The two VMC-VINS study sites were established in May, one in the stunted spruce-fir forest just below the summit ridge on Mt. Mansfield, the other in a predominantly northern hardwood forest on the lower flanks of Mt. Mansfield in Underhill State Park. Each site consists of a series of five sampling points (stations) spaced 200-300 meters apart. Each point is a doubly or triply blue-flagged tree bearing a small metal tree tag inscribed with, for example, "VINS MM #1". Because the Mt. Mansfield stations lie on the Amherst and Lake View trails, no intermediate flagging between points was used at that site. The Underhill State Park stations all lie off-trail and are connected by blue flagging at 25-50 meter intervals, to facilitate movement between points. Detailed instructions on locating both study sites and the sampling points at each are available on file.

Each site was censused twice during the height of breeding activities in June. Each census consisted of 10-minute counts at each of the five sampling points. Censuses were conducted in the early morning and during favorable weather conditions. The locations of all birds seen and heard were plotted on field maps, using standard symbols to indicate the status of each bird recorded (e.g., singing male, pair, female, calling bird, etc.). Each individual field encounter was considered to represent a breeding pair (i.e., 2 birds) if recorded as a singing male, observed pair, occupied nest, or family group. Calling birds or observed single individuals were counted as one bird in the totals. The field data were transcribed onto standardized forms and subsequently computerized, using DBASE3.

Vegetation sampling, which had been planned for 1991, was postponed until a future field season. Because a continentwide, standardized protocol for measuring habitat in relation to bird diversity and abundance is still being developed, we felt that this aspect of the study should be deferred. We believe that it is critical to standardize both bird and habitat sampling techniques with those of other, similar monitoring programs, so that results can be compared over broad geographic areas. A widely-accepted system of vegetation sampling should be in place by 1992 or 1993, and we intend to sample both sites then. Because the two sites represent mature forest communities, their vegetative composition and structure are unlikely to change significantly in the near future.

Results and Discussion: Species diversity was low at each site, surprisingly so at Underhill State Park, where both diversity and abundance were expected to be significantly higher than on Mt. Mansfield. Only 12 species were recorded at the Underhill site, with a maximum of 49 individuals and a mean of 38.5 for both visits (Table 2). These totals are much lower than those from VINS' five other northern hardwood sites in Vermont, which averaged 22 species and 114 individuals per site in 1991. Singing activity during the two Underhill site visits may have been depressed by weather conditions or other factors. Eleven species were recorded on Mt. Mansfield, with a maximum of 94 individuals and a two-visit mean of 90. In order of decreasing abundance, the five most numerous species on Mt. Mansfield were Yellow-rumped (Myrtle) Warbler, Blackpoll Warbler, Winter Wren, White-throated Sparrow, and Gray-cheeked (Bicknell's) Thrush (Table 2). At Underhill State Park, Black-throated Blue Warbler, Black-throated Green Warbler, Ovenbird, Rose-breasted Grosbeak, and Red-eyed Vireo were the five most abundant species (Table 3). Red-eyed Vireos and Ovenbirds were significantly less abundant than expected at the Underhill site. These were the two most abundant species at each of the five other Vermont northern hardwoods sites in 1991, with respective means of 23 and 21 birds per site.

It is premature to interpret these results, as they constitute the first year of a long-term database. Several years of additional data collection will be necessary to elucidate population trends of various species and groups in these two habitats. Both year-to-year sampling errors and actual, short-term population changes may mask longer-term trends. Many factors are known to cause short-term fluctuations in breeding bird populations. These include: 1) changes in food availability, 2) weather during the breeding season, 3) changes in habitat structure, 4) species interactions and competition, and 5) overwinter mortality. Different combinations of these and other regulatory factors may differentially affect populations of forest-breeding bird species. It is hoped that this study, in conjunction with others under the Vermont Monitoring Cooperative, will detect both short- and long-term population changes and will address their causative influences. The data collected at these two study sites will complement those from VINS' other Vermont sites, and will be used in the generation of both site-specific and statewide trend analyses.

Future Plans: Bird sampling is planned to continue indefinitely at both study sites. Habitat sampling will take place in 1992 or 1993. An intensive research and monitoring program on the population status and breeding ecology of Gray-cheeked (Bicknell's) Thrush on Mt. Mansfield is planned to begin in 1992. This study will incorporate data from the long-term point counts described above and is anticipated to use data collected by other VMC Cooperators on topics such as vegetation distribution, structure and health, insect diversity and abundance, precipitation and aerosol pollutant deposition patterns, and climate change.

Funding: Funding for VINS' work at these two forest sites in 1991 was provided entirely by the VMC, at a cost of $1335. Support for monitoring at VINS' additional 14 Vermont forest bird study sites was provided by a grant from the Merck Family Fund.

Figure 1. Vermont Forest Bird Monitoring Study Sites

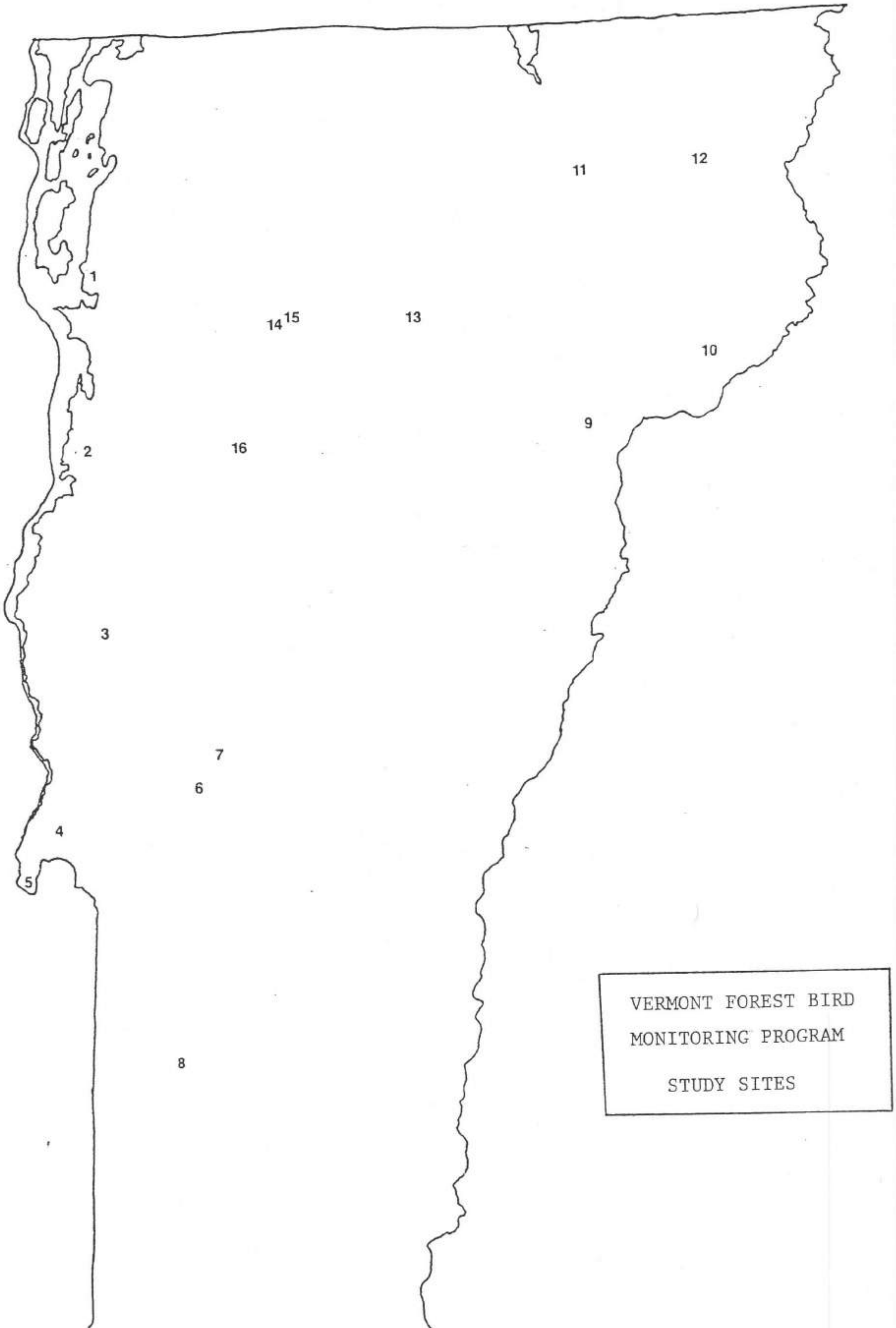


Table 1. Vermont Forest Bird Monitoring Sites - 1991

Site	Town	Habitat	Observer
1. Sandbar WMA	Milton	Floodplain	T. Johansson
2. Pease Mountain	Charlotte	Oak-hickory	S. Staats
3. Cornwall Swamp	Cornwall	Maple Swamp	W. Ellison
4. Shaw Mountain	West Haven	Oak-hickory	W. Ellison
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	T. Johansson
9. Roy Mountain WMA	Barnet	Cedar-spruce	C. Rimmer
10. Concord Woods	Concord	N. Hardwoods	C. Rimmer
11. May Pond Preserve	Barton	N. Hardwoods	T. Johansson
12. Wenlock/Buxton's	Ferdinand	Spruce-fir	T. Johansson
13. Bear Swamp	Wolcott	Spruce-fir	B. Pfeiffer
14. Underhill S.P.	Underhill	N. Hardwoods	B. Wright
15. Mt. Mansfield	Stowe	Subalpine	C. Rimmer
16. Camel's Hump	Huntington	Subalpine	C. Fichtel

Table 2. Numbers of individual birds recorded on Mt. Mansfield in 1991. Maximum count for each species repesents relative abundance index to be used in future analyses.

Species	07 June	18 June
Winter Wren	16	20
Gray-cheeked Thrush	2	10
Swainson's Thrush	2	6
American Robin	2	2
Nashville Warbler	2	4
Magnolia Warbler		2
Yellow-rumped Warbler	22	8
Blackpoll Warbler	20	14
Lincoln's Sparrow	4	
White-throated Sparrow	14	12
Dark-eyed Junco	8	6
Purple Finch	2	2
Number of individuals	94	86
Number of species	11	11

Table 3. Numbers of individual birds recorded in Underhill State Park in 1991. Maximum count for each species represents relative abundance index to be used in future analyses.

Species	18 June	26 June
Pileated Woodpecker		2
Blue Jay	2	1
Veery	2	
Wood Thrush	1	1
American Robin		1
Solitary Vireo	1	
Red-eyed Vireo	5	1
Magnolia Warbler	1	
Black-throated Blue Warbler	11	3
Black-throated Green Warbler	8	9
Ovenbird	7	1
Canada Warbler	4	
Rose-breasted Grosbeak	5	7
White-throated Sparrow	2	2
Number of individuals	49	28
Number of species	12	10

Mountain Biogeography Project

William G. Howland
Department of Geography - Middlebury College

Objectives

This study is designed to address three primary objectives. The first is to gather, through field sampling and existing literature, basic biogeographic data for Mt. Mansfield, resulting in a plant association map. The second objective is to begin long term monitoring of selected physical environmental parameters on the mountain and detailed floristic data, within ten long term study sites. The third objective is to conduct a series of experimental research projects designed to further understanding of the contemporary physical environments and biotic distributions on Mt. Mansfield.

Methods

The research began in June, 1991 and continues, the expected duration of the project being many years. Field sampling of the flora follows two plans. Within the 50 x 50 meter long-term study sites, floristic data, as frequency for all species, are gathered in a restricted randomized array of fixed quadrats at least every second year for the period of the study. Observations of soil properties, local geomorphology, and microclimatic conditions are also to be monitored as possible in long term sites.

The sampling design for the broader biogeographic investigation of the floristic composition of the vegetation of the summit and western slopes of Mt. Mansfield follows a random sampling scheme stratified by elevation. The vegetation of the summit (alpine tundra) area is to be examined within a randomized quadrat array of higher sample frequency, so that the results are suitable for both ecological analyses and mapping purposes.

Spatial control is comprised of site markers for fixed quadrats, and GPS data at each vegetation sample site. These data, phrased as UTM and VT state plane coordinates, provide the linkage required for remote sensing image analysis, which is the basis for the extended plant association mapping, beyond intensively sampled areas of the mountain.

Provisional Results

Biogeographic Data

Higher vascular plants (357 vouchers) and the cryptogamic flora (98 vouchers) from the montane forest on the western slopes of Mt. Mansfield were sampled using a restricted random model. At twenty one sites, located at 200 foot AMSL elevation intervals on existing trails, belt transects of twenty five square meters were positioned upslope from the trail, and begun at a five-meter distance from the trail. Within each transect, comprehensive presence/absence data were collected for all visible species of the higher vascular flora and also for cryptogams. At two random locations along each transect, quadrats of one square meter were positioned and frequency data for all visible species gathered; 42 quadrats were assessed in this manner. At a third random location on each belt transect, a ten-meter diameter sample area for tall shrubs and trees was positioned; the data acquired in these samples included stem counts by species for each dbh class, by quarters.

Determinations of all but a few higher vascular vouchers has been completed. Determinations of crytogam vouchers are complete. All herbarium collections and vouchers are housed in the Geography Department at Middlebury College.

Long Term Studies:

The locations of seven of the ten long term monitoring sites planned for the summit and western side of the mountain have been determined, although the corner markers and UTM coordinates will not be established until late May, 1992. One site has been authorized at the University of Vermont Proctor Maple Research Center and its location at about 1400 feet AMSL will serve as the base of the transect. Two sites have been fixed in the Alpine tundra zone, with approval of the University of Vermont (Natural Areas Program) near the chin and just below the west chin. Four additional sites have been located in the upper and lower krummholz zone on Sunset Ridge. The locations of these and three additional long term sites will be determined by GPS survey early in the 1992 field season.

Experimental Research:

Three experimental projects were undertaken this year: 1) to examine the freezing temperatures and microclimate in the krummholz zone, 2) to determine the coniferous foliar and soil nutrient status on an elevation gradient on the western slopes of Mansfield, and 3) to measure variations with elevation, of the accretion of rime ice on Sunset Ridge.

1) Research designed to clarify the relations between the freezing of *Abies balsamea* tissues and ambient air temperature was conducted in the krummholz zone on the west chin through the fall and early winter. Internal twig temperatures and corresponding air temperature controls were monitored from October through December at 6-second intervals, to identify the freezing exotherm and monitor its response to cyclic temperatures through the season of cold hardening.

2) Soil and tree foliar nutrient characteristics were sampled in late October, 1991 at 38 locations along the Sunset Ridge trail, with replicates at 200 foot intervals, and numerous elemental analyses conducted using an inductively coupled plasma spectrometer. Paired with soil samples in collection and analyses, were foliar tissues from *Picea rubens* and *Abies balsamea*. Resulting data, which are provisional, (being part of a senior thesis in progress) indicate a strong correspondence with soil depth and development, site elevation, and other site specific environmental conditions, in both foliar tissues and soils.

3) Rime ice accretion was monitored weekly (almost) at four winter test sites on an elevation gradient on Sunset ridge through the beginning and middle part of winter. Six collectors at each site were harvested of ice as frequently as conditions permitted. The research first produced a unique collector design, and then yielded data that, from provisional analysis, both demonstrate an elevation gradient in the severity of rime ice accretion, and also show that patterns of accretion are highly sensitive to synoptic climatic variations.

METEOROLOGICAL AND PRECIPITATION CHEMISTRY MONITORING

Tim Scherbatskoy
School of Natural Resources
University of Vermont

Cooperators:

Sumner Williams, Mel Tyree, UVM Proctor Maple Research Center
Jim Kellogg, VT Department of Environmental Conservation
WCAX-TV staff at Mt. Mansfield transmitter
National Atmospheric Deposition Program
US Geological Survey
NOAA National Weather Service
Electric Power Research Institute (EPRI)

Objectives:

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

Methods:

Several monitoring stations were operated in 1991:

1. Basic meteorology (continuous temperature, relative humidity, wind speed and direction, and precipitation amount) is monitored at the main air pollution monitoring station at PMRC (400 m). This station has remote (modem) access and has been in continuous operation since 1988. Data are updated continuously and are locally stored electronically and in hard copy, and are available from the project manager Tim Scherbatskoy. Cooperators are Sumner Williams and Mel Tyree at PMRC. Funding to support this station comes from the VMC. During its first two years it was operated by EPRI.

2. 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 main air pollution 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, from whom data are available. Cooperators are Sumner Williams at PMRC and the staff at the WCAX-TV transmitter facility. Funding to support these two station comes from the VT Department of Environmental Conservation.

3. The National Weather Service under NOAA supervises a cooperative weather station at the WCAX-TV transmitter station near the nose of Mt. Mansfield (1205 m), as well as at 42 other stations around 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 NOAA National Climatic Data Center. The VMC does not directly support this station, but has access to its data, which are available for the period 1954-1991 from Tim Scherbatskoy. Funding for this station comes from the National Weather Service and the cooperation of WCAX-TV.

4. The NADP/NTN (National Atmospheric Deposition Program/National Trends Network) maintains a site at the main air pollution 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. The site supervisor is Tim Scherbatskoy, and the site operator is Sumner Williams at PMRC. Funding to support this station comes from the US Geological Survey.

Significant Findings:

At this time, no major results from these projects are available, except for the raw data itself. Database consolidation for the basic meteorology station at PMRC (1 above) is still in progress; completion and subsequent analysis is expected by June 1. The database for VAPMP (2 above) is up-to-date, but no data interpretation is planned for individual stations or the program in the near future; the last program report was in 1986. Analysis of data from the Mt. Mansfield weather station (3 above) is underway; results are expected in May, 1992. Data analysis of the NADP station (4 above) is available for each preceeding quarter from the site supervisor, and is available for the entire network annually from NADP; the last annual data summary is dated 1990.

Future Plans:

All of these stations will continue to operate in 1992-93. Updates for the Mt. Mansfield weather station (as well as all other National Weather Service Vermont stations) will be obtained annually.

In addition, two new monitoring projects will come on-line in 1992. Ambient atmospheric mercury concentrations will be monitored at the PMRC basic meteorology site (1 above) beginning in June. This project will measure gaseous, aerosol, and precipitation phases of total mercury several times a week throughout the year. This work will be supported by NOAA and the Lake Champlain Research Consortium. A second related project coming-on line in June is the monitoring of meteorology and ozone at multiple locations in a hardwood canopy at PMRC. Details about this project are provided in this volume under the research abstract "Measurement of environmental and pollutant gradients in the forest canopy."

MEASUREMENT OF ENVIRONMENTAL AND POLLUTANT GRADIENTS IN THE FOREST CANOPY

Tim Scherbatskoy
School of Natural Resources
University of Vermont

Cooperators:

Deane Wang, UVM School of Natural Resources

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 in a mature hardwoood stand at the Proctor Maple Research Center (PMRC). At each of five heights from ground-level to above the canopy we will:

1. monitor ambient environmental conditions (ozone concentration, temperature, relative humidity, wind speed and direction, and surface wetness; total solar radiation, photosynthetically active radiation (PAR), and ultraviolet radiation will also be monitored above the canopy;

2. measure leaf area distribution (LAI), foliage distribution, and PAR;

3. relate these data (1 and 2) to evaluate the relationship between in-canopy ozone concentrations, meteorology and canopy structure;

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

Methods:

In 1991, the tower was constructed, planning for this project was conducted, and supplies and equipment were ordered. All canopy measurements will commence by May and extend through October. Ambient meteorology and ozone measurements will be conducted continuously at five sampling points between the ground and tower top. Ozone measurements will be made with an automatic switching valve (Scan Co. ScaniValve) alternately sampling each location using a TECO ozone monitor. Meteorological variables will be measured at the same locations for temperature and relative humidity (CSI model 207), wind speed and direction (R.M. Young AQ wind monitors), and surface wetness (CSI model 237). Solar radiation will also be measured at the top of the canopy as PPFD, solar irradiance (400-1100 nm), and UV-B irradiance (Licor models 190SA, 200SA, and Solar Light Co. UV Biometer, respectively). Meteorological data signals will be routed to a CSI model 21X data logger and a microcomputer for collection as half-hour means.

Micro-meteorological wind data will be collected utilizing three dimensional anemometers (R.M. Young UVW monitors). These data and the ozone data will be used in eddy correlation calculations to estimate gas flux to the canopy at three heights. Typically these calculations require fast (< 1 s) gas data acquisition, but we anticipate being able to make meaningful calculations with our present standard monitors.

Phenology of leaf-out in spring and canopy structural changes through the season will be estimated by taking periodic measurements of leaf area distribution frequently during May and June and periodically through the growing season. Leaf area index and foliage distribution will be estimated at each height using several techniques: a LiCor LAI 2000 canopy analyzer (LiCor, Lincoln, NE), PAR attenuation using a Ceptometer PAR wand (Decagon Devices Inc., Pullman WA), hemispherical photograpy, and a photographic sight-obstruction technique, both using image analysis hardware and software.

Significant Findings:

At this time there are no research results. Much of the preliminary experimental design and procedure work has been accomplished. In the course of this planning, possible collaborative research relationships have been identified with the SUNY Albany Atmospheric Science Research Center, the US Forest Service Rocky Mountain Forest and Range Experiment Station, and NOAA.

Future Plans:

This research project will run for at least two years and may be expanded if pending grant proposals are funded. In addition, year-around basic forest meteorological data will be summarized on a regular basis. Possible future work involves adding multiple measurements in the horizontal direction in order to expand our data base to three dimensions for the purpose of scaling physiological responses from the leaf to the whole stand level. Discussions are currently underway (April 1992) with several research groups to cooperate on (1) enhancing the micro-meteorological studies, (2) measuring mercury deposition to the canopy, (3) measuring nitric acid vapor and other forms of N deposition to the canopy, and (4) developing dry deposition measurement capabilities at the site.

Funding Sources:

Support from this project comes from the UVM Research Advisory Council, the VMC, the US Forest Service Northeastern Forest Experiment Station, and the UVM School of Natural Resources.

Growing-Season Ozone Monitoring at the VMC Site

R. Poirot, VT Div. Air Pollution Control and S. Wilmot, VT Div. Forest Protection

Air Quality monitoring at the Underhill, VT VMC site includes an ozone monitoring station in the EPA SLAMS network (State and Local Air Monitoring Sites), operated by the Vermont Division of Air Pollution Control. Beginning in 1989, hourly ozone concentrations have been measured during the warm season (April 1 - October 31) using EPA Reference Methods (UV Photometry). Similar methods are employed at a southern Vermont site in Bennington, as well as at numerous other EPA sites in the U.S. The monitoring objective is to determine compliance with the 1 hour ozone national ambient air quality standard (120 ppb).

Quality-assured data are stored in the EPA AIRS database (Aerometric Information Retrieval Service) within 45 days of the end of each seasonal sampling quarter, and can be obtained through VTDAPC (contact: Janice Lemieux (802) 244-8731).

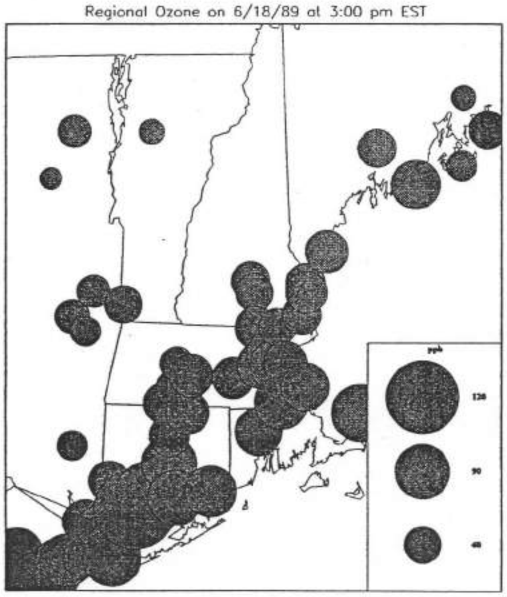
Summer, 1991 VT Ozone Summary

Monitor Site	# of hrs. ≥60 ppb	# of hrs. ≥80 ppb	Max. 1 hr.	Date of Max. 1 hr.	# of Episodes
Underhill	366	42	93 ppb	5/24	3
Bennington	419	104	126 ppb	8/17	6

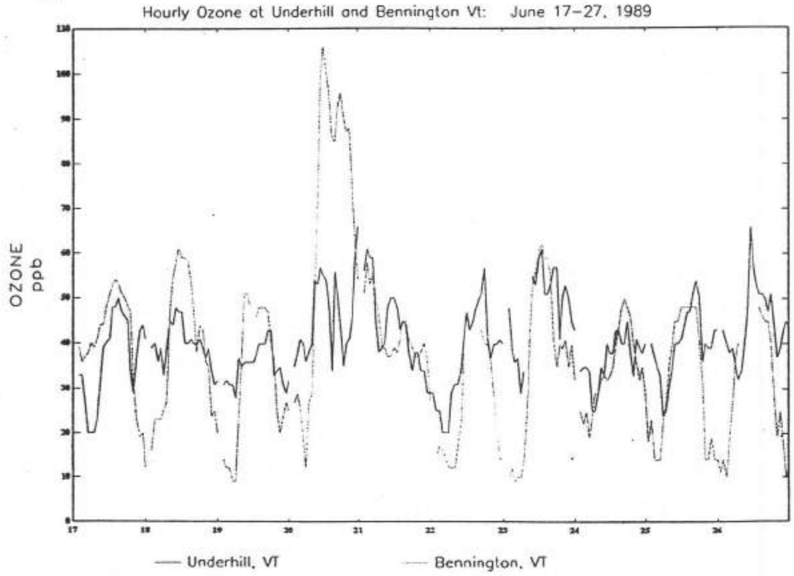
* Episode = 2 consecutive days when $O_3 \geq 80$ ppb for 2 hrs.

Selected ozone data from VT and other NE sites are also being converted in Voyager format and will be processed into various biologically relevant indices as part of the VMC Data Integration Pilot Project (contact Rich Poirot: (802) 244-8731). The fine time resolution, standard methods and Voyager formatting allow detailed evaluation of spatial and temporal patterns, as illustrated below.

Regional Ozone on 6/18/89 at 3:00 pm EST



Hourly Ozone at Underhill and Bennington Vt: June 17-27, 1989



A REGIONAL COMPUTER-BASED OZONE DATA REPORTING NETWORK

Tim Scherbatskoy
School of Natural Resources
University of Vermont

Cooperators:

Northeast States for Coordinated Air Use Management (NESCAUM)
John Lydick, UVM Environmental Studies Program
Ian Martin, UVM School of Natural Resources

Objectives:

The goal of this project is to develop a real-time ozone data network available to scientists, managers, and planners in the northeastern region. Working with the Northeast States for Coordinated Air Use Management (NESCAUM), 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 available to the state air programs and other selected users (e.g. forest managers, field crews, researchers) through DELPHI. Specific objectives include:

1. Facilitating data transferral by the states
2. Compiling and editing all data into master files
3. Preparing ASCII, spreadsheet and Voyager files of ozone and time data
4. Posting data on DELPHI for use by NESCAUM and selected others

Methods:

Procedures for compiling data include accessing DELPHI and downloading data three times per week, using a word processor to scan and compile data, using a program to extract the relevant data from the master data sets, using a spreadsheet to format master data files for distribution as ASCII and spreadsheet (Lotus or Quattro) files, building these data into Voyager files, and distributing these data on diskettes or posting them on DELPHI.

Significant Findings:

Turning around data on a weekly basis as originally intended proved to be difficult to accomplish due to (a) irregularities in rates of data submission by cooperators and (b) the initial difficulty of methods development. By the end of the 1991 ozone season, methods were perfected to the point where this will be practical in the future. All data have been compiled into monthly ASCII an dspreadsheet data files and into one Voyager file for the entire season. Both daily maximum ozone concentration and time(s) of occurrence are included.

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 weekly 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 desireable.

Future Plans:

This project will continue in 1992. Additional goals for 1992 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.

Funding Sources:

Support for this project came from the US Forest Service Northeastern Forest Experiment Station, the UVM School of Natural Resources, and the Northeast States for Coordinated Air Use Management (NESCAUM).

BIOMONITORING OZONE WITH WHITE CLOVER CLONES

Tim Scherbatskoy
School of Natural Resources
University of Vermont

Cooperators:

Sumner Williams, UVM Proctor Maple Research Center
Air Resources Program, North Carolina State University, Raleigh

Objectives:

Development of methods to use an ozone-sensitive clone of white clover as a biomonitor for ambient ozone exposure. Conducting initial research to develop culture methods and techniques for scoring and evaluating injury.

Methods:

Two clones of white (Ladino) clover, originally isolated at North Carolina State University for their tolerance and sensitivity to ozone, were grown in pots of greenhouse soil under standard greenhouse cultural conditions. During the summer months multiple pots of each clone were placed outside at the Proctor Maple Research Center (PMRC) or used in ozone fumigation experiments at UVM. Experimental exposures consisted of 3 daily 6 hr exposures of both clones to 100-150 ppb ozone; there were no control (non-ozone) treatments. Measures of response (foliar chlorosis, necrosis and chlorophyll concentration and shoot and root biomass) were evaluated 10 days after treatments.

Significant Findings:

No significant differences were measured for the plants grown at PMRC. During the period of exposure (August-September, 1991) maximum ozone concentrations did not exceed 75 ppb, with an average daily maximum around 50 ppb.

Exposure to experimental ozone treatments caused significant differences in chlorophyll, chlorosis and necrosis. Cholophyll-a was reduced 20% in the sensitive plants compared to the resistant ones. Necrosis and chlorosis were approximately 50% and 15% respectively greater in the sensitive plants compared to the resistant ones. Root biomass was much greater (240%) in the sensitive clones, but this was probably an inherent property of the plants rather than a result of exposure to ozone, since the time between ozone exposure and measurement was so brief (< 10 days).

These results indicate that these plants do respond differently to acute (>100 ppb) ozone expoure, but not to chronic low level exposure. It must be stressed that this was a short-term (<8 weeks) pilot investigation. Additional work is needed to characterize and calibrate responses of these plants over longer time periods.

Future Plans:

Further work is needed to identify long-term responses of these plants to chronic and acute ozone exposures. In 1992 multiple pots of sensitive and resistant clover will be placed in the field in mid-May at PMRC, Underhill State Park, and, in conjunction with the Vermont Dept. of Agriculture, 4 sites around Vermont (southern, central, northwest, northeast). In addition, experimental exposures to varying ozone levels will be conducted during the summer at UVM. Clover condition data will be assessed regularly and correlated with local or regional measures of climate and ozone concentration.

Funding Sources:

This work was supported by the UVM School of Natural Resources and the US Forest Service Northeastern Forest Experiment Station.

Nescaum Regional Particle Monitoring Network

Richard Poirot, VT Division of Air Pollution Control

Air Quality monitoring at the Underhill, VT VMC site includes a station in a regional particle monitoring network, initiated in 9/88 by the Northeast States for Coordinated Air Use Management (NESCAUM). The NESCAUM monitoring objective is to promote a better understanding of aerosol concentration and composition in the northeastern US. Seven regionally representative sites are operated by the State Air Pollution Control Programs in NY, NJ, CT, MA, ME, NH, and VT, in cooperation with the Crocker Nuclear Laboratory at the University of California at Davis (UCD).

Fine fraction (< 2.5 micron) particles are collected for 24 hours, 3 times a week, and analyzed at UCD for mass, light absorption and the elements: Al, As, Br, Ca, Cr, Cl, Cu, Fe, H, K, Mg, Mn, Na, Ni, Pb, Se, Si, S, Ti, V, and Zn. Particles in this size range include a majority of aerosol-phase sulfates, nitrates, toxic metals and organics which potentially affect human health and visibility. They are particularly susceptible to long-range atmospheric transport, and form efficient condensation nuclei, ultimately transferred by rain, snow, fog and clouds to terrestrial and aquatic ecosystems at considerable distance from pollutant sources.

NESCAUM sampling and analytical methods are compatible with several larger US networks, including the National Park Service Congressional network (NPSC), and the Interagency Monitoring of Protected Visual Environments (IMPROVE). The NESCAUM sites are scheduled for inclusion in the planned EPA Clean Air Status and Trends Network (CASTNET). The NESCAUM aerosol data through 11/31/91 are readily available in ASCII or Voyager formats, and will be included in the VMC Data Integration Pilot Project. A list of currently available reports and publications is attached.

The high-resolution sampling and analytical methods provide a detailed picture of aerosol concentration and composition at the VMC site, as in Figure 1. Comparable methods and data format allow the data to be viewed in a larger regional or national context, as in figure 2. Inclusion in CASTNET would assure continuation of a relatively long-term record.

Fig. 1. Monthly Fine Particle Composition at Underhill, VT VMC Site

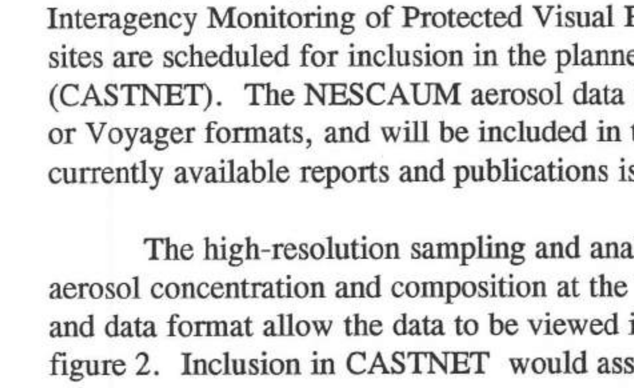
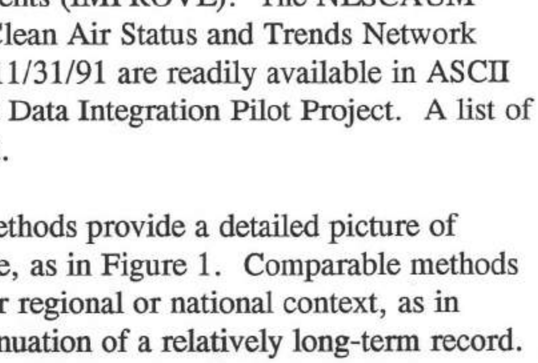


Fig. 2. Fine Particle Sulfur in NESCAUM, IMPROVE and NPS Networks on 7/19/89



NESCAUM Regional Particle Monitoring Network (NEPART)
Reports and Publications Utilizing NEPART Data

R.G. Flocchini, T.A. Cahill, R.A. Eldred and P.J. Feeney (1989), "Particulate Sampling in the Northeast: A Description of the Northeast States for Coordinated Air Use Management (NESCAUM) Network", Transactions AWMA/EPA Spec. Conference on Visibility and Fine Particles, C.V. Mathai ed., pp. 197-206.

R.L. Poirot, R.G. Flocchini and R.B. Husar (1990), "Winter Fine Particle Composition in the Northeast: Preliminary Results from the NESCAUM Monitoring Network", 90-84.5, 83rd Annual AWMA Meetings, Pittsburgh, PA.

R.L. Poirot, P.J. Galvin, N. Gordon, S. Quan, A. Van Arsdale, R.G. Flocchini (1991), "Annual and Seasonal Fine Particle Composition in the Northeast: Second Year Results from the NESCAUM Monitoring Network" 91-49.1, 84th Annual AWMA Meetings, Vancouver, B.C.

W.C. Malm, Y. Golestani, T.A. Cahill, R.A. Eldred, R.L. Poirot and K.A. Gebhart (1991), "Estimation of Aerosol Acidity in the Eastern United States", 91-89.3, 84th Annual AWMA Meetings, Vancouver, B.C.

B. Schichtel and R. Husar (1991), "Composition of Aerosols over the Continental U.S." Report PL-TR-91-2180, Phillips Laboratory, Air Force Systems Command, Hanscom AFB, MA.

B. Schichtel and R. Husar (1991), "Apportionment of Light Extinction by Aerosol Types over the U.S." Report to Phillips Laboratory, Air Force Systems Command, Hanscom ARB, MA.

B.A. Schichtel and R.B. Husar (1992), "Aerosol Types over the Continental U.S.: Spatial and Seasonal Patterns", 92-60.07, 85th Annual AWMA Meetings, Kansas City, MO.

B.A. Schichtel, R.B. Husar, W. Wilson, R.L. Poirot and W.C. Malm (1992), "Reconciliation of Visibility and Aerosol Composition Data over the U.S.", 92-59.08, 85th Annual AWMA Meetings, Kansas City, MO.

R.B. Husar and R.L. Poirot (1992), "Exploration of the AIRS Database: Weekly Cycle of Ozone and PM-10 Aerosols", 92-77.06, 85th Annual AWMA Meetings, Kansas City, MO.

S.T. Rao and P.S. Porter (1992), "Estimation of Central Tendency from Multiply Censored Air Monitoring Data" to be presented at AWMA International Symposium on the Measurement of Toxic and Related Air Pollutants, R.T.P., N.C.

P.S. Porter, S.T. Rao and R.L. Poirot (1992), "Statistical Analysis of Environmental Data Affected by Limits of Detection: A Question of Measurement Error" to be presented at the International Symposium on Environmetrics, Espoo, Finland.

R. Poirot, P. Wishinski, R. Flocchini, R. Husar, B. Schichtel, P. Galvin, G. Keeler, R. Artz, A. Van Arsdale (1992), "Transboundary Implications of Visibility--Impairing Aerosols in the Northeastern United States (Part I): Space/Time Patterns from the NESCAUM Aerosol Network", to be presented at 1992 Joint Spring Session AGU/CGU/MSA, Montreal, Quebec.

P. Wishinski, G. Keeler, R. Artz, P. Galvin, R. Flocchini, R. Husar, B. Schichtel, A. Van Arsdale, R. Poirot (1992), "Transboundary Implications of Visibility--Impairing Aerosols in the Northeastern United States (Part II): Air Trajectory Assessment of the NESCAUM Aerosol Data", to be presented at 1992 Joint Spring Session AGU/CGU/MSA, Montreal, Quebec.

CANOPY ION EXCHANGE MECHANISMS

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University of Vermont

Cooperators:

Gary Lovett, Institute of Ecosystem Studies, Millbrook, NY

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) develop a mechanistic model predicting canopy ion exchange rates.

Methods:

Integrated field and laboratory experiments are being 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.

Multiple paired branches were selected to receive treatments on two replicate open-grown trees. One branch per pair was manually defoliated in early July. Branches were pre-rinsed to remove surface deposits. Artificial precipitation at pH 4.4 was applied for three hours in branch chambers and foliar leachate collected every 15 min. Foliage and leachate samples were analyzed for all major nutrient cations and anions. Laboratory studies examined the ion transport properties of isolated leaf cuticles from the field foliage in order to calculate ion permeability rates.

Significant Findings:

Analysis of this work is still underway, including evaluation of the exchange kinetics from the field studies and cuticular ion permeability analyses. Preliminary analysis of the field work indicates that stems are very important contributors to canopy ion exchange processes such as foliar leaching. When expressed on a leaf and stem surface-area basis, stems released as much as 18 times more of an ion than foliated branches. This is summarized in the following table as the relative proportion of stem leaching to foliated branch leaching over the entire three hour precipitation event.

RATIO OF STEM/WHOLE-BRANCH LEACHING ON A SURFACE-AREA BASIS

Na	K	Ca	Mg	NO_3	SO_4	Cl
10.2	17.3	2.93	15.7	1.23	18.4	17.5

Thus, on a unit-area basis stems alone leach 2.93 times more Ca than whole foliated branches, 17.3 times more K, etc. This result incorporates several factors: the relatively small surface area of stems (6% of the total surface area of stems plus leaves), the relatively small amount of water that actually contacts the stems, and the relatively high "leachability" of stems compared to leaves. The first two factors tend to work toward a small contribution from stems; thus, the third factor - a high leaching rate for bark - counteracts these factors significantly. This finding is important new information about the canopy ion exchange process, and has not been documented before.

The relatively small surface area of stems, however, limits their contribution to nutrient flux in throughfall. The fractional contribution of stem leaching to total branch leaching is shown in the following table.

RATIO OF STEM/WHOLE-BRANCH ION QUANTITY IN THROUGHFALL

Na	K	Ca	Mg	NO_3	SO_4	Cl
0.69	1.03	0.16	0.92	0.03	0.96	1.06

Thus, for the total quantity of ions contributed to a throughfall sample, stems contribute 16% of the Ca, all the K, etc. The conclusion from this observation is again that stems are important contributors to the ion exchange process in canopies, particularly for some ions such as K, Mg, SO_4 and Cl.

NH_4 showed consistent uptake by foliage and leaching by stems. Here again, stem leaching was about 17.8 times greater on a surface-area basis than (the absolute value of) foliated branch uptake.

Future Plans:

In 1992, the objective is to evaluate the contribution of leaf surface deposits to canopy exchange. Using similar procedures to 1991, the chemistry of foliar leachate from acid-washed, distilled water-washed, and un-washed foliage will be compared, and the kinetics of ion exchange within each component will be evaluated by sequential leachate sampling. Branches will be pre-washed in branch chambers with pH 3 or deionized water, and a third set of branches will not be rinsed to serve as the control. Artificial precipitation will be applied at pH 3.8 and 5.4, and foliar leachate collected for analysis. Leaf and branch tissues will also be analyzed for major ions, and relationships between tissue and leachate ion concentrations evaluated.

Funding Sources:

Funding for this research comes from a grant from the USDA Cooperative State Research Service Forest Biology Program.

VMC Data Integration Pilot Project

R. Poirot, VT DEC, Div. Air Poll. Control
S. Wilmot, VT DFPR, Div. Forest Protection
T. Scherbatskoy, SNR, University of VT
R. Husar, CAPITA, Washington University

Integration of environmental monitoring and research activities is a principal objective of the VMC, providing a common bond among all VMC cooperators, as well as those in other related state, federal and private programs. Monitoring and research measurements in multiple environmental media at the Mansfield site provide a site-specific, multi-disciplinary **Integration of Variables**. Many of these measurements are collected within statewide, regional or international networks, employing common methods , and providing a substantial degree of **Integration over Space**. Some of the site-specific or network-wide measurements are characterized by significant historical and continuing records, providing a growing degree of **Integration over Time**.

A critical additional step, to realize the maximum return from these integrated monitoring and research programs, is to achieve an effective **Integration of Data**. Towards this goal, the VMC, with technical assistance from *Lantern Corporation*, and supplemental funding support from the VT Division of Air Pollution Control, has initiated a **Data Integration Pilot Project**. The principal cooperators include the above listed individuals, and other VMC cooperators who are supplying data for this effort. The objective is to demonstrate that an effective and useful degree of data integration can be achieved using recent data processing developments in the field of Environmental Informatics and readily accessible, PC-based computer software. The methods include:

1. Collecting a limited number of disparate data sets in multiple environmental media,
2. Processing the data into comparable units and compatible space/time domains,
3. Converting the resultant data into common computer format (*ASCII* and *Voyager*),
4. Evaluating and interpreting the data using the PC-based ***Voyager Development Kit,***
5. Exchanging resultant data and interpretations with any interested parties using the shareware ***Voyager Viewer*** Program.

Voyager provides simultaneous, linked views of data in Time, Space, Variable, and Relational (scatter) views, providing fast and easy browsing, evaluation and interpretation of spatial, temporal and relational patterns underlying complex environmental data sets. Specific data sets for incorporation in this pilot project include:

1. Annual Forest Condition data from all VT sites in the New England Forest Health Monitoring Program (FHM), 1990-1991,
2. Annual Forest Condition data from all VT sites in the North American Sugar Maple Decline Project (NAMP), 1988-1991,
3. Seasonal Aquatic Chemistry data from the VT Long-Term Lake Monitoring Program (LTM), 1980-1990,
4. Monthly Climatological data from all US long-term (>80 yrs) NWS cooperative sites (compiled by Oak Ridge), <1907-1987,
5. Daily Climatological data from all VT NWS cooperative sites, start of record -1990,
6. Weekly Precip. Chemistry from all northeastern sites in National Atmospheric Deposition Program (NADP), 1980-1991,
7. Daily Precip. pH data from all sites in the Vermont Acid Precip Monitoring Program (VAPMP), 1979-1991,
8. Daily Aerosol Chemistry from the NESCAUM Regional Particle Monitoring Network (NEPART), 1988-1991
9. Hourly Ozone data (processed into biologically relevant indices) from all sites in USEPA Regions I, II and III reporting to EPA AIRS database 1980-1991.
10. Several high-resolution maps (surface waters, roads, elevation, etc.) are also being obtained from various GIS data bases for use in this project.

The initial phase of database collection and some processing and formatting have been completed as of May, 1992. Some preliminary Voyager maps and processed data sets should be available to interested VMC cooperators be June, 1992. Pending a successful demonstration project, the principal cooperators plan to develop a more comprehensive funding proposal in the Fall of 1992.

APPENDIX

Vermont Monitoring Cooperative

Program Structure, Goals, Objectives, Functions and Activities

A. STATEMENT OF GENERAL PURPOSE

Several organizations concerned with environmental change and related impacts on natural resources in Vermont have joined together to create the Vermont Monitoring Cooperative (VMC). The principle focus of the VMC is a long-term integrated monitoring program to measure conditions and changes in the environment and the flora and fauna of our forested ecosystems. In addition, the VMC conducts a research program concerned with responses of forested ecosystems to environmental change and integration of monitoring and research data from multiple disciplines. Involved are many state agencies, the University of Vermont, the U. S. Forest Service and various other organizations.

B. STATEMENT OF GOALS AND OBJECTIVES

The health and productivity of our forests is of great concern to Vermonters. Current and anticipated changes in our environment and related forest stressors stimulate questions about how this will affect the vigor of our forested ecosystem. The complexity of interactions within a forest makes it difficult to single out one cause with one effect. The growing need for information on many variables affecting forests has prompted the initiation of the VMC, whose goals are:

To promote an improved understanding of the conditions, trends and relationships in the physical, chemical and biological components of the forested ecosystems in Vermont; and

To promote the efficient coordination of multi-disciplinary environmental monitoring and research activities among Federal, State and Private Sector Agencies and Institutions with common interests in the long-term understanding, management or protection of forested ecosystems.

The specific near future objectives of this Cooperative are to:

1. Establish and maintain an intensive integrated Forest Ecosystem monitoring site at Mount Mansfield, centered at the Proctor Maple Research Center in Underhill, where long-term monitoring and shorter-term directed research activities will be conducted to identify conditions, trends and relationships among physical, chemical and biological components of the forested ecosystem.

2. Establish a formal mechanism to facilitate and support coordination of multi-disciplinary environmental monitoring and research activities among State and Private Sector entities and to further coordinate these activities with parallel monitoring and research activities sponsored by

other International, Federal, State and Private Sector entities.

3. Establish a structured mechanism for integrating monitoring data, for use in generating an annual status report, and to facilitate analysis of trends and relationships existing in this forested ecosystem and to help direct future monitoring efforts.

A future objective is to expand the spatial context of the VMC to include other areas in Vermont. But completion of the first three objectives need to be satisfied in order to proceed with a well structured program capable of securing and digesting additional data.

C. FUNCTIONS

The VMC will facilitate, coordinate and integrate monitoring and research activities at the Mansfield site through cooperative planning, providing a base of information to build on, and in some cases, obtaining financial support for specific functions. It will coordinate monitoring and research activities to the extent of choosing appropriate activities and sites, preventing conflicting land uses, and providing a forum for interdisciplinary information exchange.

Documentation of program activities will be enhanced through monitoring and research work plans, which will be revised as needed. Quality Assurance and Quality Control sections will appear under each planned activity to emphasize a high degree of planning to insure high quality data. The VMC will identify and periodically reassess monitoring and research information needs to progress towards it's goals.

The VMC will link monitoring and research data to allow a more thorough understanding of forest trends and interactions. It will also link monitoring activities performed on a larger scale around the state together at one site, enhancing the interpretation of information obtainable for Vermont as a whole.

The VMC will serve as a demonstration program on ecosystem monitoring and research. As such, it will establish a system for information and educational exchanges as an integral part of the program.

ORGANIZATION AND RESPONSIBILITIES

(See Organizational Chart, Figure 1)

A. STEERING COMMITTEE

The Steering Committee sets program policy and direction,

Figure 1. **VMC ORGANIZATION CHART**

STEERING COMMITTEE

USFS-S&PF	STATE	UNIVERSITY	USFS-NEFES
MICHAEL RAINS	CONRAD MOTYKA	LAWRENCE FORCIER	DENVER BURNS

COORDINATION COMMITTEE

SANDY WILMOT
(Monitoring Coord.)
RICH POIROT
BRENT TEILLON
DOUG BURNHAM

TIM SCHERBATSKOY
(Research Coord.)
DEANE WANG

MONITORING
ADVISORY
COMMITTEE

SANDY WILMOT
Monitoring Coordinator

AGRICULTURE-JON TURMEL
AIR-RICH POIROT
FISH & WILDLIFE-LARRY GARLAND
FOREST INDUSTRY-DAVE MARVIN
FORESTRY-BRENT TEILLON
GMNF-NANCY BURT
PMRC-MEL TYREE
PUBLIC HEALTH-BILL BRESS
USFS FPM-MARGARET MILLER-WEEKS
USFS NFHM-CHRIS EAGAR

RESEARCH
ADVISORY
COMMITTEE

TIM SCHERBATSKOY
Research Coordinator

STATE-RICH POIROT
UVM BOTANY-MEL TYREE
UVM FORESTRY-JOHN DONNELLY
UVM FORESTRY-DEANE WANG
UVM WATER-AL MACINTOSH
UVM WILDLIFE-DAVE CAPEN
UVM WILDLIFE-DAVE HIRTH
USFS NEFES-CHRIS EAGAR

WORKING SUBCOMMITTEES

LAND USE
Monitoring Coord.
Research Coord.
PMRC Director
Landowner(s)

ANIMAL MONITORING
Monitoring Coord.
Research Coord.
UVM Entomologist
VINS Research Dir.
USDI F&W Coop. Dir.
VT ANR Heritage Dir.
UVM Ornithologist
UVM Wildlife Biol.
Middlebury Herpetol.

GIS
Monitoring Coord.
Research Coord.
UVM GIS Consultant
VT ANR GIS Coord.
UVM GIS Coord.

specifically as it relates to other related state, regional and nationalmonitoring and research programs. Within these related programs, the Steering Committee will promote the goals and objectives of the VMC.

B. MONITORING COORDINATOR

The Monitoring Coordinator serves as the chair for the Coordination Committee and the Monitoring Advisory Committee and, in general, insures that monitoring activities are well coordinated and integrated. The Coordinator is responsible for developing a monitoring program work plan and annual reports, with the assistance of the Coordination Committee, to be reviewed and approved by both the Monitoring Advisory Committee and the Steering Committee State Representative. To facilitate appropriate site selections for monitoring activities, the Coordinator serves on the Land Use Committee as the liaison between this committee and the groups involved in monitoring. In addition, it is the role of the Monitoring Coordinator to promote the VMC monitoring activities locally and regionally, and to make budget decisions based on recommendations from the Monitoring Advisory Committee.

C. RESEARCH COORDINATOR

The Research Coordinator serves as the chair for the Research Advisory Committee and, in general, insures that research activities within the VMC are well coordinated and integrated with monitoring programs. The Coordinator is responsible for developing a research plan and annual reports, with assistance from the Coordination Committee, to be reviewed and approved by both the Research Advisory Committee and the Steering Committee University Representative. To facilitate appropriate site selections for research activities, the Coordinator serves on the Land Use Committee as the liaison between this committee and the groups involved in research. In addition, it is the role of the Research Coordinator to promote the VMC research activities locally and regionally, and to make UVM budget decisions based on recommendations from the Research Advisory Committee.

D. COORDINATION COMMITTEE

The Coordination Committee represents State Departments actively involved in VMC monitoring and University programs actively involved in VMC research. Members on this Committee will change as changes occur in the VMC. This Committee serves to facilitate implementation of represented Department's monitoring activities on the site, to facilitate annual data analysis by the represented Department and to advise the Committees and Coordinators of changes in the status of their monitoring activities. Level of involvement in the decision making process is greater in this Committee than in the Advisory Committees.

E. MONITORING ADVISORY COMMITTEE

The Monitoring Advisory Committee serves as an advisory group to the Monitoring and Research Coordinators, and the Steering Committee, for planning and implementing activities, and integrating VMC data. Members represent State Departments interested in long-term environmental monitoring, the University of Vermont, the USDA Forest Service-Northeast Forest Experiment Station and Forest Pest Management, and public forestry interests. It is chaired by the Monitoring Coordinator. Specific responsibilities include identifying and periodically reassessing monitoring and research information needs, reviewing and approving program work plans and annual reports.

F. RESEARCH ADVISORY COMMITTEE

The Research Advisory Committee serves as an advisory group to the Research and Monitoring Coordinators, and the Steering Committee, for planning, implementing and integrating research activities as part of the VMC. Members represent University programs in forest ecosystem research complimentary to the goals and objectives of this Cooperative. It is chaired by the Research Coordinator. Specific responsibilities include identifying and periodically reassessing research information needs, reviewing and approving general research plans and status reports.

G. WORKING SUBCOMMITTEES

The function of these subcommittees is to address specific questions or needs of the VMC in more detail and depth than can be addressed by other committees. The number of subcommittees and the length of their existence will vary depending on their need. It is the intent that the membership on these committees be large enough to include persons with major contributions, yet small enough to remain a constructive working group.

1. Land Use Subcommittee

This Committee coordinates monitoring and research activities at given locations to avoid conflicting land use. The Land Use Subcommittee reviews land use requests and makes preliminary approval of site selections for monitoring and research activities within VMC. Final approval is made by the landowner (Proctor Maple Research Center Director, State Lands Director, Mt. Mansfield Collocation Committee or private landowner).

2. Animal Monitoring Subcommittee

This subcommittee consists of people actively involved in or interested in involvement in animal monitoring. Its function is to make recommendations to the Monitoring and Research Coordinators on animal monitoring and research appropriate to the

VMC. Periodic meetings will allow for re-evaluation of VMC animal monitoring activities.

3. Geographic Information System (GIS)

This subcommittee will aid in identifying existing data, establishing a GIS plan, and organizing a system for data entry and extraction. Members represent the University of Vermont, the VT Agency of Natural Resources and the USDA Forest Service GIS operations. Periodic, but infrequent, meetings would facilitate information exchange on new equipment, techniques or changes in GIS processes that would be pertinent to maintaining an up-to-date system.

MONITORING ACTIVITIES AT THE MANSFIELD SITE

Monitoring activities under the VMC can be divided into three categories: biological monitoring, physical monitoring and chemical monitoring. Under each of these categories is a list of general activities to be implemented in 1991, plus future plans, if known.

A. BIOLOGICAL MEASUREMENTS

1. Forest health plots will be used to characterize the condition of forests and monitor changes that occur over time. This will include annual measurements of: growth, mortality, dieback, transparency, foliage discoloration, bole injury and incidence of stressors. Additional tree condition monitoring on individual trees will include: phenology, seed production, tree growth, and in the future, starch reserves.

2. Major forest pests and their associated damage to trees will be monitored to determine incidence and population trends.

3. Aerial surveys will be conducted annually and infra red photographs taken periodically over the Mansfield area to monitor the overall health of the forest as viewed from the air. This will detect large-scale problems not detected from the ground, and provide a historical record for future activities at the site.

4. Animal survey and monitoring activities will include: insects, amphibians, birds and in the near future, small mammals.

5. A vegetation survey will be conducted to aid in establishing long-term plant monitoring.

6. On-site stream macroinvertebrate surveys will be conducted annually.

7. Four ozone sensitive bioindicator plants (milkweed, black cherry, blackberry and ozone-sensitive white clover) will be monitored to determine biological impacts from on-site ozone levels.

B. PHYSICAL MEASUREMENTS

1. Two meteorological stations will be operating at the PMRC to record: continuous ambient and soil temperatures, relative humidity, precipitation, wind speed and direction and solar radiation (including ultraviolet [UV-B]. One station will be in an open field and the other in a forest. Additional weather information will be obtained from a high elevation meteorological station on Mt. Mansfield (3950 ft. elevation), where continuous ambient temperature and precipitation data is collected.

2. General site characteristics such as soil type, elevation, aspect, forest types and terrain will be determined using existing records. More specific information will be obtained in the future using Geographic Positioning System (GPS) and on-site characterization.

3. Air trajectory calculations will be made to compare local scale climate and pollution variations with synoptic scale air mass transport.

C. CHEMICAL MEASUREMENTS

1. Air quality monitoring will include: ozone (recorded from April to October), fine particulate matter (PM-2.5)[i.e. mass and chemical composition], course particulate matter (PM-10) [i.e. mass and sulfate].

2. Precipitation chemistry, including pH, major inorganic ions, phosphorus and total volume will be measured weekly and on an event basis.

3. Ambient mercury in precipitation, gas and aerosol phases will be monitored year round, as will atmospheric dry deposition using the NOAA Dry Deposition Inferential Measurement (DDIM).

RESEARCH ACTIVITIES

A detailed VMC Research Plan is under development. Twelve research projects are planned for 1992 that are linked with the VMC. These projects address: characteristics and effects of environmental change and pollutants on forests, local and meso-scale meteorology interpretation, integrated data evaluation, plant and animal biodiversity and biogeography, and improvements in monitoring methods.

In the past there has been extensive research at the PMRC on forest tree physiology, genetics and management, and characteristics of atmospheric chemical deposition. Some of these studies provide important data bases to build future research on. The present VMC research program focuses on characterizing current conditions and relationships in atmospheric and ecological processes in forested ecosystems. This is being accomplished by coordinating and integrating research in multiple fields (air, water, wildlife, forests) to identify: (a) conditions and trends in the physical and chemical environment and the biotic components and processes of ecosystems, and (b) relationships between changes in the environment and changes in ecosystem communities and processes.

The long-term objective of the VMC research program is to improve our understanding of: (a) the structure and function of forested ecosystems as integrated systems and (b) the responses of ecosystem components (trees, stands, wildlife, surface waters, etc.) to specific environmental stresses. Future research efforts will address the role of elevational and climatic gradients on nutrient cycling and biogeography, seasonal variability in foliar chemistry and function, scaling from the leaf to the stand level, and multi-disciplinary data integration and evaluation.

DATA MANAGEMENT AND INTEGRATION

Data analysis for monitoring activities will be done by the group responsible for each monitoring activity. This will maximize the use of preexisting methodologies on appropriate data handling and prevent duplication of efforts between groups analyzing statewide data sets and the VMC.

Although the short-term data management will be accomplished within each monitoring group, a re-evaluation of this method will be made by the Coordination Committee after two years, to discuss the need for a centralized VMC data management system. In the event that a centralized system is favored, steps are being taken to insure that this is possible. In the VMC Monitoring Work Plans, under each specific monitoring activity is listed the type of data management system to be used, the type of output, the location of data files and a contact person to gain access to the data. This will also facilitate data access for use by researchers.

Research data will have restricted access until such time as it is released for general use by them. If the research involves collection of data useful for monitoring purposes, the VMC will encourage the eventual release of the data for use in long-term monitoring. As with monitoring data, an inventory of data management systems, data file contents, location and contact person, will be made periodically on research data to facilitate use by monitoring groups in the future.

One function of the VMC is to facilitate integration of different types of environmental data that might otherwise be incompatible. Towards this end, the VMC has several initiatives that attempt to pull together data into one common system where integration is possible.

The first effort towards data integration was the preparation of a (IBM-PC-Compatible) computerized "data directory" (in dBASE III PLUS), and an associated report entitled **"Status of Ecological Monitoring Data in Vermont"** (Scherbatskoy, 1990). This comprehensive environmental data directory seeks to describe the contents of and means of access to a large number of Mansfield and/or statewide data bases of potential relevance to the condition of the State's forested ecosystems. As such, it is subject to continual upgrade and revision, as new data are collected or "discovered". Efforts are currently underway to explore the feasibility of translating this VMC directory into the standardized NASA/Global Change Directory Interchange Format (DIF).

A second effort towards data integration has collected a number of disparate data sets from assorted environmental media, and is translating these into a common format to facilitate an intercomparison of their spatial, temporal and relational aspects, using the **"Voyager Data Viewing Software"** (Husar et al., 1990).

This demonstration project uses spatially comparable subsets from several environmental data bases: Precipitation Chemistry (NADP); Aerosol Chemistry (NESCAUM); Ozone (NAMS, SLAMS); Climatology (NWS); Aquatic Chemistry (EPA Eastern Lake Survey, VT Long-Term Lake Study); and Forest Condition (NFHM, NAMP). The selected data is being processed as appropriate to facilitate temporal and relational comparability. For example, hourly ozone data is converted into a series of monthly and seasonal indices of "biological relevance", (such as 1 hour maximum, 7 hour seasonal mean, "sum >60 ppb", etc.). These data are compiled in Voyager format which permits a powerful, user-friendly browsing and intercomparison of spatial, temporal and relational data attributes with the Voyager software. There, for example, ozone data can be integrated with other data, such as forest condition or symptomology on ozone sensitive bioindicator plants, to allow for relational interpretations. Anticipated completion date for this demonstration project is September 1992. Results and copies of the shareware Voyager Viewer Program will be distributed to all interested parties. Pending a successful demonstration project, a proposal will be developed to fund a more comprehensive VMC data integration effort.

A third effort towards data access and integration is the development and implementation of a regional computerized data exchange network using ozone and forestry data, with the intent of providing widespread and rapid access to ozone exposure (daily data access) and related effects. This project was initiated in 1991 in coordination with the Northeastern States for Coordinated Air Use Management (NESCAUM).

REPORTING

Once data have been analyzed, the Coordination Committee will review and discuss results, and assist in the preparation of an annual report. Periodically, a more detailed report will be written that will include an integrated assessment of ecosystem conditions and trends. The Monitoring Advisory Committee will review and the appropriate State or University Representative on the Steering Committee will approve all monitoring or research reports, respectively.

GEOGRAPHIC INFORMATION SYSTEM (GIS)

It is the intent of the VMC to make GIS an integral part of the monitoring activities occurring on site. Four basic objectives for it's use are:

1. to facilitate accurate and updated plot locations for planning and spatial comparisons,
2. to see changes within and between plots over time,
3. to make comparisons between forest ecosystem components over time, and
4. to provide a link between information at this site and others in the state or region.

A GIS plan will be developed to detail objectives, methods and utilization. There are five presently operating GIS systems that have information potentially of interest to the Mansfield site: University of Vermont Natural Resources, Vermont Agency of Natural Resources, Lamoille County Regional Planning Commission, Underhill Town and Chittenden County Regional Planning Commission. These groups will be queried to determine what is available and the quality of the data, and based on this, priorities will be established on information needs and how to accomplish them.

BUDGET

The VMC is a cooperative effort, and as such, many of the initial monitoring activities are being covered by existing funds within each of the groups participating. Additional activities and equipment purchases have been made possible through an initial allocation of $ 202,000 through the U.S.D.A. Forest Service, Northeast Forest Experiment Station. It is anticipated that at the completion of the first three years, the VMC will be fully operational and highly competitive for other Federal or Private funds to continue this long-term program.

Since base funding support for VMC projects comes from both VMC and state sources, this emphasizes the priority already placed on environmental and ecological monitoring by the cooperators. State funding is being used to support such activities as: ozone monitoring, acid precipitation monitoring, and forest health condition monitoring. VMC funding has been used to attain baseline data on wildlife (birds, insects and amphibians) that would otherwise have been unavailable from the monitoring site. In addition, some projects are funded jointly by VMC and other sources, such as the data integration demonstration project, which is funded by the VMC and the VT Air Quality Division, in cooperation with the Center for Air Pollution Integration and Trend Analysis (CAPITA).

Funding of VMC activities through special VMC funds adds to the ability of this program to seek out and accomplish additional monitoring activities. Likewise, the depth of pre-existing and on-going monitoring activities greatly augments the capabilities of the VMC to accomplish it's goals and objectives with minimal external support.