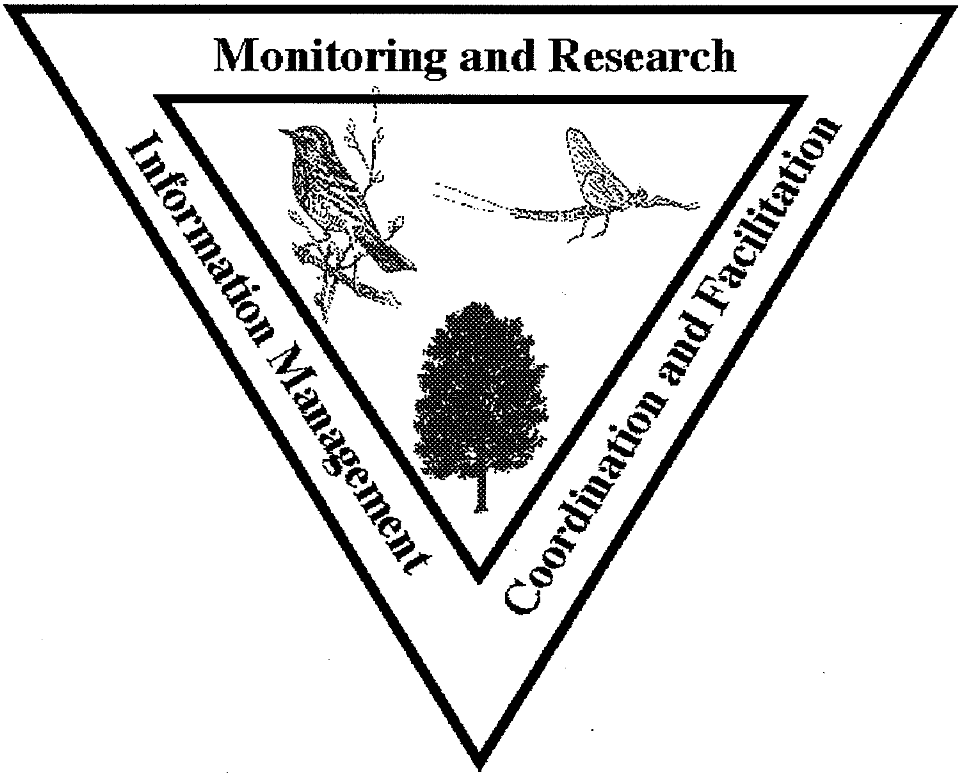
Vermont's Intensive Forest Ecosystem Monitoring and Research Program



Providing the information needed to understand,
manage and protect Vermont's forested ecosystems
within a changing global environment

Administered by:
Vermont Agency of Natural Resources - University of Vermont - Green Mountain National Forest

Vermont
Monitoring
Cooperative

1997 Annual Report

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Vermont Monitoring Cooperative

Annual Report for 1997

Sandra Wilmot, Timothy Scherbatskoy,
Judy Rosovsky and Phil Girton

(Editors)

The VMC is Vermont's Cooperative Monitoring and Research Program, administered by the Vermont Agency of Natural Resources, the University of Vermont, and the Green Mountain National Forest.

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

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Introduction

The purpose of the Vermont Monitoring Cooperative (VMC) Annual Report is to provide annual documentation of results from studies conducted at the two VMC sites at Mount Mansfield and the Lye Brook Area. Cooperating scientists working at the two study sites are invited to submit their findings (preliminary or otherwise) for the year in a form that is easily understood by non-experts with an interest in forested ecosystems. A broader goal of this publication is to stimulate further exchange of information and ideas that expand our understanding of forest ecosystems, and that these scientific conclusions aid in more ecologically based natural resource management.

This document begins with an overview of program highlights for 1997, then proceeds to specific study results. Results are organized by the type of information collected (atmospheric, flora, etc.), and includes studies conducted at Mount Mansfield and the Lye Brook Wilderness Area.

Programmatic Highlights

- In 1997, the VMC continued steps to shift from a publicly supported program administered by the Agency of Natural Resources, the University of Vermont, and the Green Mountain National Forest, to becoming incorporated as a non-profit organization. We became incorporated by the Secretary of States office but not before having to change our name to the Vermont Forest Ecosystem Monitoring program. Our current Steering Committee became the Board of Directors, and we began submitting grant proposals to private foundations to support ongoing monitoring projects. Federal and State support for the program was minimal, and many studies were scaled back or discontinued.

- Funding threatened operations of the Mansfield wet deposition monitoring station in the National Atmospheric Deposition Program (NADP), as the program shifted funding agencies. Support letters from VMC Cooperators, State Agencies and our Congressional staff helped secure this site within the national network.

- The Annual Cooperators meeting theme for 1997 was "Resource Management in the 21st Century – Applications for Research and Monitoring". Natural resource management challenges were presented to stimulate research in support of ecologically based management for the future.

- The VMC Information Services team, working with the Department of Forests, Parks and Recreation, developed a web site to provide internet access to forest pest information and experts. The web site will be hosted by the US Forest Service.

- A group of scientists from Vermont, Massachusetts and New York formed a Taconics Research Consortium to meet periodically to discuss information about this region. VMC met with the group to offer assistance in data and information management options.

- VMC was featured in the Vermont Quarterly Magazine with an article titled "Monitoring the Mountain: Cooperation Key to Mansfield Research". Other articles featuring VMC results included an article in the Christian Science Monitor (September 25) "Why Northeast Forests Don't Pass the Acid Test" and a Times Union (Albany newspaper) article on fall color monitoring at Mount Mansfield.

- VMC supported the development of a new web site with the purpose of providing a forum for atmospheric data and information sharing within the northeast region. The NEARDAT site has featured ongoing VMC projects, such as the air trajectory climatology work.

- A new proposal has been submitted to the Agency of Natural Resources by the Stowe Mountain Resort to build a water pipeline from the Waterbury Reservoir, through Ranch Valley to the ski area for snow making purposes. This would reduce the impacts of water withdrawal from local streams by the ski area under its current practice. Running the pipeline through the VMC research area in Ranch Valley would alter the areas current designation as "minimally disturbed". The decision making process is expected to take several years. In addition to the pipeline proposal, the Department of Forests, Parks and Recreation was considering installing a State Park in Ranch Valley as part of the State-Stowe Mountain Resort land swap agreement. Under this agreement, the Smugglers Notch State Park would need to be relocated. Ranch Valley was later rejected as a possible State Park site due to conflicts with critical bear habitat.

- The Department of Forests, Parks and Recreation began the process of developing a 5-year Forest Resource Plan. VMC participated on the Ecosystem Workgroup Committee. In the Plan, VMC is expected to play a major role in forest ecosystem research in Vermont.

Atmospheric

Meteorological Conditions at VMC Sites in 1997

Judy Rosovsky, Tim Scherbatskoy and Carl Waite
VMC and School Of Natural Resources, University Of Vermont

Cooperators:

UVM Proctor Maple Research Center (PMRC), VT Department of Environmental Conservation (DEC), WCAX-TV staff at Mt. Mansfield transmitter station, US Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), Lake Champlain Research Consortium (LCRC) and National Weather Service (NWS).

Introduction:

Continuous monitoring of basic meteorological variables continued in 1997 at several VMC sites. Hourly meteorology data from Proctor Maple Research Center (PMRC) are available from 1988 to present, and daily temperature and precipitation data from the summit of Mt. Mansfield (1205 m) are available from 1954 to present. These two stations provide the longest records of meteorological data in close proximity to the VMC's Mt. Mansfield Study Area.

This report is based on data from the PMRC air quality monitoring station (PMRC AQ, 400 m), established in 1988; the VMC meteorological stations on the west side of Mt. Mansfield (MMWest, 880 m); Colchester Reef (CR, 38 m), established in 1996; and from the Clean Air Status and Trends Network (CASTNET) in the Lye Brook Wilderness Area. The principle purpose of the these stations are to provide high-quality, continuous, and long-term records of basic meteorological variables to VMC cooperators, other researchers, and other interested user groups.

Other sources of meteorological data not included in the report, but available through the VMC data library, include within-forest meteorological data from the forest canopy tower at PMRC and Nettle Brook. The VMC has access to National Weather Service (NWS) data, via the National Climate Data Center (NCDC). The VMC archives data from 45 currently active cooperative observer stations in Vermont, including the Mount Mansfield summit station. Data are available in Excel, Lotus, ASCII and other formats by request from the VMC data manager.

Methods:

Campbell CR10X dataloggers are used to log either hourly (PMRC AQ) or 15 minute average (MMWest; CR) values for each parameter at each site. These three stations are remotely linked to the VMC server via telephone modem (PMRC AQ) or radio (MMWest; CR). CASTNET data are downloaded from the Environmental Protection Agency web site annually. Data files are continuously updated and are screened according to established QA/QC protocols. The meteorological stations are supervised by Tim Scherbatskoy and operated by Miriam Pendleton, Richard Furbush, and Carl Waite.

Variables collected at VMC sites:

	VMC Site			
	CASTNET	**Colchester Reef**	**Mount Mansfield (W)**	**PMRC**
Start Of Data Collection:	January 1994	November 1996	January 1997	January 1988
Variables Collected:	Air Temperature	Air Temperature	Air Temperature	Air Temperature
	Relative Humidity	Relative Humidity	Relative Humidity	Relative Humidity
	Wind Speed	Wind Speed	Wind Speed	Wind Speed
	Wind Direction	Wind Direction	Wind Direction	Wind Direction
	Precipitation		Precipitation	Precipitation
		Barometric Pressure		Barometric Pressure
		Water Temperature		
	Solar Radiation	Solar Radiation	Solar Radiation	
			Photosynthetically Active Radiation (PAR)	

The criteria for data completeness are as follows: each hour must include a minimum of one 15 minute interval data set and each day must have at least 75% of the hourly data. Number of days in the month are reported in Table 2. Data for MMWest in September 1997 has been excluded from this report due to lack of completeness.

Data are reported in a variety of temporal formats. Fifteen minute average data (from MMWest, CR and CASTNET) are arithmetically averaged to provide hourly means, which are then averaged into daily means. Monthly and yearly summaries are created from daily data. A number of summary statistics including means, maximum and minimum values, and number of observations are generated. Growing degree days are calculated by adding the degrees above freezing for a given day to the next day's above freezing value. Days when temperature does not go above freezing are given a value of zero.

Results and Discussion:

Yearly and monthly 1997 data summaries for each of the sites are presented in Tables 1 and 2, respectively. Variables (mean air temperature, mean relative humidity, mean barometric pressure, mean total solar irradiance (pyranometer), and mean resultant wind speed) are summarized by month and displayed for site to site comparison (Figure 1); note that Y-axis scales vary. Figure 2 shows a comparison of several meteorological variables at individual sites.

Daily total precipitation by month for PMRC AQ is summarized in Figure 3; note that the Y-axis scale has been standardized to facilitate comparisons across time. Daily mean, minimum, and maximum temperatures at PMRC AQ are shown by month in Figure 4. Please note that the X-axis crosses the Y-axis at 0 degrees Celsius and the Y-axis scale is standardized for ease of comparison.

Cumulative growing degree days are based on start temperatures of 32 and 50 degrees Fahrenheit, temperature thresholds for plants and insects, respectively, and are plotted together in Figure 5.

The Northeast Regional Climate Center reported that in 1997 overall regional temperatures produced a warm winter and cold spring. Most of the northeast was dry, but Vermont was not, with flooding occurring in Montgomery in July 1997.

Two excellent resources for meteorological information are the VT Climatology web site, *www.uvm.edu/~ldupigny/sc/,* and the Northeast Regional Climate Center (NRCC). NRCC provides interpretive monthly climate summaries and can be accessed via *www.nws.noaa.gov/.*

Table 1: VMC Yearly Data Comparisons For 1997

Site							*Wind Speed:*			*Wind Direction:*	
	Air Temp	*H2O Temp*	*Barom Press*	*Rel Humd*	*Precip*	*Pyranom*	*Max*	*Mean Resultant*	*Mean Horizontal*	*Mean Resultant*	*Std Dev*
	degrees C		*mb*	*%*	*mm*	*watts/m^2*		*m/second*		*degrees*	
ColchReef											
Mean	7.50	15.00	1010.87	73.07		121		6.25	6.00	201.00	8.00
Max	30.29	24	1039	102.6		953	25.00	21.05	21.00	360.00	78.00
Min	-21.15	-1	980	20.77		0	0.00	0.00	0.00	0.00	0.00
N	353	353	353	353		353	353	353	353	353	353
Sum											
LYE145											
Mean	4.64			76.40	0.13			2.72	3.00	211.00	26.00
Max	26.8			100	21.25			21.25	21.00	360.00	90.00
Min	-26.5			6.45	0			0.03	0.00	0.00	0.00
N	355			355	355			355	355	355	355
Sum					1118.52						
PMRC AQ											
Mean	6.64		948.84	63.60	2.70			1.90			
Max	28.1		978	99.6	9.70			7.50			
Min	-36.2		930	20	0			0.00			
N	321		321	321	321			321			
Sum					867.20						
West2900											
Mean	2.53			80.79	9.49	93		0.77	1.00	206.00	
Max	26.82			57.35	10.00	1140	12.00	8.50	9.00	360.00	
Min	-30.01			20.11	0	0	0.00	0.00	0.00	0.00	
N	300			300	300	300	300	300	300	300	
Sum					1006.00						

Table 2: VMC Meteorological Monthly Data Comparisons For 1997

Site							*Wind Speed:*		*Wind Direction:*	
Month	*Air Temp*	*H2O Temp*	*Barom Press*	*Rel Humd*	*Precip*	*Pyranom*	*Max*	*Mean Resultant*	*Mean Resultant*	*StDev*
	degrees C		*mb*	*%*	*mm*	*watts/m ^{2}*	*m/second*		*degrees*	
ColchReef										
Jan										
Mean	-5.88		1011.11	71.18		47.783		8.55	206.40	8.62
Max	9.81		1039	100.7		523.7	23.2	21.05	359.20	76.20
Min	-21.15		983	29.6		0	0.83	0.08	0.46	1.64
N	31	31	31	31		31	31	31	31	31
Sum										
Feb										
Mean	-3.34		1016.35	72.20		80.449		7.18	176.82	7.17
Max	10.36		1039	102		672.3	21.5	19.25	359.80	72.60
Min	-17.96		989	36.15		0	0.76	0.13	0.01	1.21
N	28	28	28	28		28	28	28	28	28
Sum										
Mar										
Mean	-1.75		1012.42	69.54		117.18		7.24	194.13	7.14
Max	12.54		1037	102.2		760	23.6	21.01	359.90	75.50
Min	-14.83		987	32.44		0	0.55	0.09	0.04	0.86
N	31	31	31	31		31	31	31	31	31
Sum										
Apr										
Mean	4.86		1009.07	65.75		143.91		5.77	186.97	7.12
Max	19.61		1024	102.6		892	17.7	15.04	359.90	72.90
Min	-9.57		993	20.77		0	0.29	0.02	0.11	0.27
N	29	29	29	29		29	29	29	29	29
Sum										
May										
Mean	9.86	5.45	1007.72	67.58		166.91		5.98	223.07	7.26
Max	20.94	14	1026	100.8		905	16.5	14.88	360.00	73.30
Min	2.61	1.86	988	27.34		0	0.3	0.06	0.16	0.76
N	29	29	29	29		29	29	29	29	29
Sum										

Site							*Wind Speed:*		*Wind Direction:*	
Month	*Air Temp*	*H2O Temp*	***Barom Press***	*Rel Humd*	*Precip*	*Pyranom*	*Max*	*Mean Resultant*	*Mean Resultant*	*StDev*
	degrees C		*mb*	*%*	*mm*	*watts/m* ^{2}	*m/second*		*degrees*	
ColchReef										
Jun										
Mean	18.63	16.3	1010.48	71.47		227.1		4.72	215.77	7.20
Max	29.84	20.2	1020	102.5		953	19.7	15.03	359.90	71.00
Min	10.47	10.1	994	26.26		0	0	0.00	0.00	0.00
N	30	30	30	30		30	30	30	30	30
Sum										
Jul										
Mean	20.52	20	1010.31	73.39		198.31		5.11	215.47	7.04
Max	29.33	24	1022	102.3		883	17.5	13.31	359.90	74.00
Min	13.45	10.9	994	32.14		0	0.27	0.01	0.28	0.97
N	31	31	31	31		31	31	31	31	31
Sum										
Aug										
Mean	19.72	20.8	1011.50	76.62		172.18		4.73	189.63	7.84
Max	30.29	23.3	1022	100.3		810	19.5	15.70	359.90	76.50
Min	13.77	19.0	998	34.94		0	0.28	0.04	0.21	0.92
N	31	31	31	31		31	31	31	31	31
Sum										
Sep										
Mean	16.37	18.0	1010.24	80.15		115.92		6.31	214.43	6.47
Max	25.23	22.2	1020	101		692.7	17.6	13.45	360.00	60.60
Min	7.55	13.3	980	38.95		0	0.47	0.13	0.32	0.95
N	26	26	26	26		26	26	26	26	26
Sum										
Oct										
Mean	9.25	12.5	1014.51	73.52		94.519		5.94	201.04	7.93
Max	22.84	14.4	1027	99.1		535	16.1	14.28	359.80	78.40
Min	0.217	10.2	991	31.21		0	0.57	0.04	0.11	0.93
N	29	29	29	29		29	29	29	29	29
Sum										

Site							*Wind Speed:*		*Wind Direction:*	
Month	*Air Temp*	*H2O Temp*	*Barom Press*	*Rel Humd*	*Precip*	*Pyranom*	*Max*	*Mean Resultant*	*Mean Resultant*	*StDev*
	degrees C		*mb*	*%*	*mm*	*watts/m ^{2}*	*m/second*		*degrees*	
ColchReef										
Nov										
Mean	3.35	8.7	1009.59	77.92		48.386		6.82	204.74	7.89
Max	16.55	10.7	1029	102.1		411.5	20.0	18.53	360.00	73.30
Min	-6.87	6.43	985	42.9		0	0.7	0.10	0.24	1.36
N	27	27	27	27		27	27	27	27	27
Sum										
Dec										
Mean	-1.31	2.04	1007.32	78.35		33.49		6.69	189.64	8.26
Max	6.722	6.65	1029	101.8		382.7	25.1	17.10	359.80	62.92
Min	-16.87	-1	980	40.44		0	0.83	0.32	0.02	1.97
N	31	31	31	31		31	31	31	31	31
Sum										
LYE145										
Jan										
Mean	-8.65			79.07	0.05	39.405		3.89	222.75	22.16
Max	9.1			99.65	3.302	480.22		354.42	10.00	69.00
Min	-26.5			20.75	0	0.698		0.65	2.88	0.00
N	31			31	31	31		31	31	31
Sum					38.61					
Feb										
Mean	-4.48			76.41	0.06	76.289		3.32	219.62	22.34
Max	12.5			99.55	3.81	653.33		360.00	7.90	72.00
Min	-19.6			30.15	0	0		0.13	0.90	0.00
N	28			28	28	28		28	28	28
Sum					40.89					
Mar										
Mean	-3.79			75.36	0.09	103.53		3.39	221.78	24.11
Max	13.6			99.95	6.35	804.1		356.94	8.65	80.00
Min	-18.2			27.75	0	0.698		0.15	2.88	0.00
N	31			31	31	31		31	31	31
Sum					64.52					

Site							*Wind Speed:*		*Wind Direction:*	
Month	*Air Temp*	*H2O Temp*	*Barom Press*	*Rel Humd*	*Precip*	*Pyranom*	*Max*	*Mean Resultant*	*Mean Resultant*	*StDev*
	degrees C		*mb*	*%*	*mm*	*watts/m ^{2}*	*m/second*		*degrees*	
LYE145										
Apr										
Mean	3.42			64.40	0.13	191.98		2.87	217.80	26.72
Max	19.65			99.65	9.388	907.4		359.28	9.75	78.62
Min	-13.65			21.2	0	0.698		0.53	0.90	4.52
N	30			30	30	30		30	30	30
Sum					96.26					
May										
Mean	8.16			69.67	0.34	173.49		3.30	217.33	24.13
Max	21.25			99.65	21.25	1020.5		358.92	21.25	62.73
Min	-1.7			6.45	0	0		0.38	0.00	0.00
N	31			31	31	31		31	31	31
Sum					250.2					
Jun										
Mean	16.62			69.68	0.08	236.17		2.23	184.46	30.76
Max	26.8			100	20.07	949.28		359.82	17.85	74.47
Min	6.45			17.85	0	0		0.48	0.90	4.89
N	30			30	30	30		30	30	30
Sum					57.98					
Jul										
Mean	17.10			76.58	0.17	227.32		2.02	205.02	31.05
Max	26.55			100	17.78	996.74		359.28	5.08	70.92
Min	7.95			40.35	0	0		0.60	3.96	0.00
N	31			31	31	31		31	31	31
Sum					125.5					
Aug										
Mean	15.78			80.57	0.23	182.67		2.03	187.80	30.87
Max	26.45			100	16.8	850.86		359.28	16.50	69.21
Min	8.11			16.5	0	0		0.53	0.90	5.87
N	31			31	31	31		31	31	31
Sum					166.1					

Site							*Wind Speed:*		*Wind Direction:*	
Month	*Air Temp*	*H2O Temp*	*Barom Press*	*Rel Humd*	*Precip*	*Pyranom*	*Max*	*Mean Resultant*	*Mean Resultant*	*StDev*
	degrees C		*mb*	*%*	*mm*	*watts/m* ^{2}	*m/second*		*degrees*	
PMRC AQ										
Feb										
Mean	-3.72		951.39	61.19	1.63			2.34	197.88	27.39
Max	13.9		978	90.1	6.9			6.70	360.00	69.20
Min	-21.1		930	20.4	0			0.20	0.00	12.50
N	20		20	20	20			20	20	20
Sum					32.5					
Mar										
Mean	-0.26		960.34	59.78	2.34			2.30	196.75	27.68
Max	13.7		978	99.1	2.5			5.80	360.00	69.40
Min	-14.7		938	20	0			0.10	0.00	7.50
N	16		16	16	16			16	16	16
Sum					37.5					
Apr										
Mean	4.05			47.16	2.60			2.27	195.94	27.47
Max	19.7			98.2	4.8			6.60	360.00	77.60
Min	-13.6			20.2	0			0.20	0.00	7.50
N	30		30	30	30			30	30	30
Sum					78					
May										
Mean	7.69			60.69	4.10			2.59	224.11	28.29
Max	17.4			97.7	8.6			7.30	360.00	81.20
Min	-1.8			20.8	0			0.10	0.00	8.30
N	26		26	26	26			26	26	26
Sum					106.7					
Jun										
Mean	18.34		947.88	55.46	2.20			1.54	183.13	33.65
Max	28.1		957	90.5	9.4			6.40	359.00	80.60
Min	6.2		933	24.3	0			0.00	1.00	2.70
N	28		28	28	28			28	28	28
Sum					61.6					

Site							*Wind Speed:*		*Wind Direction:*	
Month	*Air Temp*	*H2O Temp*	*Barom Press*	*Rel Humd*	*Precip*	*Pyranom*	*Max*	*Mean Resultant*	*Mean Resultant*	*StDev*
	degrees C		*mb*	*%*	*mm*	*watts/m ^{2}*	*m/second*		*degrees*	
PMRC AQ										
Jul										
Mean	18.25		948.11	65.08	3.51			1.47	180.20	33.53
Max	27.6		958	99.6	9.7			3.90	360.00	82.60
Min	9.1		932	21.4	0			0.00	0.00	4.10
N	31		31	31	31			31	31	31
Sum					108.7					
Aug										
Mean	16.90		949.12	69.16	3.41			1.40	171.12	33.91
Max	27.7		958	99.6	7.4			4.60	360.00	83.40
Min	9.2		940	34.3	0			0.10	0.00	3.80
N	31		31	31	31			31	31	31
Sum					105.8					
Sep										
Mean	12.81		948.06	75.48	3.63			1.61	175.81	36.06
Max	23.6		957	96.1	6.9			4.70	360.00	78.90
Min	1.4		930	20.3	0			0.10	0.00	4.70
N	30		30	30	30			30	30	30
Sum					108.8					
Oct										
Mean	7.32		950.66	61.50	1.97			1.72	183.66	31.38
Max	23.1		962	98.8	4.6			5.90	360.00	72.90
Min	-4.5		930	20.8	0			0.10	0.00	6.40
N	31		31	31	31			31	31	31
Sum					61					
Nov										
Mean	0.33		946.46	72.18	3.17			1.82	201.59	29.65
Max	15.6		964	96.4	6.9			5.90	360.00	81.10
Min	-11.8		930	35	0			0.00	0.00	7.00
N	29		29	29	29			29	29	29
Sum					92					

Site Month							Wind Speed:		Wind Direction:	
	Air Temp	H2O Temp	Barom Press	Rel Humd	Precip	Pyranom	Max	Mean Resultant	Mean Resultant	StDev
	degrees C		mb	%	mm	watts/m ^{2}	m/second		degrees	
PMRC AQ										
Jul										
Mean	18.25		948.11	65.08	3.51			1.47	180.20	33.53
Max	27.6		958	99.6	9.7			3.90	360.00	82.60
Min	9.1		932	21.4	0			0.00	0.00	4.10
N	31		31	31	31			31	31	31
Sum					108.7					
Aug										
Mean	16.90		949.12	69.16	3.41			1.40	171.12	33.91
Max	27.7		958	99.6	7.4			4.60	360.00	83.40
Min	9.2		940	34.3	0			0.10	0.00	3.80
N	31		31	31	31			31	31	31
Sum					105.8					
Sep										
Mean	12.81		948.06	75.48	3.63			1.61	175.81	36.06
Max	23.6		957	96.1	6.9			4.70	360.00	78.90
Min	1.4		930	20.3	0			0.10	0.00	4.70
N	30		30	30	30			30	30	30
Sum					108.8					
Oct										
Mean	7.32		950.66	61.50	1.97			1.72	183.66	31.38
Max	23.1		962	98.8	4.6			5.90	360.00	72.90
Min	-4.5		930	20.8	0			0.10	0.00	6.40
N	31		31	31	31			31	31	31
Sum					61					
Nov										
Mean	0.33		946.46	72.18	3.17			1.82	201.59	29.65
Max	15.6		964	96.4	6.9			5.90	360.00	81.10
Min	-11.8		930	35	0			0.00	0.00	7.00
N	29		29	29	29			29	29	29
Sum					92					

Site *Month*	*Air Temp*	*H2O Temp*	*Barom Press*	*Rel Humd*	*Precip*	*Pyranom*	*Wind Speed:* *Max*	*Wind Speed:* *Mean Resultant*	*Wind Direction:* *Mean Resultant*	*Wind Direction:* *StDev*
	degrees C		*mb*	*%*	*mm*	*watts/m* ^{2}	*m/second*		*degrees*	
PMRC AQ										
Dec										
Mean	-4.28		943.47	73.07	1.94			1.74	192.65	28.61
Max	7.2		961	98.6	4.3			6.00	360.00	80.60
Min	-21.6		930	27.7	0			0.10	1.00	9.00
N	31		31	31	31			31	31	31
Sum					60.1					
West2900										
Jan										
Mean	-10.88			87.70		17.715		1.04	215.05	37.81
Max	8.35			101.5		234.9	12.1	8.50	360.00	80.20
Min	-30.01			20.44		0	0	0.00	0.00	0.00
N	31			31	31	31	31	31	31	31
Sum										
Feb										
Mean	-7.05			84.29		30.734		0.75	242.62	40.00
Max	11.11			101.4		528	8.64	6.08	360.00	80.60
Min	-24.19			25.45		0	0	0.00	0.00	0.00
N	27			27	27	27	27	27	27	27
Sum										
Mar										
Mean	-5.83			81.49		72.658		0.98	227.22	39.10
Max	12.73			101.9		802	9.13	5.10	360.00	79.70
Min	-21.12			21.77		0	0.22	0.01	0.28	2.43
N	30			30	30	30	30	30	30	30
Sum										
Apr										
Mean	0.41			66.89		150.47		0.81	207.60	39.00
Max	15.63			101.9		1086	6.54	4.48	359.90	80.30
Min	-18.14			20.26		0	0	0.00	0.00	0.00
N	30			30	30	30	30	30	30	30
Sum										

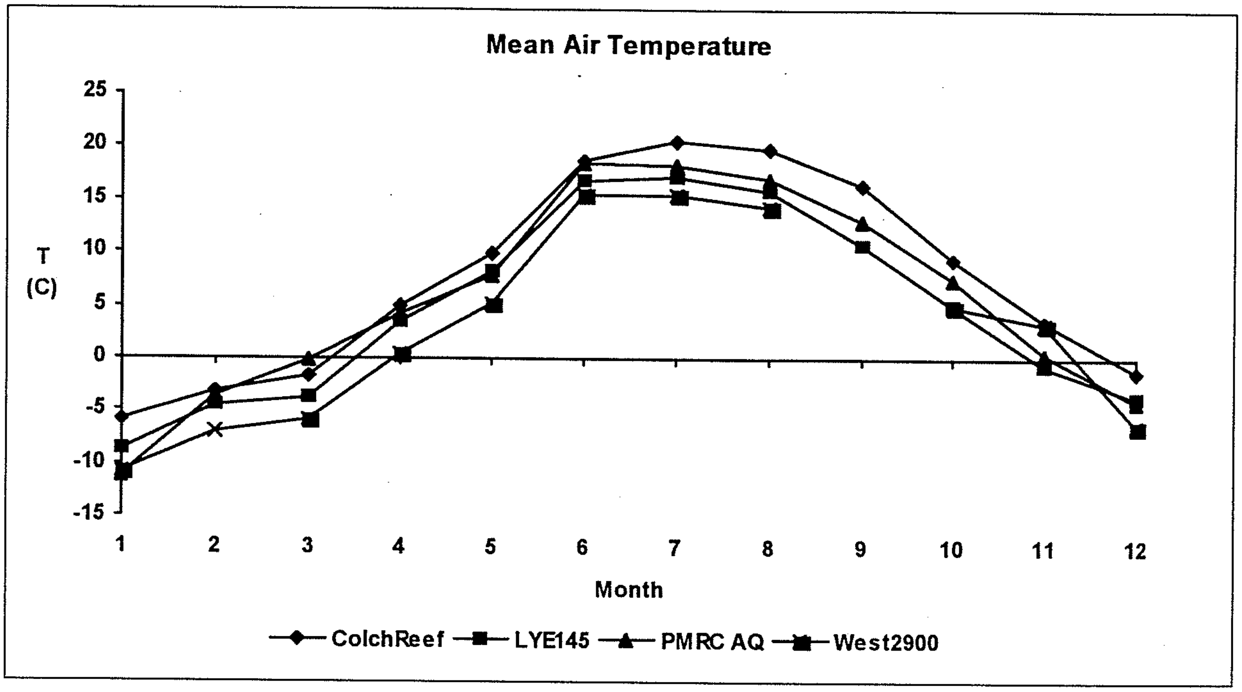
Site							Wind Speed:		Wind Direction:	
Month	Air Temp	H2O Temp	Barom Press	Rel Humd	Precip	Pyranom	Max	Mean Resultant	Mean Resultant	StDev
	degrees C		mb	%	mm	watts/m^2	m/second		degrees	
West2900										
May										
Mean	5.03			77.34		115.35		1.00	234.79	37.03
Max	20.45			101.9		1071	10.3	7.26	359.80	80.60
Min	-5.44			20.11		0	0	0.00	0.00	0.00
N	31			31	31	31	31	31	31	31
Sum										
Jun										
Mean	15.26			70.65	4.11	200.34		0.70	204.50	32.42
Max	26.82			101.5	6.4	1110	4.07	2.68	359.50	80.70
Min	0.79			24.26	0	0	0.15	0.00	0.11	1.07
N	30			30	30	30	30	30	30	30
Sum					61.6					
Jul										
Mean	15.38			82.62	4.57	159.32		0.53	195.41	32.12
Max	26.24			101.9	7.1	1140	3.44	2.12	359.70	80.80
Min	6.07			41.21	0	0	0	0.00	0.00	0.00
N	31			31	31	31	31	31	31	31
Sum					141.7					
Aug										
Mean	14.22			85.91	5.13	124.31		0.56	188.45	31.44
Max	25.01			102.1	7	1077	4.53	2.69	359.90	80.00
Min	7.52			48.37	0	0	0.18	0.01	0.01	0.00
N	28			28	28	28	28	28	28	28
Sum					143.7					
Oct										
Mean	4.82			79.04		48.938		0.74	194.32	36.90
Max	20.93			102.5		1124	8.32	5.49	360.00	80.70
Min	-8.65			20.96	0	0	0.15	0.00	0.01	1.43
N	27			27	27	27	27	27	27	27
Sum										

Site							Wind Speed:		Wind Direction:	
Month	Air Temp	H2O Temp	Barom Press	Rel Humd	Precip	Pyranom	Max	Mean Resultant	Mean Resultant	StDev
	degrees C		mb	%	mm	watts/m ^{2}	m/second		degrees	
West2900										
Nov										
Mean	3.13			81.43		43.855		0.77	142.65	29.21
Max	9.05			103.2		905	4.95	4.09	360.00	78.30
Min	-1.21			41.74	0	0	0	0.00	0.00	0.00
N	6			6	6	6	6	6	6	6
Sum										
Dec										
Mean	-6.53			92.56		5.6079		0.58	164.90	26.46
Max	3.687			103.1		253	8.64	6.20	359.90	77.70
Min	-25.25			26.68	0	0	0	0.00	0.00	0.00
N	29			29	29	29	29	29	29	29
Sum										

Table 3. PMRC Meteorological Data

	Monthly							*Long Term Average*						
	Precipitation (inches)		*Air Temperature (F)*			*Cum GDD*		*Precipitation (inches)*		*Air Temperature (F)*			*Cum GDD*	
				Absolute							*Absolute*			
Month	*Mean*	*Sum*	*Mean*	*Max*	*Min*	*32F*	*50F*	*Mean*	*Sum*	*Mean*	*Max*	*Min*	*32F*	*50F*
January	0.03	0.58	11.71	42.98	-33.16	3.15	0.00	0.10	2.99	19.41	62.78	-24.52	39.52	2.76
February	0.07	1.30	25.31	57.02	-5.98	38.79	0.00	0.07	1.85	21.94	60.28	-19.12	72.41	3.65
March	0.09	1.50	31.53	56.66	5.54	99.97	1.98	0.09	2.66	30.63	77.90	-9.58	180.33	8.39
April	0.10	3.12	39.30	67.46	7.52	361.15	14.31	0.13	3.91	41.02	73.76	7.52	458.37	30.58
May	0.16	4.27	45.85	63.32	28.76	720.43	29.25	0.14	4.10	53.73	83.89	28.76	1129.18	199.53
June	0.09	2.46	65.01	82.58	43.16	1822.29	501.11	0.12	3.54	62.09	89.24	20.84	2017.24	560.21
July	0.14	4.35	64.86	81.68	48.38	2848.65	969.47	0.15	4.80	65.68	89.78	44.42	3125.99	1082.16
August	0.14	4.23	62.42	81.86	48.56	3808.05	1370.87	0.12	3.71	63.78	84.74	28.94	4104.53	1514.96
September	0.15	4.35	55.06	74.48	34.52	4505.19	1565.09	0.16	4.81	57.06	89.01	4.28	4860.82	1786.66
October	0.08	2.44	45.17	73.58	23.90	4917.12	1639.79	0.12	3.58	45.02	73.58	22.04	5265.52	1826.36
November	0.13	3.68	32.60	60.08	10.76	5042.67	1645.37	0.10	2.98	34.95	66.56	0.68	5426.36	1834.65
December	0.08	2.40	24.30	44.96	-6.88	5057.16	1645.37	0.07	2.23	26.37	62.20	-22.72	5481.54	1834.90

Figure 1: Meteorological Variables Summarized By Month At VMC Sites



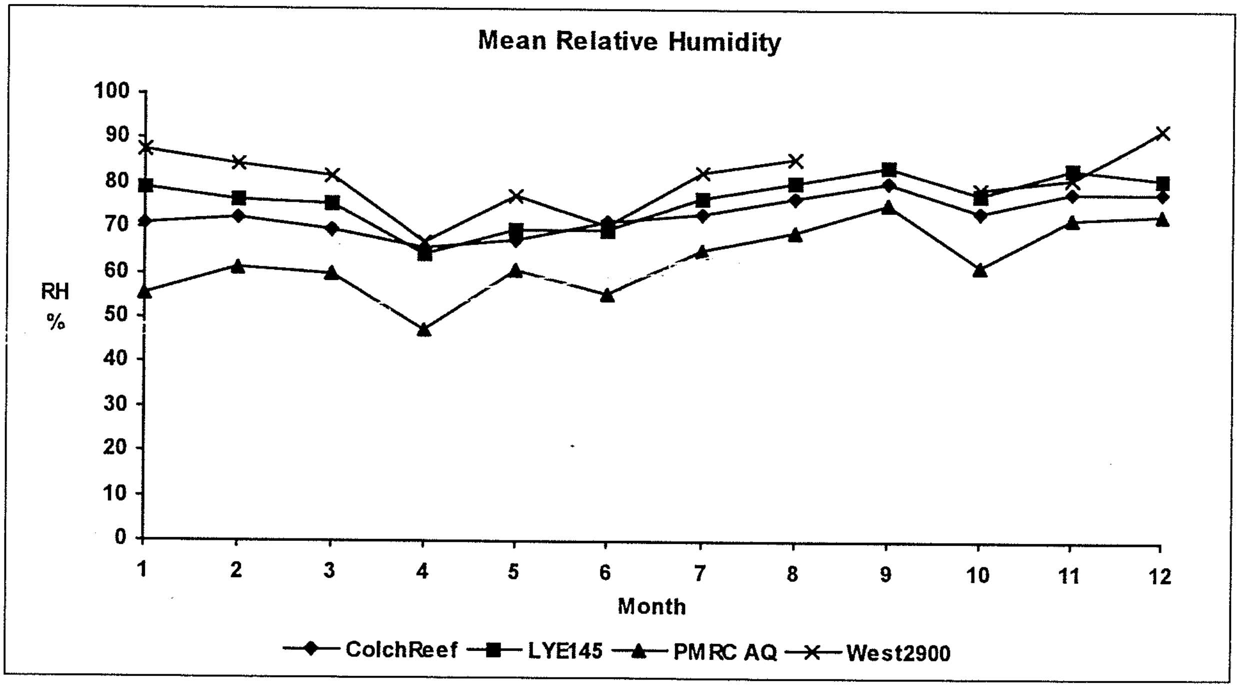
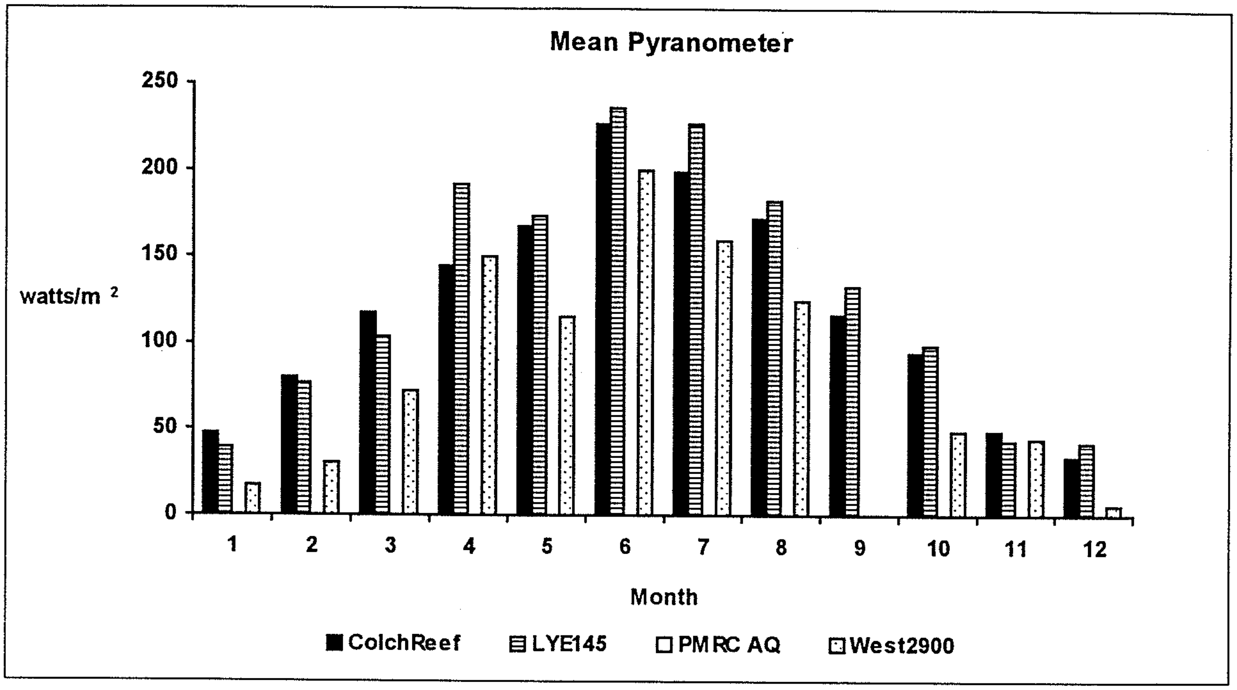


Figure 1: Meteorological Variables Summarized By Month At VMC Sites



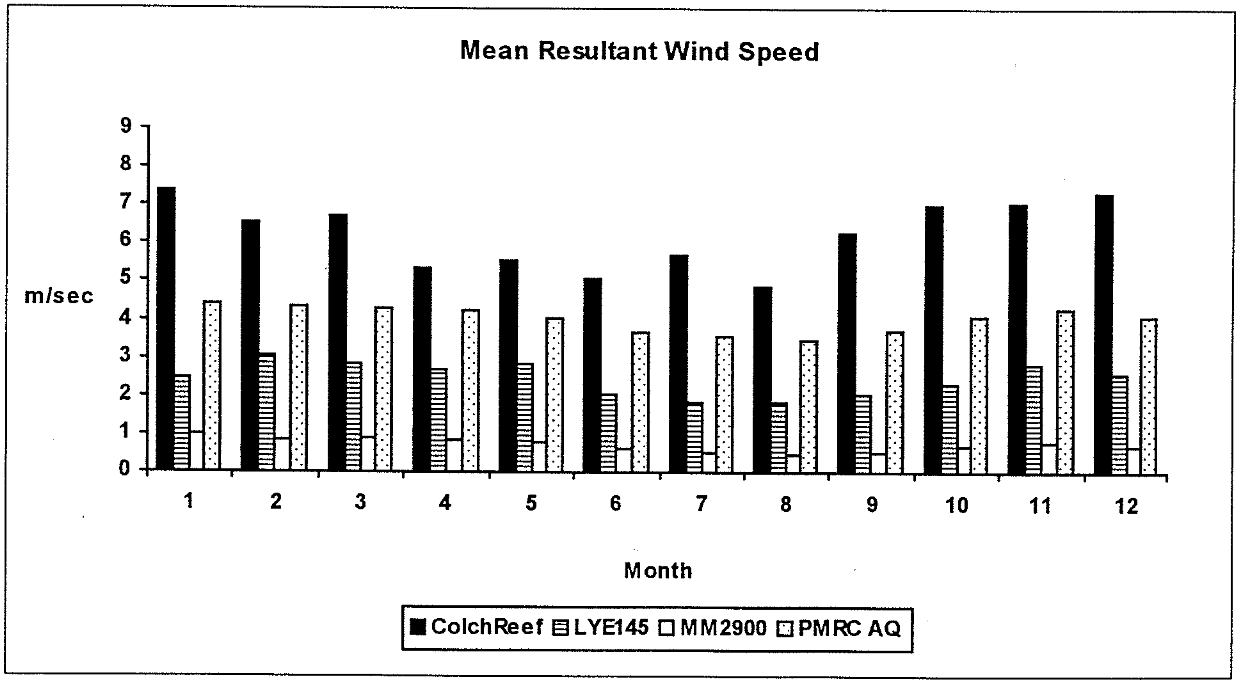


Figure 1: Meteorological Variables Summarized By Month At VMC Sites

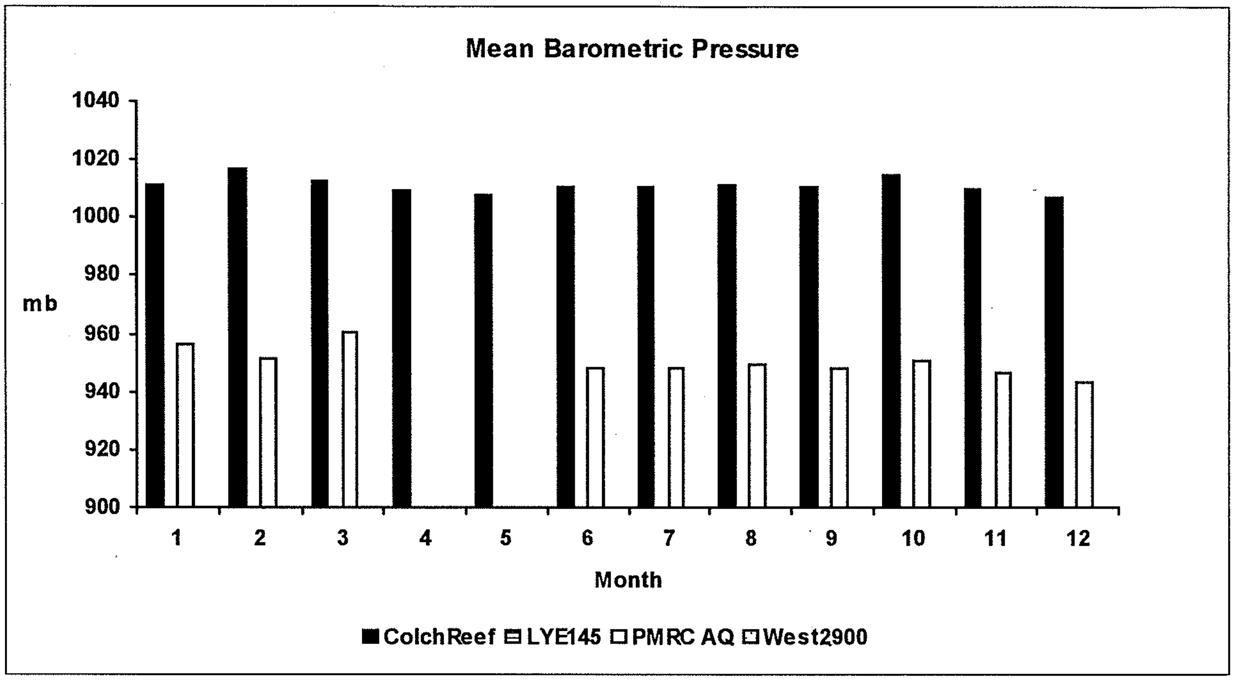
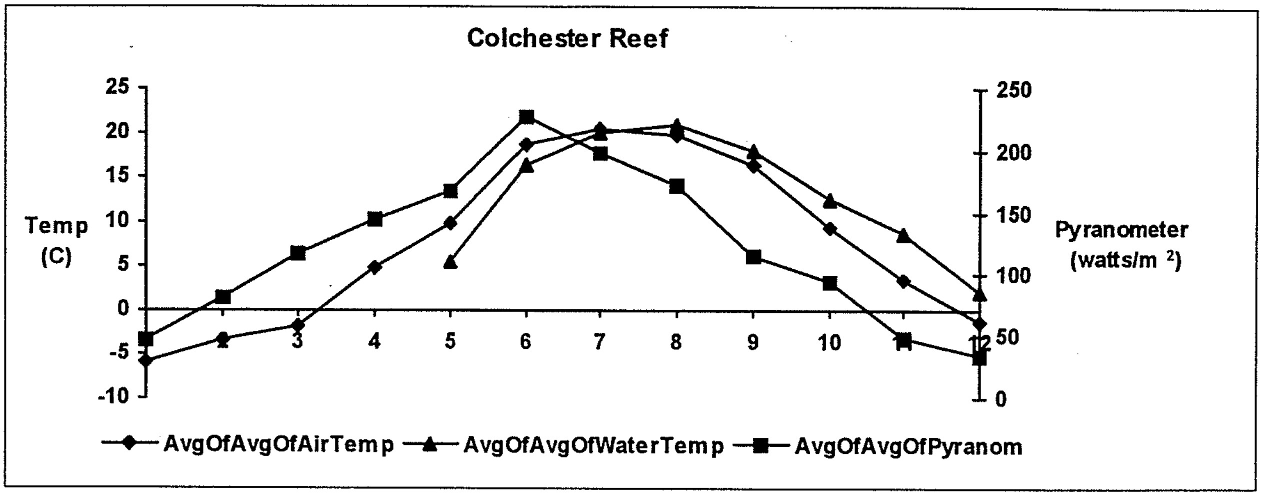
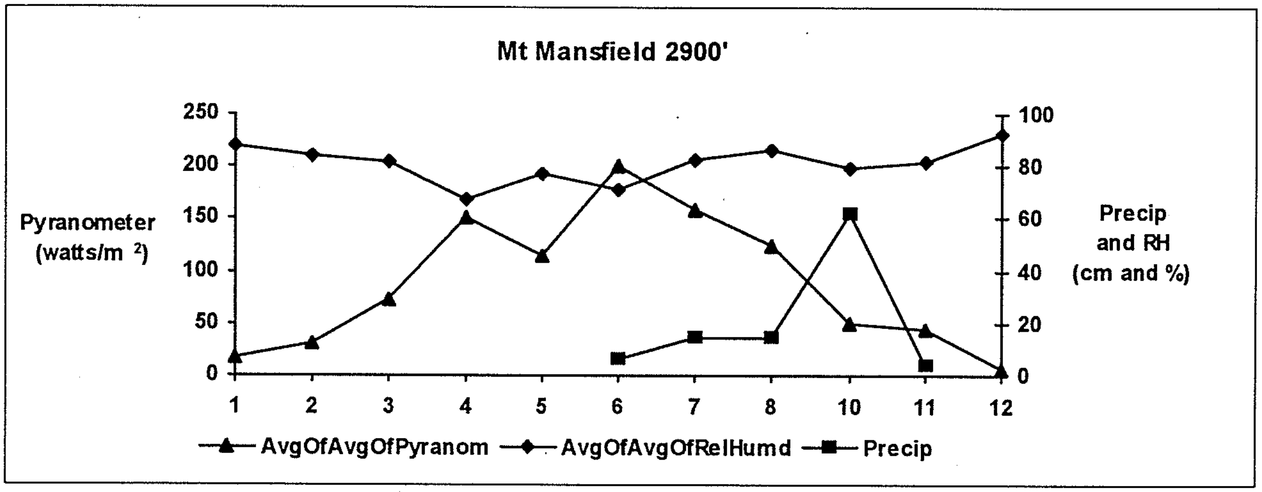


Figure 2: Meteorological Variables Summarized By Month On Individual Sites





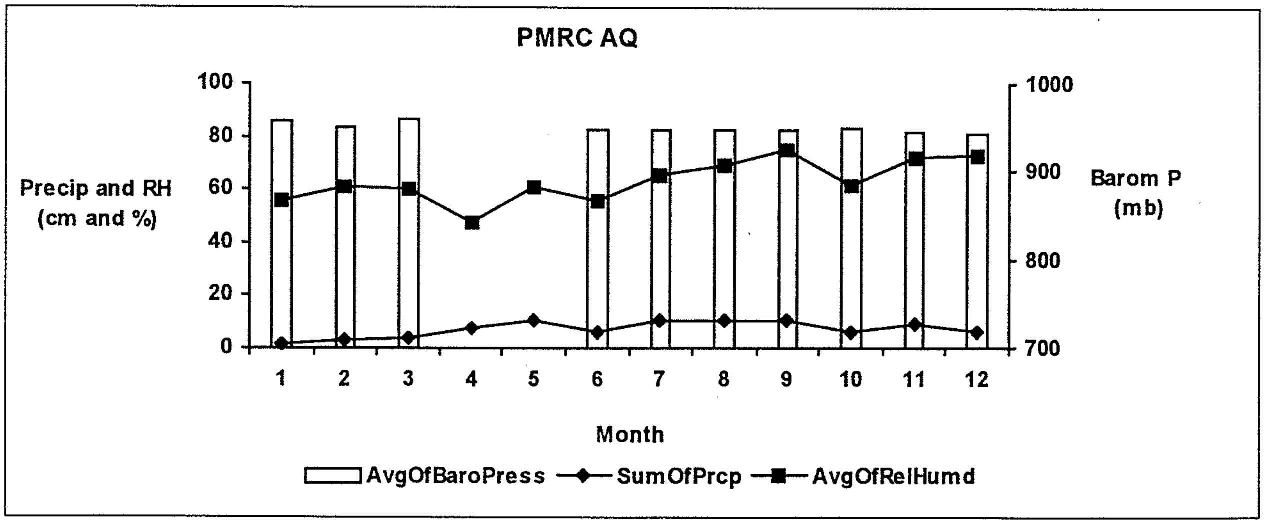
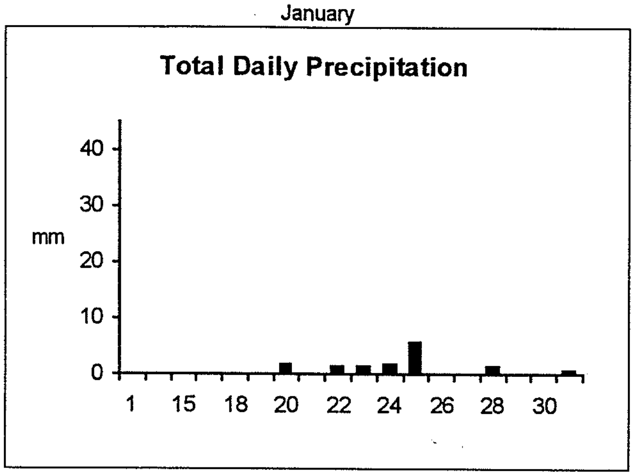
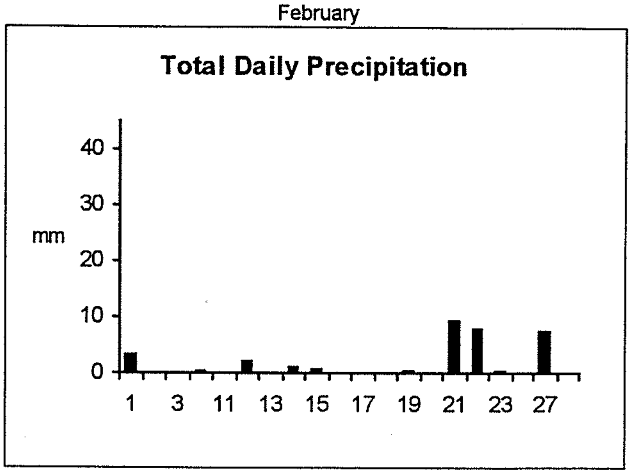


Figure 3:
PMRC AQ Total Daily Precipitation - 1997

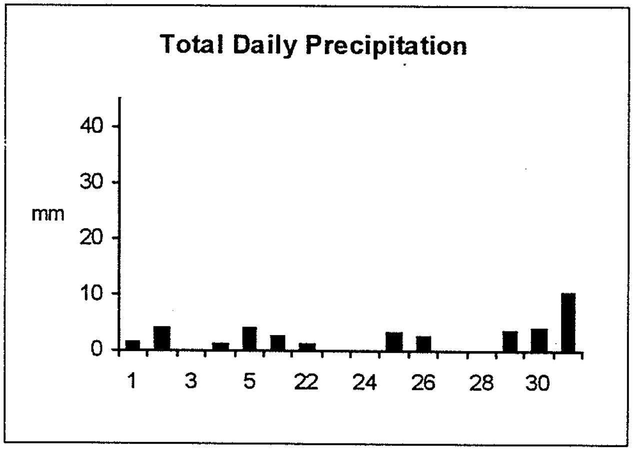
January



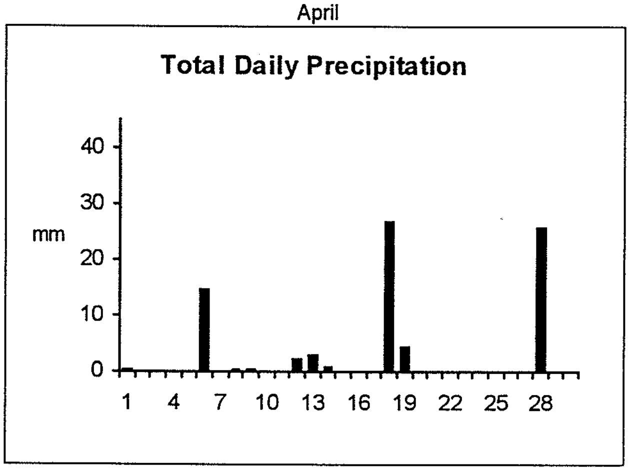
February



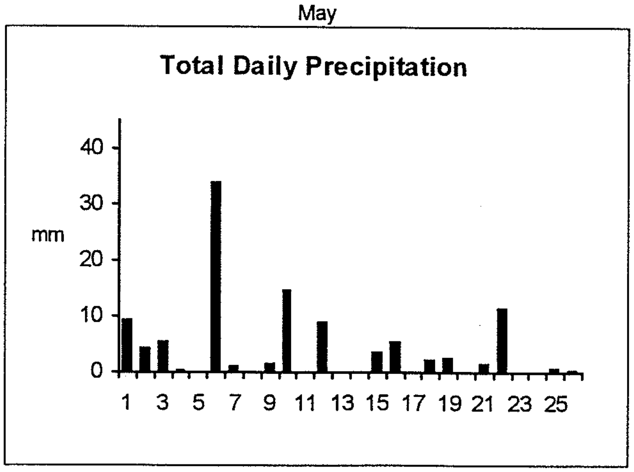
March



April



May



June

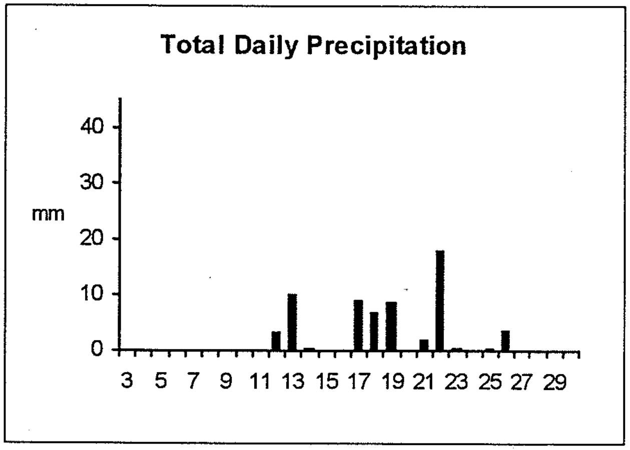
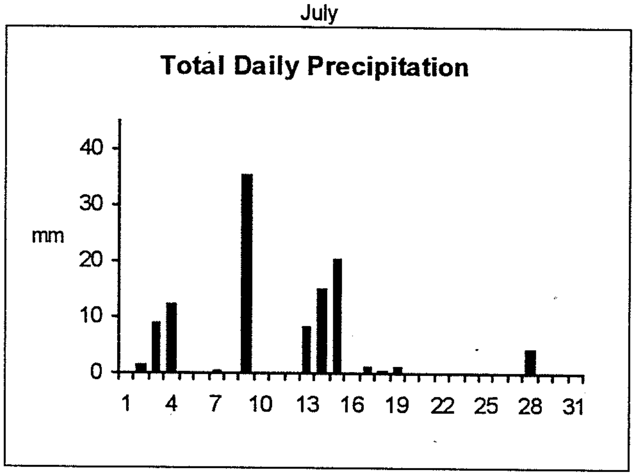
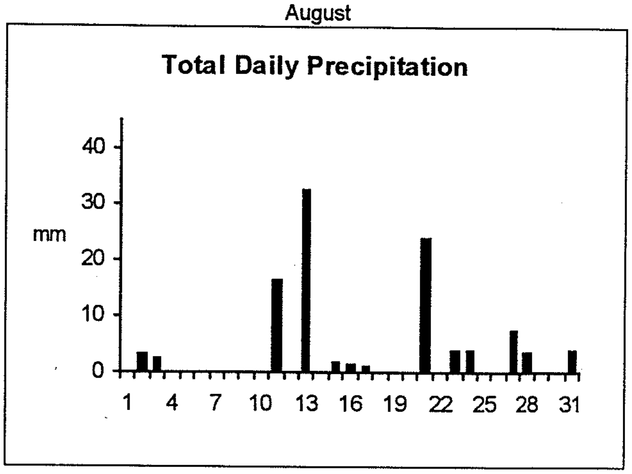


Figure 3:
PMRC AQ Total Daily Precipitation - 1997

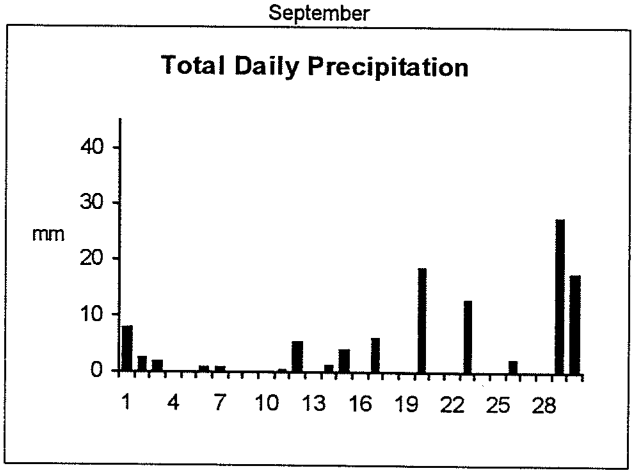
July



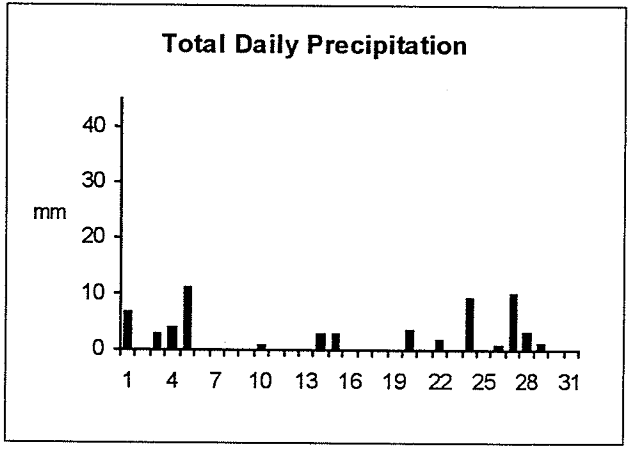
August



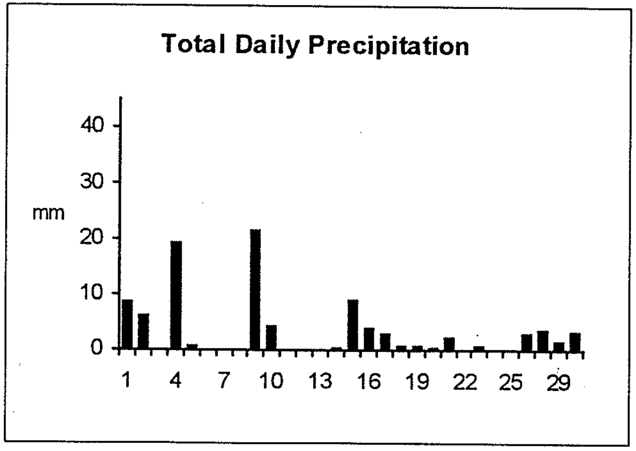
September



October



November



December

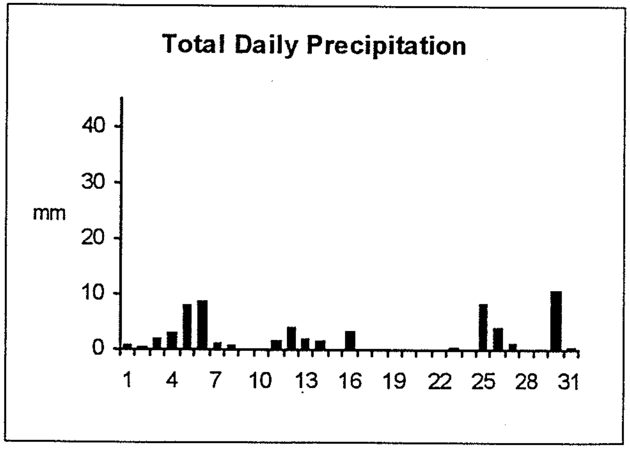
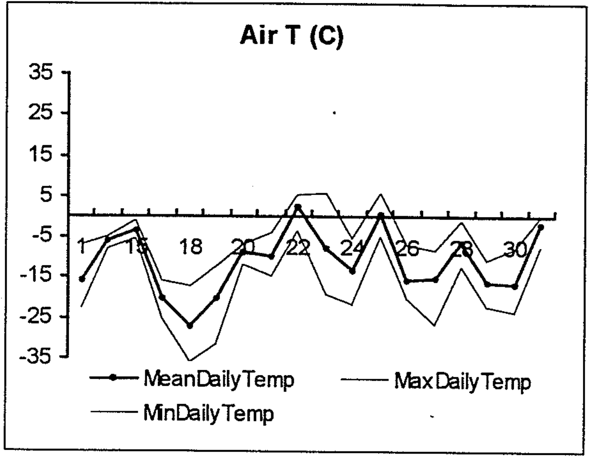
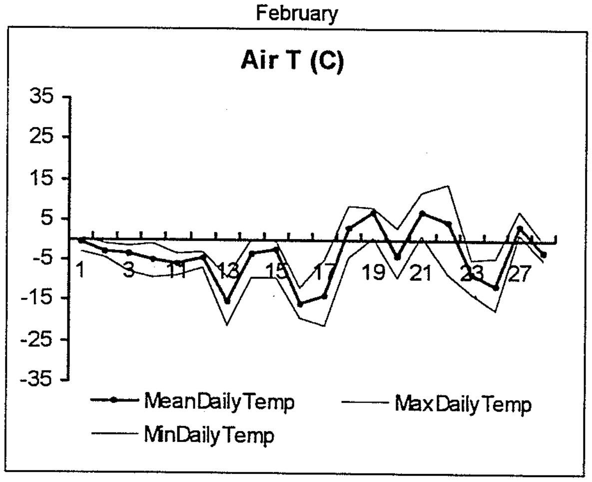


Figure 4:
PMRC AQ Daily Temperature - 1997

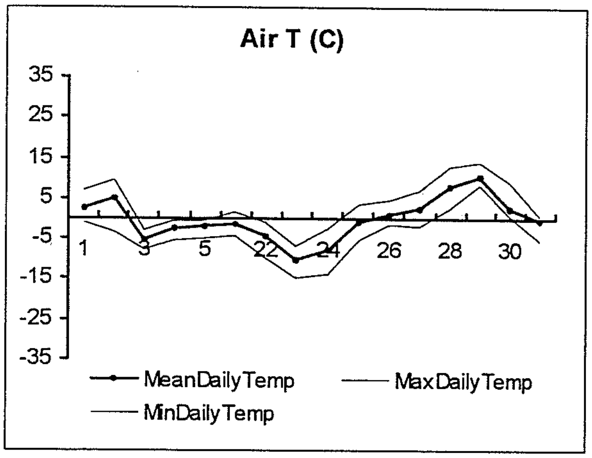
January



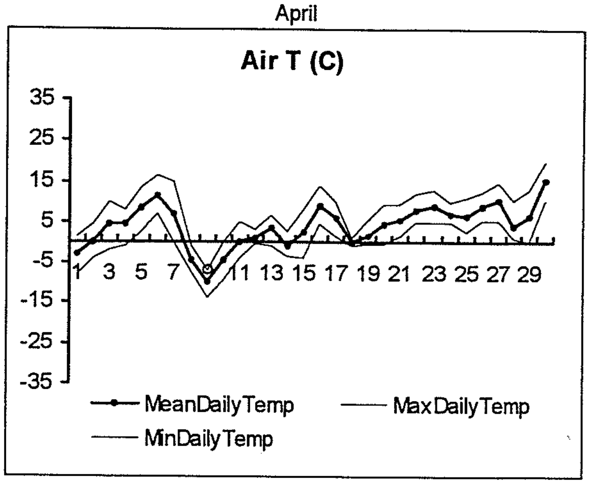
February



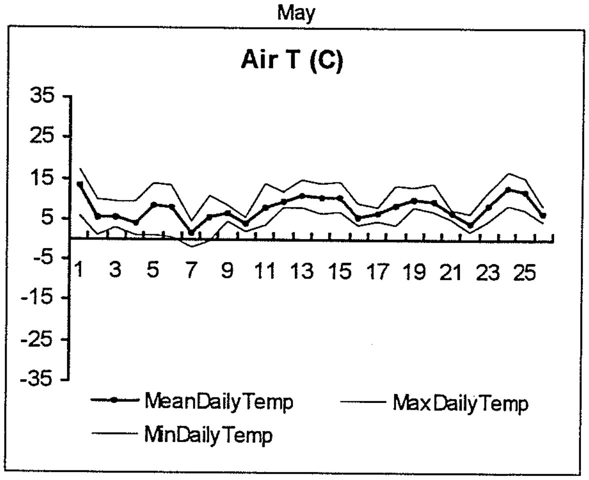
March



April



May



June

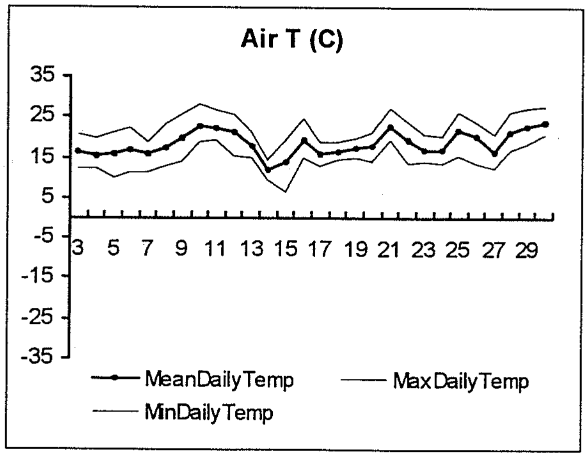
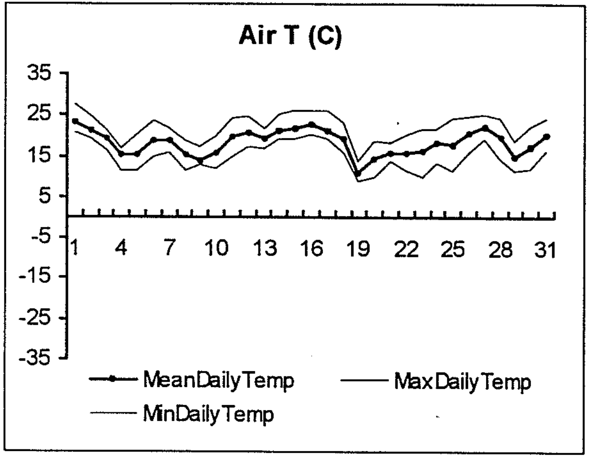
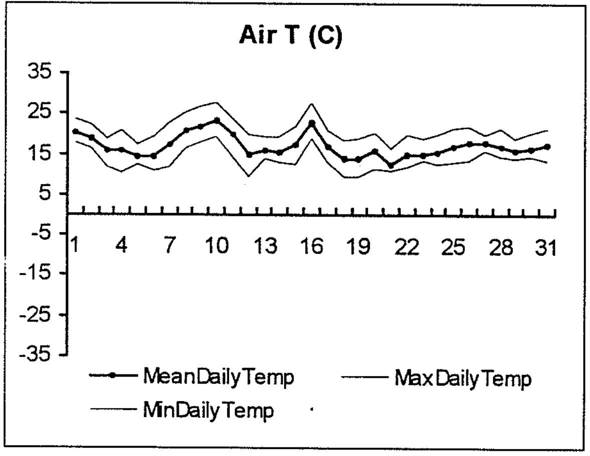


Figure 4:
PMRC AQ Daily Temperature - 1997

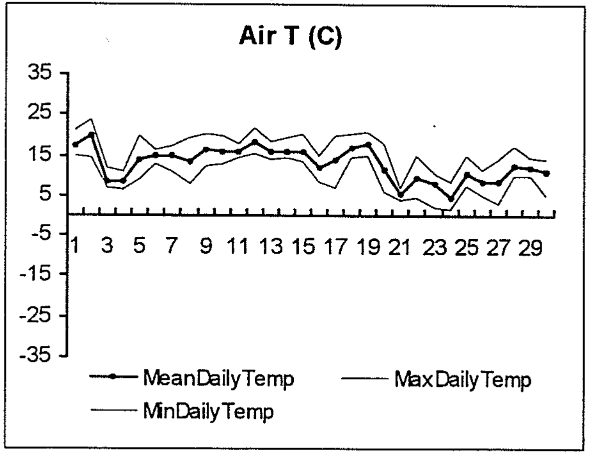
July



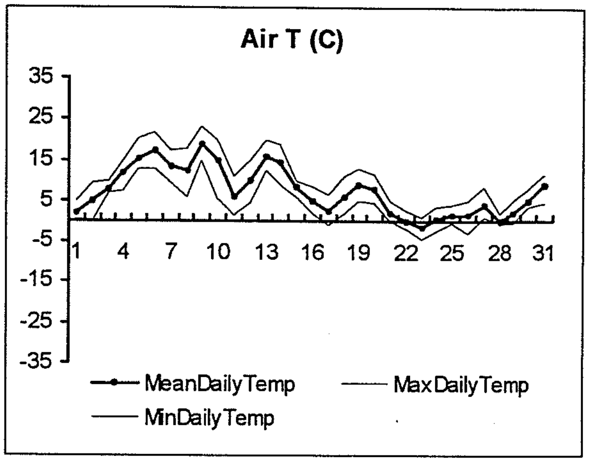
August



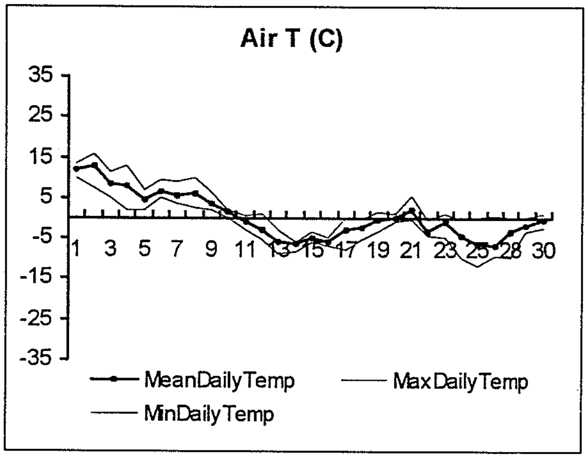
September



October



November



December

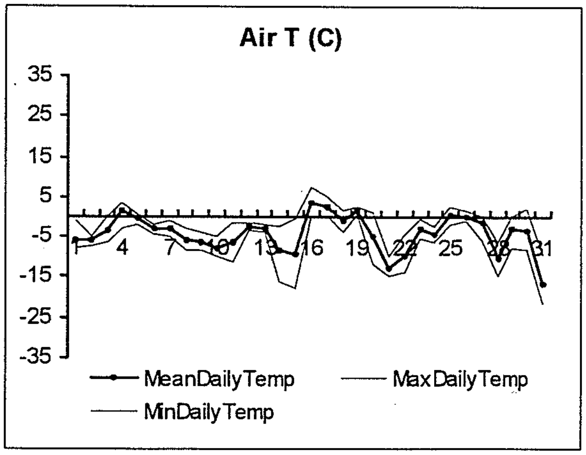
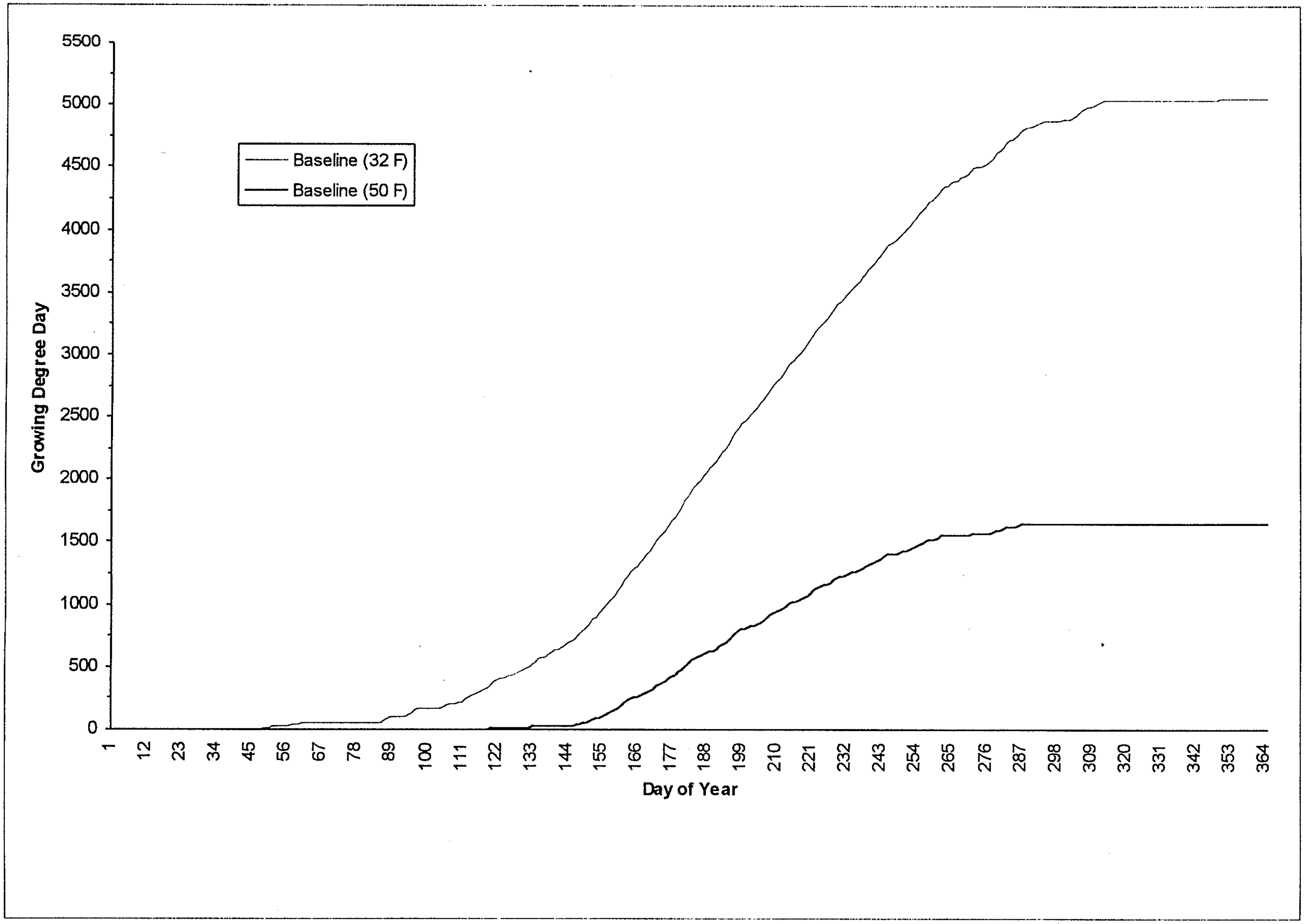


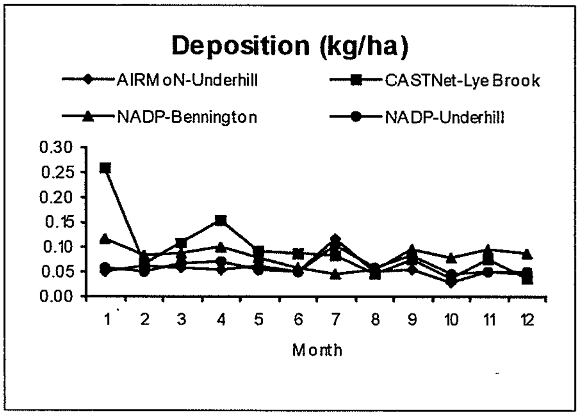
Figure 5: PMRC AQ Cumulative Growing Degree Days



Monthly Wet Deposition by Chemical 1997

Chemical: Cl

Deposition



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.05	0.05	3
February	0.06	0.05	3
March	0.06	0.06	2
April	0.05	0.08	2
May	0.06	0.05	3
June	0.05	0.08	3
July	0.12	0.10	3
August	0.05	0.06	3
September	0.06	0.05	3
October	0.03	0.03	3
November	0.05	0.05	3
December	0.04	0.03	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.26	0.26	1
February	0.07	0.07	1
March	0.11	0.11	1
April	0.15	0.15	1
May	0.09	0.09	1
June	0.09	0.09	2
July	0.08	0.09	2
August	0.04	0.04	2
September	0.07	0.06	2
October	0.04	0.12	2
November	0.07	0.07	2
December	0.04	0.07	2

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.12	0.13	12
February	0.08	0.09	12
March	0.09	0.13	12
April	0.10	0.11	12
May	0.08	0.08	12
June	0.06	0.09	12
July	0.04	0.07	12
August	0.05	0.10	11
September	0.09	0.07	11
October	0.08	0.13	12
November	0.10	0.11	12
December	0.09	0.14	11

Location NADP-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.06	0.07	12
February	0.05	0.05	12
March	0.07	0.07	12
April	0.07	0.08	12
May	0.05	0.07	12
June	0.05	0.07	12
July	0.11	0.07	12
August	0.06	0.06	12
September	0.08	0.07	12
October	0.05	0.08	12
November	0.05	0.05	12
December	0.05	0.05	12

Precipitation Chemistry Monitoring Data Report

Phil Girton, Vermont Monitoring Cooperative
Tim Scherbatskoy, School of Natural Resources, University of Vermont
Mim Pendleton, School of Natural Resources, University of Vermont
Rich Poirot, Air Pollution Control, Vermont Department of Environmental Conservation

Cooperators:
UVM Proctor Maple Research Center (PMRC), Vermont Department of Environmental Conservation (DEC), National Atmospheric Deposition Program (NADP), US Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), Green Mountain National Forest (GMNF), Clean Air Status and Trend Network (CASTNet), Lake Champlain Research Consortium (LCRC) and Atmospheric Integrated Research Monitoring Network (AIRMoN)

Abstract:
Continuous monitoring of wet deposition chemistry has been conducted at the VMC Mount Mansfield and Lye Brook Wilderness Area sites. The work is a fundamental component of the monitoring and research activities there, providing basic information on the chemical environment.

NADP has operated at PMRC since 1984 and at Bennington, Vermont since 1981, providing weekly analysis of major ions in precipitation. AIRMoN, established at PMRC in January of 1993, providing similar data on a daily basis at PMRC. CASTNet has been operating since 1994, just south of the Lye Brook Wilderness Area, providing weekly analysis of major ions in precipitation.

Wet chemical concentration data and calculated deposition are summarized and compared between networks and sites based on annual, seasonal, monthly and weekly time steps.

Objectives:
Continuous monitoring, at the VMC Mount Mansfield and Lye Brook sites, of the chemistry of precipitation. Summary of data from the chemical deposition monitoring program.

Methods:
NADP has maintained a site at the air quality monitoring station at the PMRC since 1984, and another site near Bennington since 1981. Weekly collection of precipitation for chemical analysis is performed at these sites. Precipitation amount, pH and conductivity are measured locally, and the sample is then shipped to the NADP Central Analytical Laboratory in Illinois for analysis of pH, conductivity, Ca, Mg, K, Na, NH_4, NO_3, Cl, and SO_4.

AIRMoN is an event based precipitation monitoring program established at the end of 1992 to provide high-resolution data on precipitation chemistry to support regional modeling efforts. Except for being an event based sampling program, it follows the protocol and measures the variables of the NADP program. The sampler is located at the Air Quality site at PMRC.

CASTNet is a weekly sampling program precipitation amount, pH and conductivity are measured locally, and the sample is then shipped to QST Environmental, Inc. in Florida for analysis of pH, conductivity, Ca, Mg, K, Na, NH_4, NO_3, Cl, HNO_3, H^+, and SO_4. This station is just south of the Lye Brook Wilderness Area boundary. The results are comparable with over 70 sites in the CASTNet program and over 200 sites in the NADP network.

Precipitation-weighted concentrations were calculated for annual, seasonal and monthly time steps. (A separate report summarizing and comparing weekly deposition and concentration is available upon request from the Vermont Monitoring Cooperative.)

Deposition (kg/ha) was calculated for chemicals reporting concentration in mg/l for annual, seasonal and monthly time steps. Total Nitrogen (Total N) deposition was calculated as the combined fraction of NH_4 (16/18) and NO_3 (14/62) deposition. Total Sulfur (Total S) deposition was calculated as a fraction of SO_4 (32.064/96) deposition. Charts and tables of precipitation-weighted concentrations and calculated deposition are presented. In addition the long-term average (Period of Record Average) and years of data used to calculate this average are reported. Only years with 50 weeks of data are summarized.

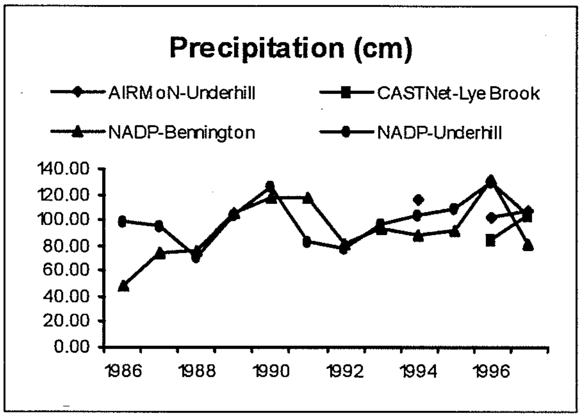
Citations:

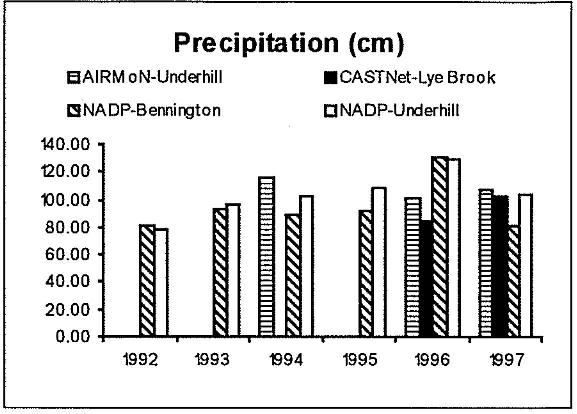
National Atmospheric Deposition Program (NRSP-3)/National Trend Network. (2000). NADP Program Office, Illinois State Water Survey, 2204 Griffith Drive, Champaign, IL 61820

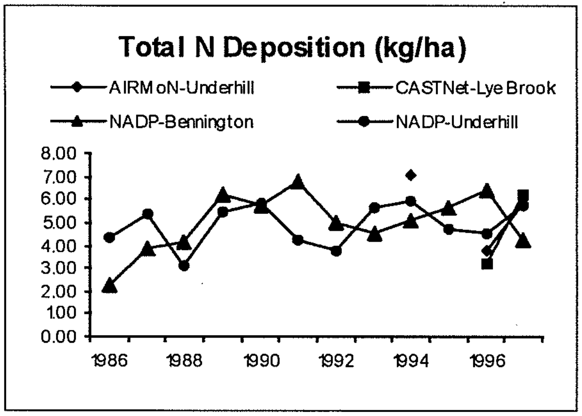
National Atmospheric Deposition Program (NRSP-3)/Atmospheric Integrated Research Monitoring Network. (2000) NADP Program Office, Illinois State Water Survey, 2204 Griffith Drive, Champaign, IL 61820

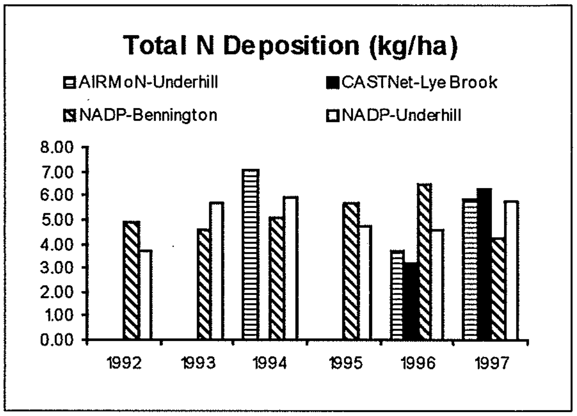
Annual Wet Deposition: Precipitation, Total Nitrogen and Sulfur Deposition 1997

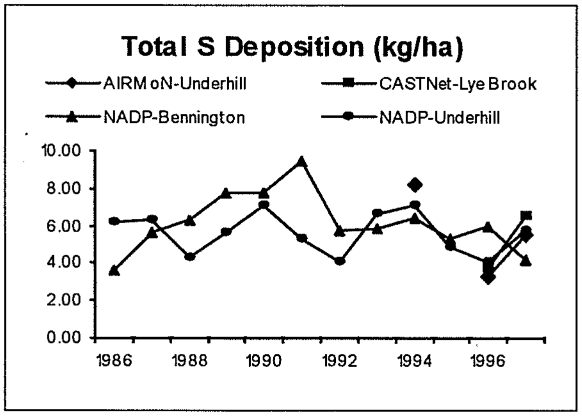
Period of Record **Last 5 years**

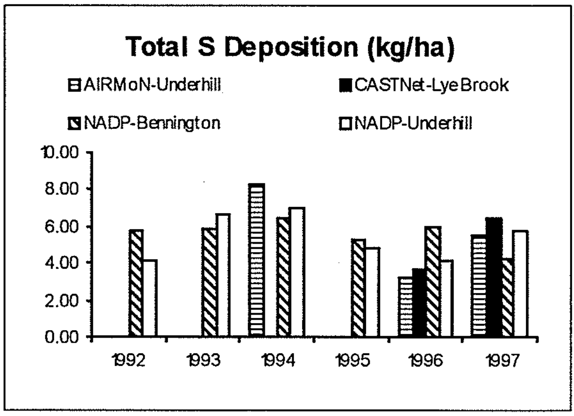










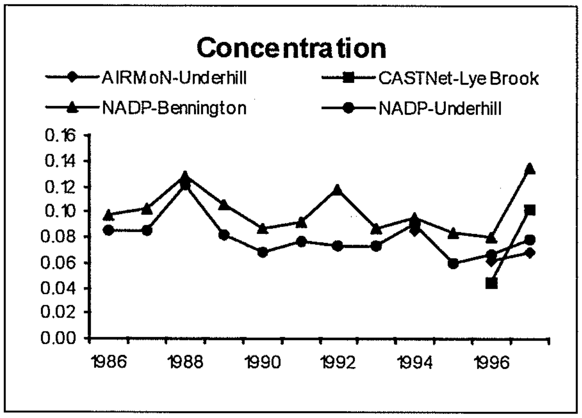


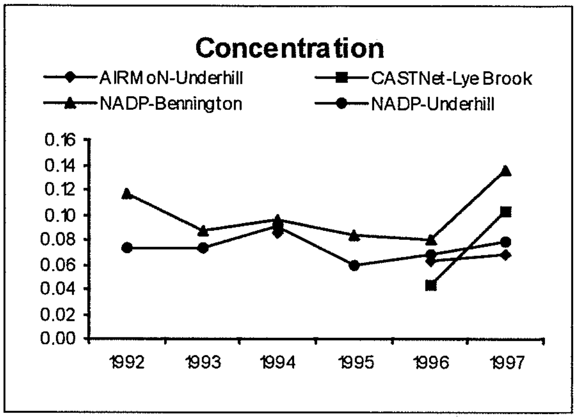
	Precipitation (cm)		Total N Deposition (kg/ha)		Total S Deposition (kg/ha)		
Location	Current Year	Period of Record Average	Current Year	Period of Record Average	Current Year	Period of Record Average)	Years of Data
AIRMoN-Underhill	106.30	107.90	5.86	5.55	5.54	5.67	3
CASTNet-Lye Brook	103.00	93.61	6.25	4.71	6.49	5.09	2
NADP-Bennington	80.69	92.10	4.20	4.98	4.20	6.17	12
NADP-Underhill	103.71	99.84	5.72	4.90	5.73	5.60	12

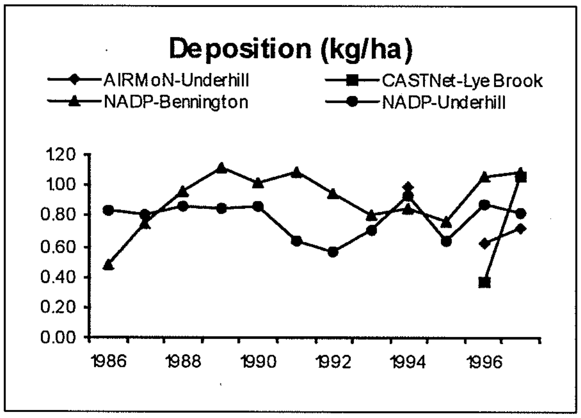
Annual Wet Deposition by Chemical 1997

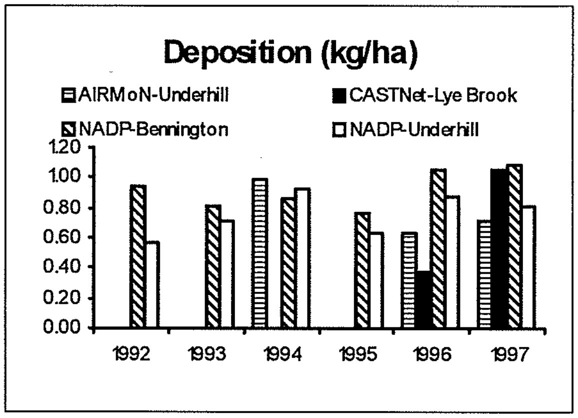
Chemical: Ca **Concentration Units:** mg/l

Period of Record **Last 5 years**







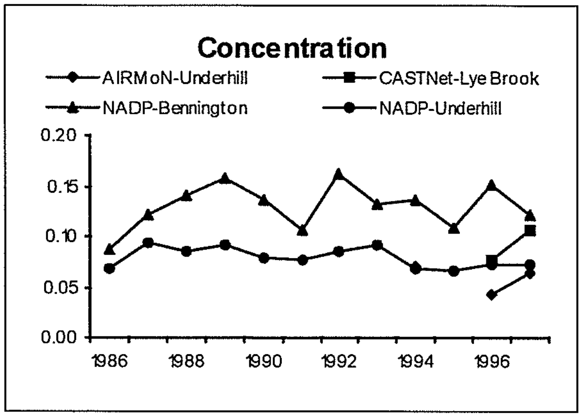


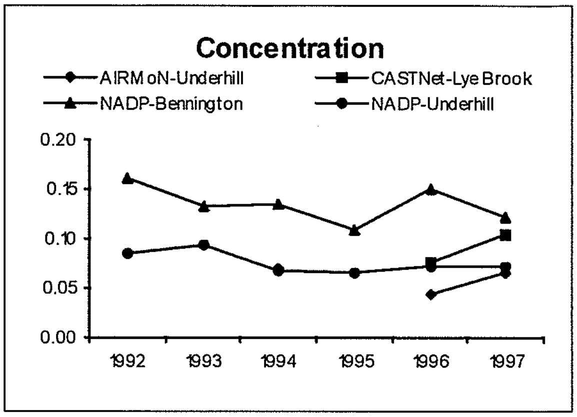
Location	Concentration		Deposition (kg/ha)		Years of Data
	Current Year	Period of Record Average	Current Year	Period of Record Average	
AIRMoN-Underhill	0.07	0.07	0.72	0.78	3
CASTNet-Lye Brook	0.10	0.07	1.06	0.71	2
NADP-Bennington	0.13	0.10	1.09	0.91	12
NADP-Underhill	0.08	0.08	0.81	0.78	12

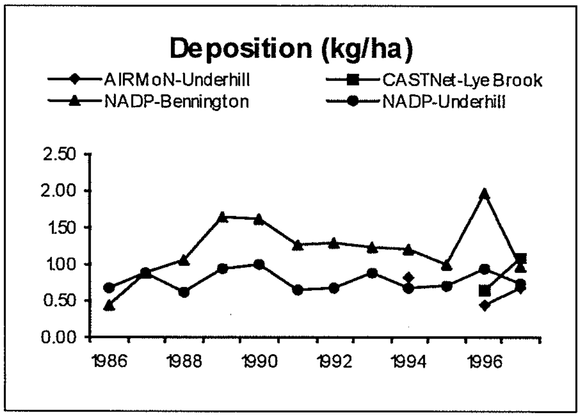
Annual Wet Deposition by Chemical 1997

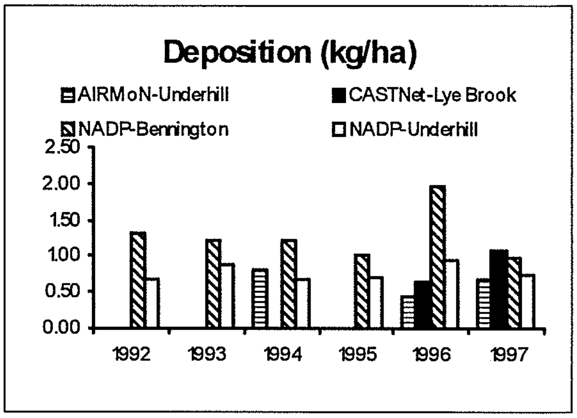
Chemical: Cl **Concentration Units:** mg/l

Period of Record **Last 5 years**







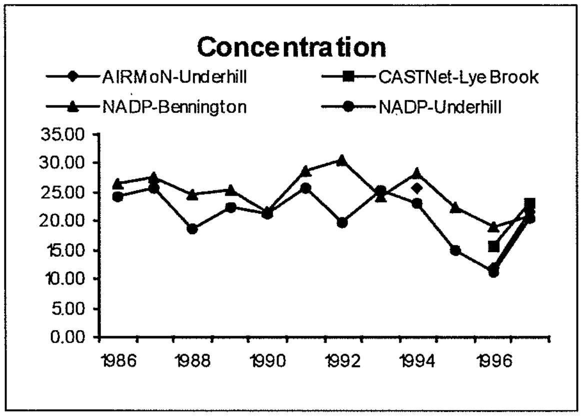


Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
AIRMoN-Underhill	0.06	0.06	0.68	0.64	3
CASTNet-Lye Brook	0.11	0.09	1.08	0.86	2
NADP-Bennington	0.12	0.13	0.98	1.22	12
NADP-Underhill	0.07	0.08	0.74	0.78	12

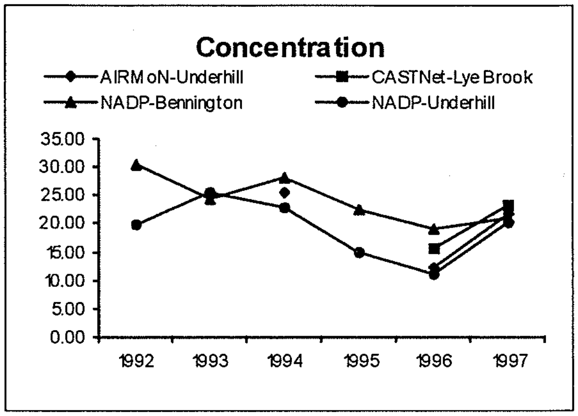
Annual Wet Deposition by Chemical 1997

Chemical: Cond-field **Concentration Units:** uS/cm

Period of Record



Last 5 years

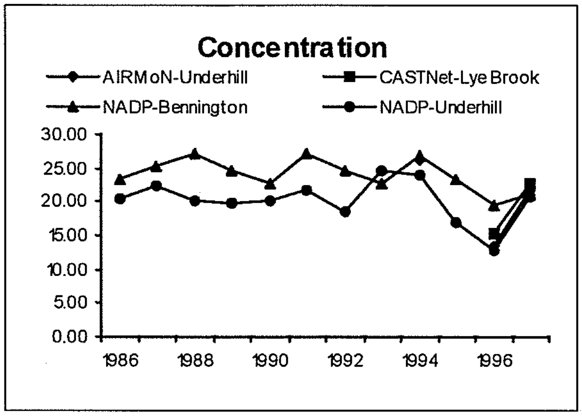


Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
AIRMoN-Underhill	21.51	19.72			3
CASTNet-Lye Brook	23.02	19.31			2
NADP-Bennington	20.93	24.94			12
NADP-Underhill	20.35	21.03			12

Annual Wet Deposition by Chemical 1997

Chemical: Cond-lab **Concentration Units:** uS/cm

Period of Record



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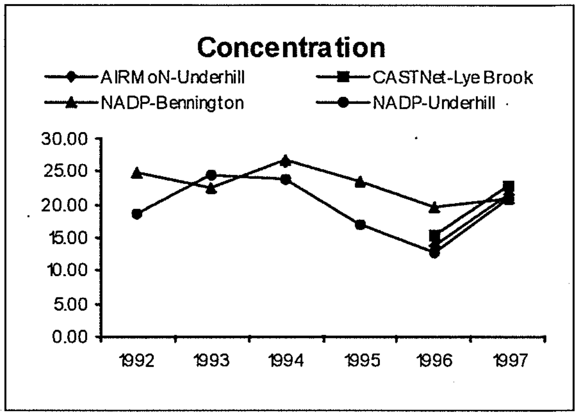
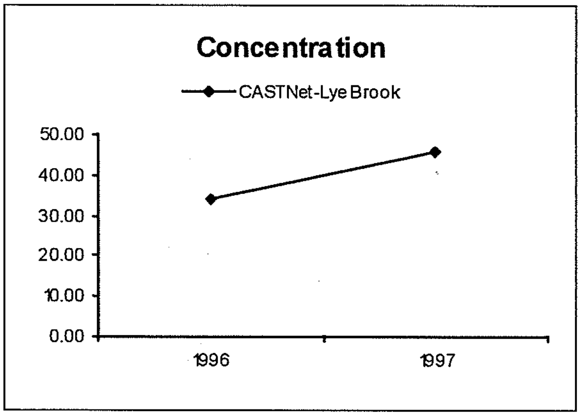


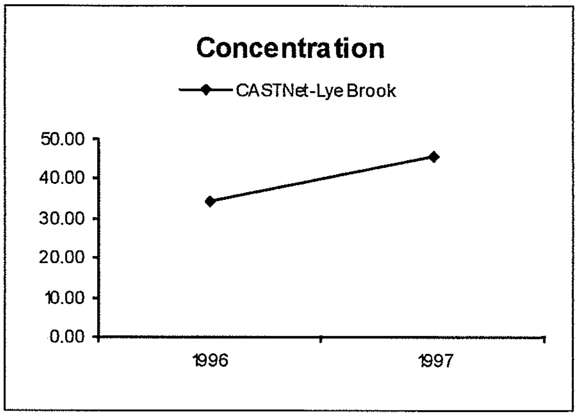
Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
AIRMoN-Underhill	21.66	20.50			3
CASTNet-Lye Brook	22.75	19.10			2
NADP-Bennington	20.98	23.99			12
NADP-Underhill	20.79	20.16			12

Annual Wet Deposition by Chemical 1997

Chemical: H **Concentration Units:** ueq/l

Period of Record **Last 5 years**



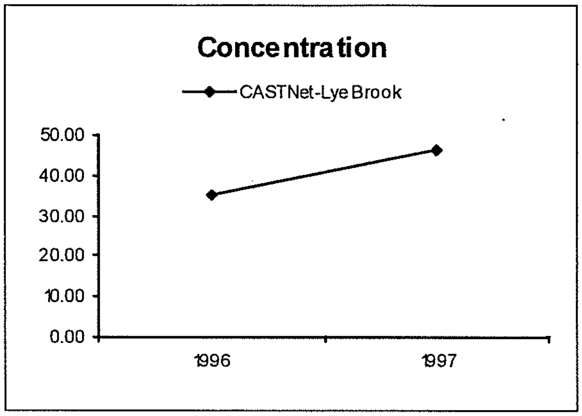


	Concentration		Deposition (kg/ha)		
Location	Current Year	Period of Record Average	Current Year	Period of Record Average	Years of Data
CASTNet-Lye Brook	45.52	39.90			2

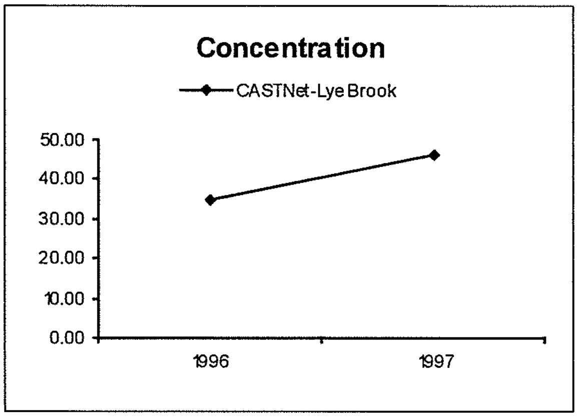
Annual Wet Deposition by Chemical 1997

Chemical: H unfiltered **Concentration Units:** ueq/l

Period of Record



Last 5 years

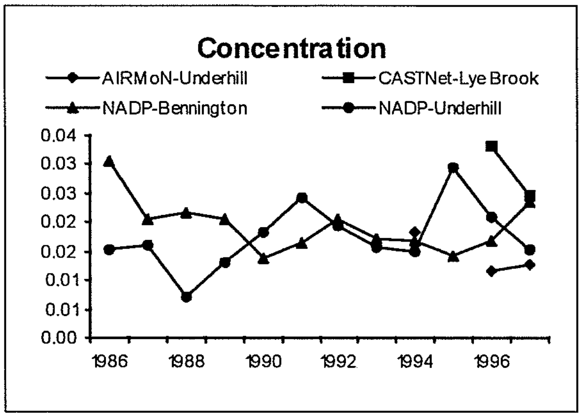


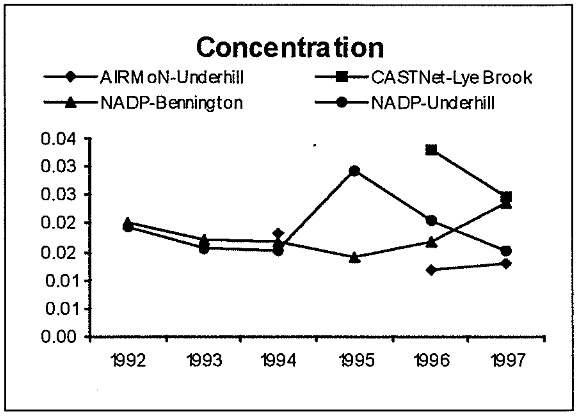
Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
CASTNet-Lye Brook	46.26	40.56			2

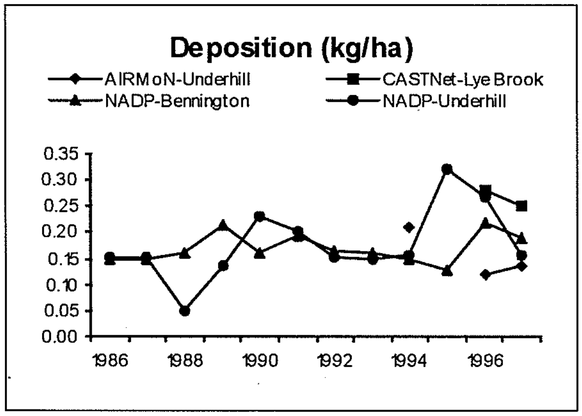
Annual Wet Deposition by Chemical 1997

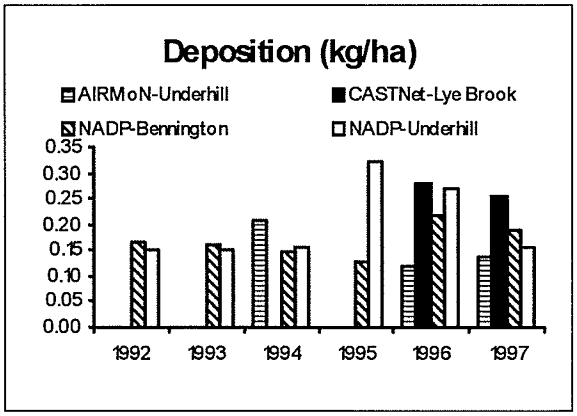
Chemical: K **Concentration Units:** mg/l

Period of Record **Last 5 years**







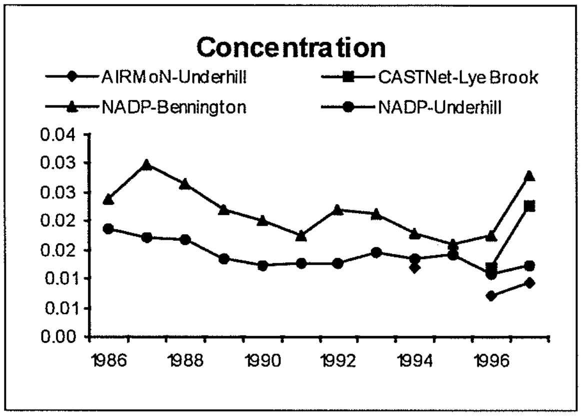


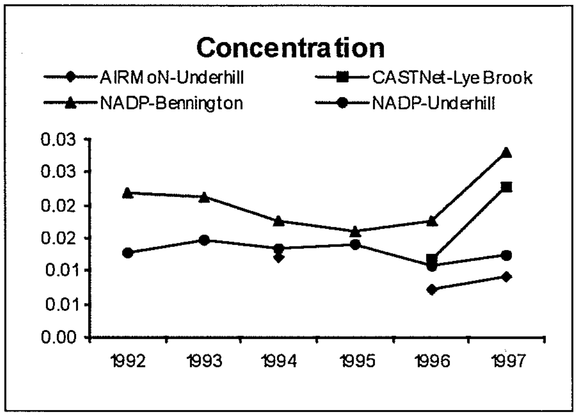
Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
AIRMoN-Underhill	0.01	0.01	0.14	0.15	3
CASTNet-Lye Brook	0.02	0.03	0.25	0.27	2
NADP-Bennington	0.02	0.02	0.19	0.17	12
NADP-Underhill	0.02	0.02	0.16	0.18	12

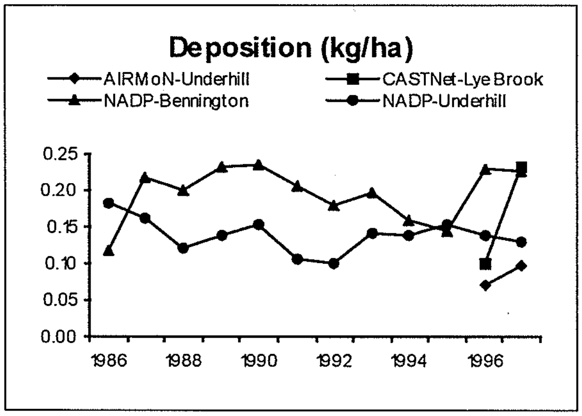
Annual Wet Deposition by Chemical 1997

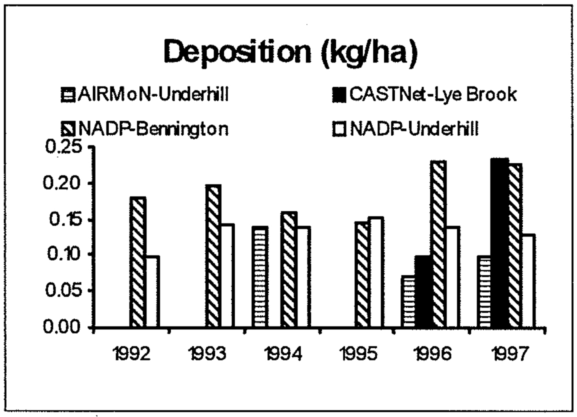
Chemical: Mg **Concentration Units:** mg/l

Period of Record **Last 5 years**







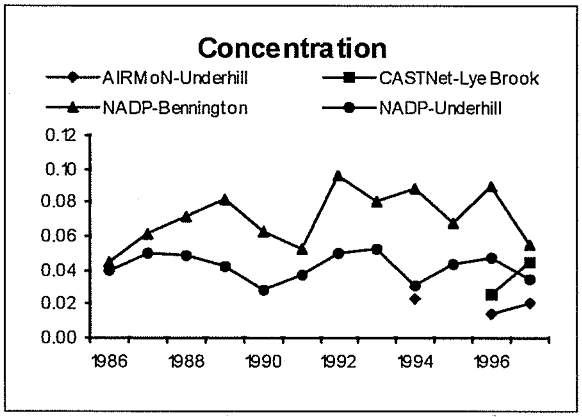


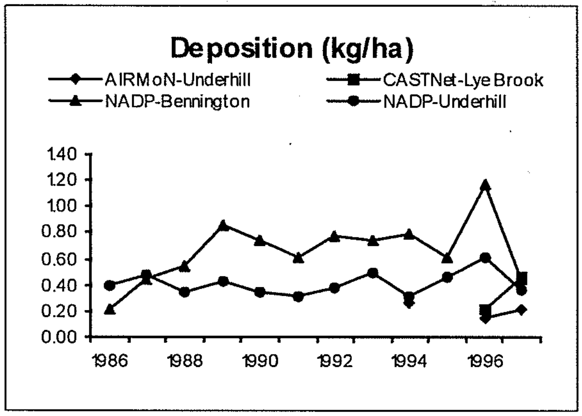
Location	Concentration Current Year	 Period of Record Average	Deposition (kg/ha) Current Year	 Period of Record Average	Years of Data
AIRMoN-Underhill	0.01	0.01	0.10	0.10	3
CASTNet-Lye Brook	0.02	0.02	0.23	0.17	2
NADP-Bennington	0.03	0.02	0.23	0.20	12
NADP-Underhill	0.01	0.01	0.13	0.14	12

Annual Wet Deposition by Chemical 1997

Chemical: Na **Concentration Units:** mg/l

Period of Record





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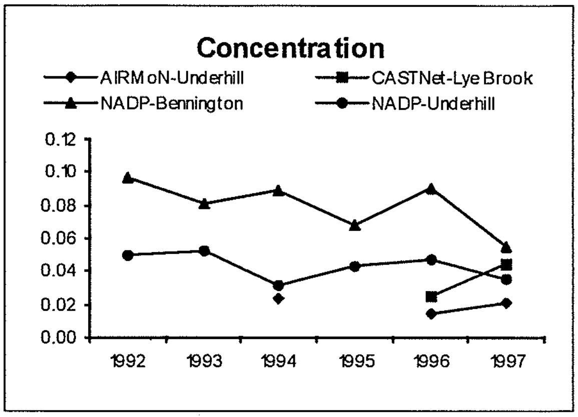
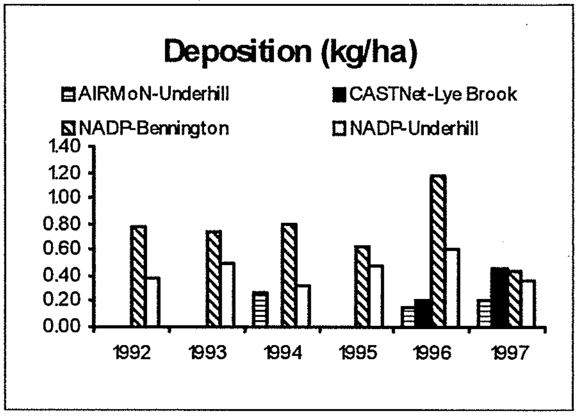


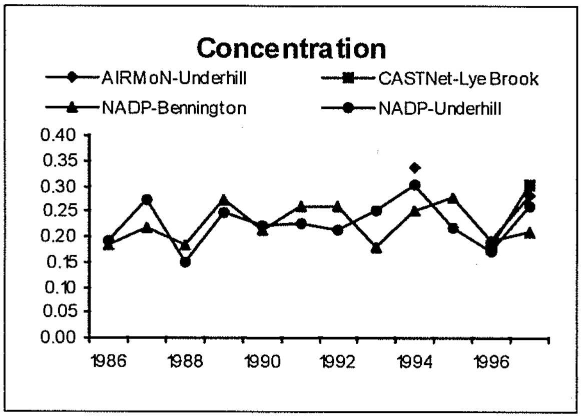


Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
AIRMoN-Underhill	0.02	0.02	0.22	0.21	3
CASTNet-Lye Brook	0.04	0.03	0.45	0.33	2
NADP-Bennington	0.05	0.07	0.44	0.66	12
NADP-Underhill	0.03	0.04	0.36	0.41	12

Annual Wet Deposition by Chemical 1997

Chemical: NH4 **Concentration Units:** mg/l

Period of Record



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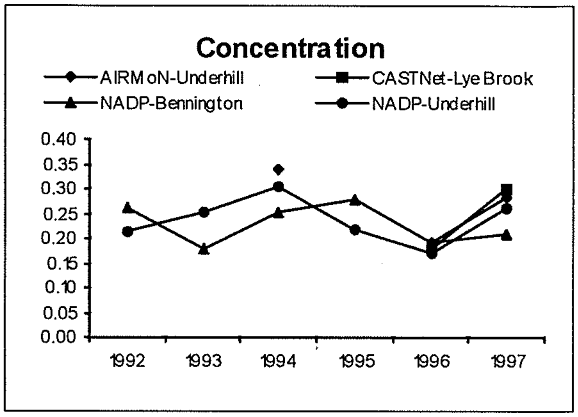
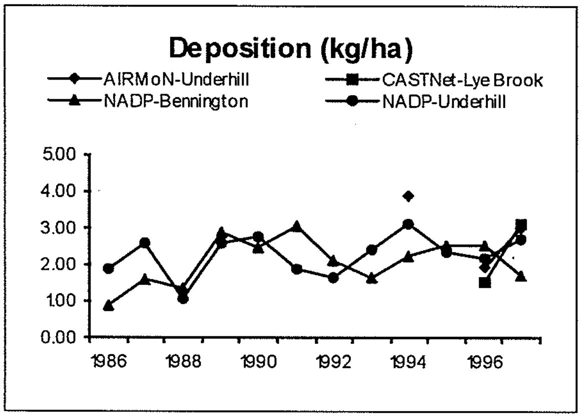
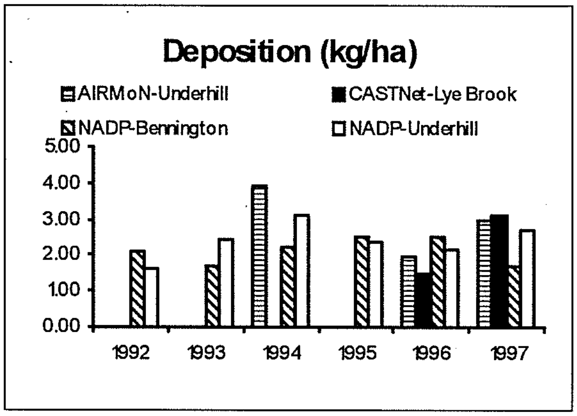




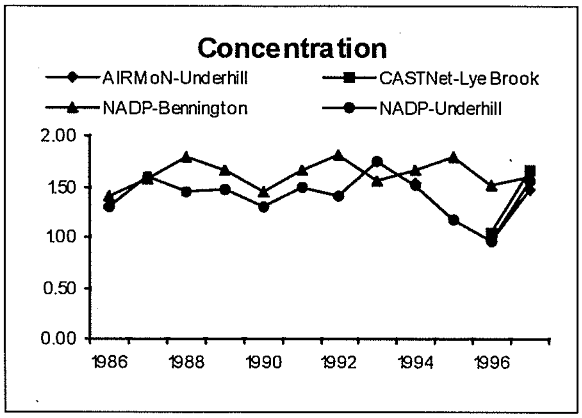


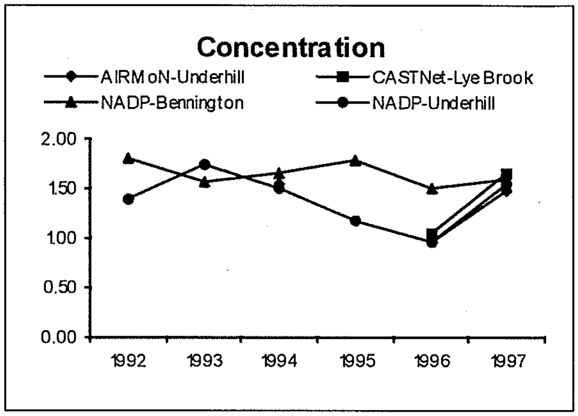
Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
AIRMoN-Underhill	0.28	0.27	3.00	2.95	3
CASTNet-Lye Brook	0.30	0.24	3.09	2.30	2
NADP-Bennington	0.21	0.22	1.69	2.09	12
NADP-Underhill	0.26	0.23	2.71	2.27	12

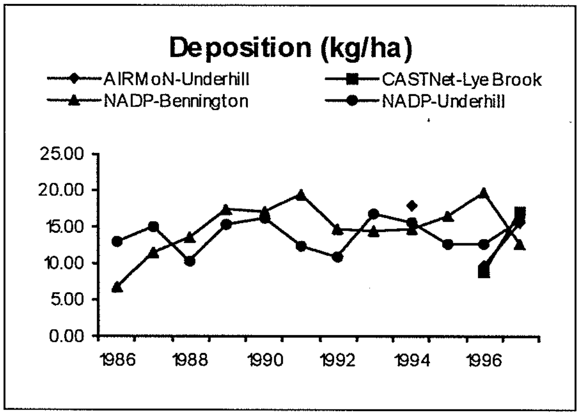
Annual Wet Deposition by Chemical 1997

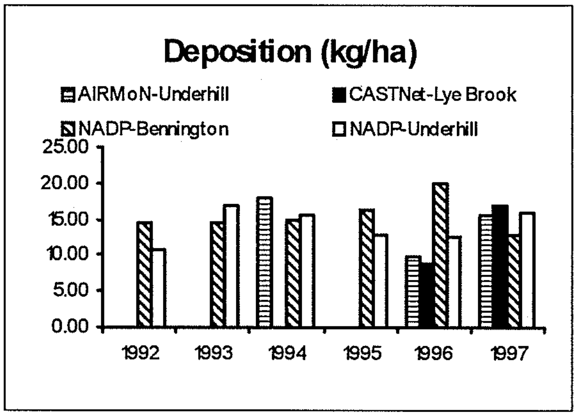
Chemical: NO3 **Concentration Units:** mg/l

Period of Record **Last 5 years**







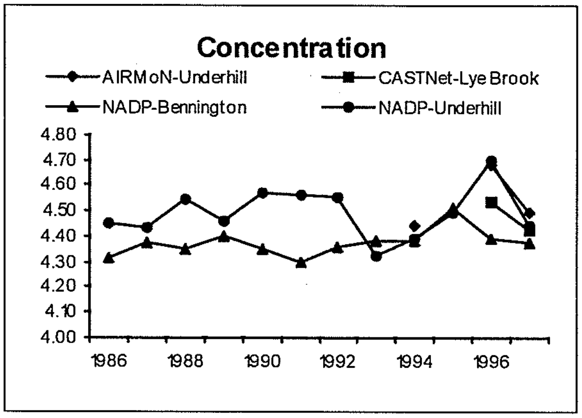


Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
AIRMoN-Underhill	1.47	1.32	15.62	14.40	3
CASTNet-Lye Brook	1.65	1.35	17.01	12.93	2
NADP-Bennington	1.59	1.62	12.79	14.87	12
NADP-Underhill	1.54	1.41	16.00	13.90	12

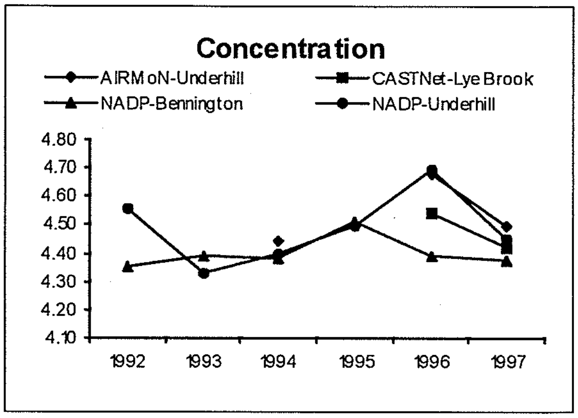
Annual Wet Deposition by Chemical 1997

Chemical: pH-field **Concentration Units:**

Period of Record



Last 5 years

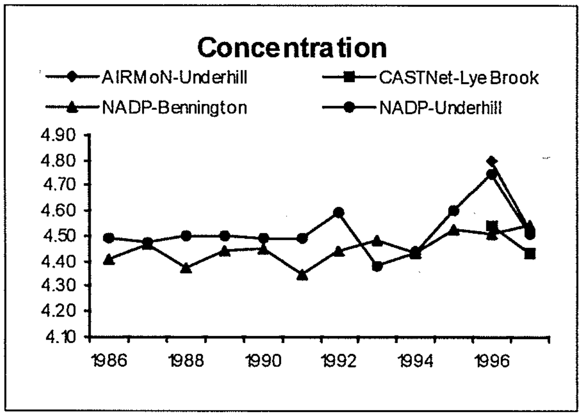


Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
AIRMoN-Underhill	4.50	4.54			3
CASTNet-Lye Brook	4.42	4.48			2
NADP-Bennington	4.37	4.37			12
NADP-Underhill	4.45	4.49			12

Annual Wet Deposition by Chemical 1997

Chemical: pH-lab **Concentration Units:**

Period of Record



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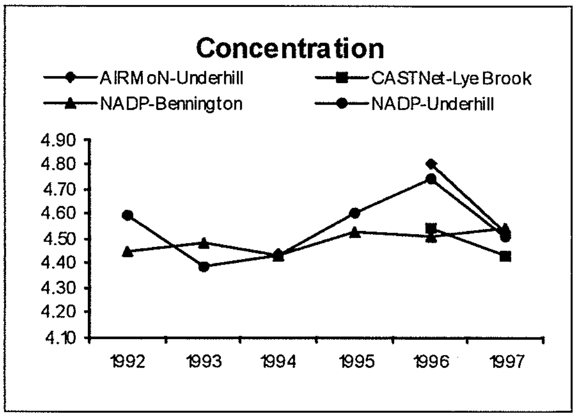
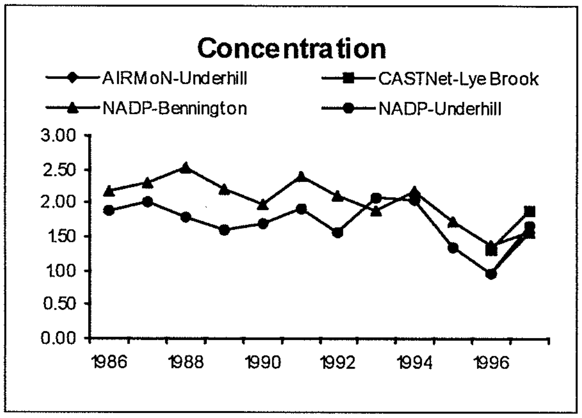


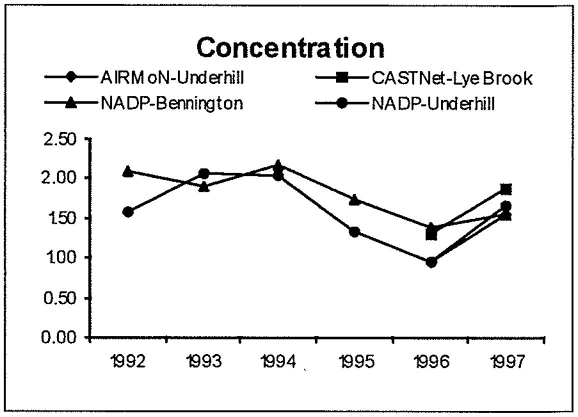
Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
AIRMoN-Underhill	4.53	4.59			3
CASTNet-Lye Brook	4.43	4.48			2
NADP-Bennington	4.54	4.45			12
NADP-Underhill	4.51	4.52			12

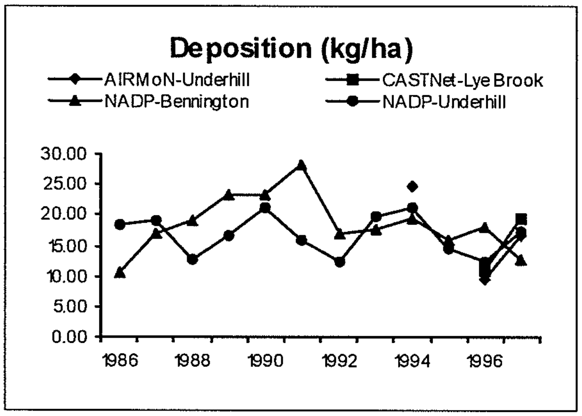
Annual Wet Deposition by Chemical 1997

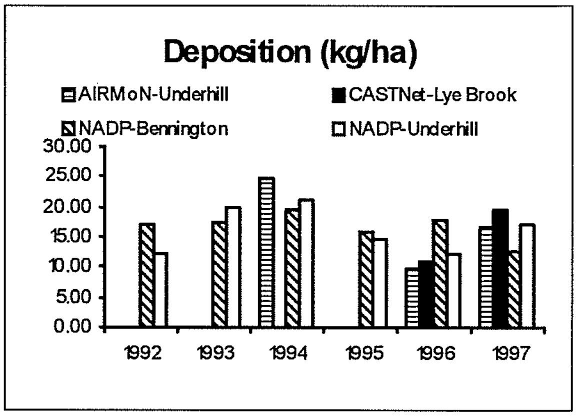
Chemical: SO4 **Concentration Units:** mg/l

Period of Record **Last 5 years**



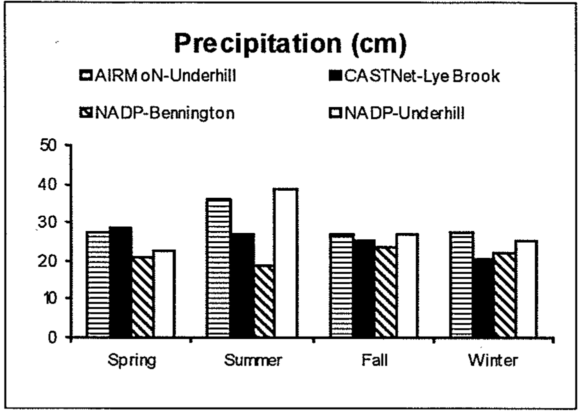


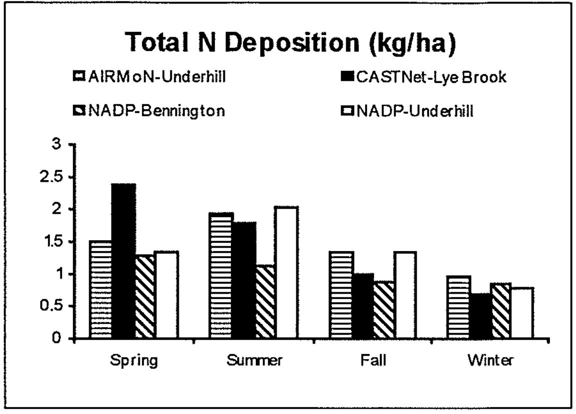




	Concentration		Deposition (kg/ha)		
Location	Current Year	Period of Record Average	Current Year	Period of Record Average	Years of Data
AIRMoN-Underhill	1.56	1.55	16.59	16.97	3
CASTNet-Lye Brook	1.89	1.60	19.42	15.24	2
NADP-Bennington	1.56	2.03	12.56	18.47	12
NADP-Underhill	1.65	1.71	17.16	16.78	12

Seasonal Wet Deposition: Precipitation, Total Nitrogen and Sulfur Deposition 1997





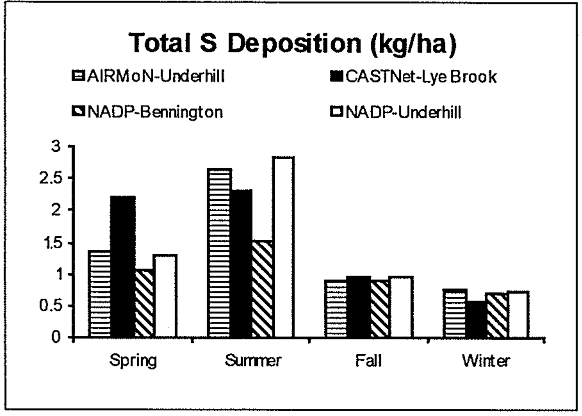
Precipitation (cm)

Season	Location	Current Year	Period of Record Average	Years of Data
Spring	AIRMoN-Underhill	27.30	24.93	3
Spring	CASTNet-Lye Brook	28.47	17.68	2
Spring	NADP-Bennington	20.75	25.00	12
Spring	NADP-Underhill	22.68	27.00	12
Summer	AIRMoN-Underhill	35.99	35.93	3
Summer	CASTNet-Lye Brook	27.00	29.08	2
Summer	NADP-Bennington	18.66	25.01	12
Summer	NADP-Underhill	38.63	30.31	12
Fall	AIRMoN-Underhill	26.76	29.67	3
Fall	CASTNet-Lye Brook	25.10	31.29	2
Fall	NADP-Bennington	23.75	25.38	12
Fall	NADP-Underhill	26.62	26.48	12
Winter	AIRMoN-Underhill	27.42	15.51	3
Winter	CASTNet-Lye Brook	20.19	24.69	2
Winter	NADP-Bennington	22.28	17.38	12
Winter	NADP-Underhill	25.09	16.24	12

Total N Deposition (kg/ha)

Season	Location	Current Year	Period of Record Average	Years of Dat
Spring	AIRMoN-Underhill	1.50	1.68	3
Spring	CASTNet-Lye Brook	2.38	1.55	2
Spring	NADP-Bennington	1.29	1.63	12
Spring	NADP-Underhill	1.34	1.48	12
Summer	AIRMoN-Underhill	1.93	1.84	3
Summer	CASTNet-Lye Brook	1.78	1.50	2
Summer	NADP-Bennington	1.13	1.49	12
Summer	NADP-Underhill	2.04	1.41	12
Fall	AIRMoN-Underhill	1.35	1.04	3
Fall	CASTNet-Lye Brook	1.01	0.98	2
Fall	NADP-Bennington	0.87	1.02	12
Fall	NADP-Underhill	1.34	1.12	12
Winter	AIRMoN-Underhill	0.97	0.79	3
Winter	CASTNet-Lye Brook	0.70	1.00	2
Winter	NADP-Bennington	0.86	0.88	12
Winter	NADP-Underhill	0.78	0.90	12

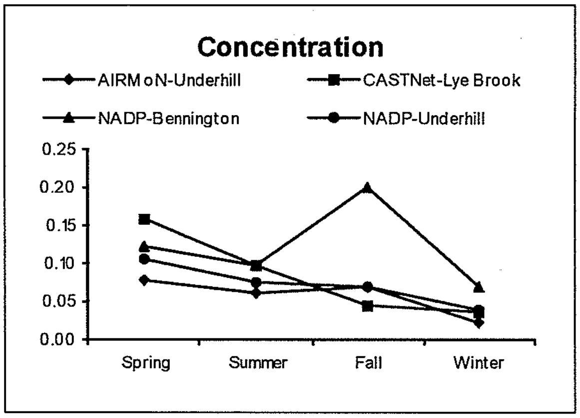
Seasonal Wet Deposition: Precipitation, Total Nitrogen and Sulfur Deposition 1997

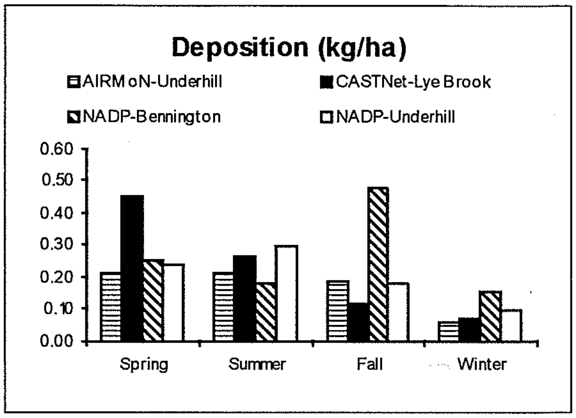


Season	Location	Total S Deposition (kg/ha) Current Year	Total S Deposition (kg/ha) Period of Record Average	Years of Data
Spring	AIRMoN-Underhill	1.36	1.82	3
Spring	CASTNet-Lye Brook	2.22	1.47	2
Spring	NADP-Bennington	1.05	1.92	12
Spring	NADP-Underhill	1.28	1.69	12
Summer	AIRMoN-Underhill	2.63	2.53	3
Summer	CASTNet-Lye Brook	2.31	1.97	2
Summer	NADP-Bennington	1.51	2.39	12
Summer	NADP-Underhill	2.84	2.20	12
Fall	AIRMoN-Underhill	0.90	0.77	3
Fall	CASTNet-Lye Brook	0.94	0.95	2
Fall	NADP-Bennington	0.90	1.11	12
Fall	NADP-Underhill	0.94	1.11	12
Winter	AIRMoN-Underhill	0.76	0.53	3
Winter	CASTNet-Lye Brook	0.56	0.94	2
Winter	NADP-Bennington	0.70	0.75	12
Winter	NADP-Underhill	0.72	0.60	12

Seasonal Wet Deposition by Chemical 1997

Chemical: Ca **Concentration Units:** mg/l

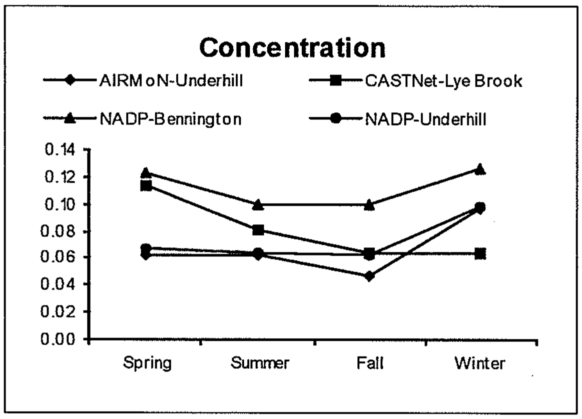


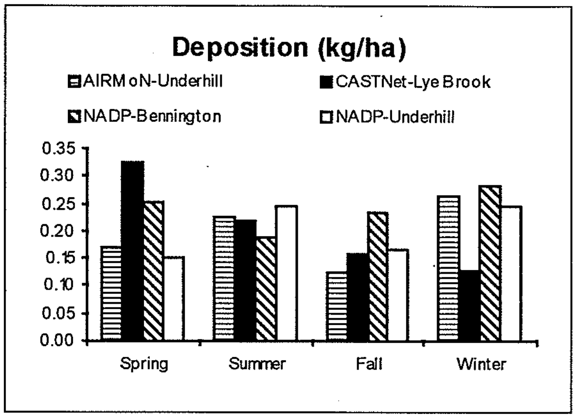


		Concentration		Deposition (kg/ha)		
Season	Location	Current Year	Period of Record Average	Current Year	Period of Record Average	Years of Data
Spring	AIRMoN-Underhill	0.08	0.10	0.21	0.28	3
Spring	CASTNet-Lye Brook	0.16	0.13	0.45	0.26	2
Spring	NADP-Bennington	0.12	0.14	0.25	0.31	12
Spring	NADP-Underhill	0.10	0.11	0.24	0.29	12
Summer	AIRMoN-Underhill	0.06	0.07	0.22	0.25	3
Summer	CASTNet-Lye Brook	0.10	0.08	0.27	0.22	2
Summer	NADP-Bennington	0.10	0.08	0.18	0.21	12
Summer	NADP-Underhill	0.08	0.08	0.29	0.24	12
Fall	AIRMoN-Underhill	0.07	0.04	0.19	0.12	3
Fall	CASTNet-Lye Brook	0.05	0.04	0.11	0.11	2
Fall	NADP-Bennington	0.20	0.10	0.48	0.23	12
Fall	NADP-Underhill	0.07	0.06	0.18	0.16	12
Winter	AIRMoN-Underhill	0.02	0.05	0.06	0.06	3
Winter	CASTNet-Lye Brook	0.04	0.06	0.07	0.16	2
Winter	NADP-Bennington	0.07	0.09	0.15	0.17	12
Winter	NADP-Underhill	0.04	0.06	0.10	0.10	12

Seasonal Wet Deposition by Chemical 1997

Chemical: Cl **Concentration Units:** mg/l

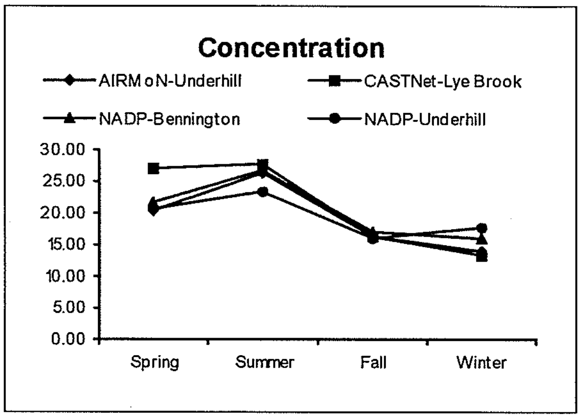




Season	Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
Spring	AIRMoN-Underhill	0.06	0.07	0.17	0.18	3
Spring	CASTNet-Lye Brook	0.11	0.13	0.32	0.21	2
Spring	NADP-Bennington	0.12	0.13	0.25	0.31	12
Spring	NADP-Underhill	0.07	0.08	0.15	0.23	12
Summer	AIRMoN-Underhill	0.06	0.05	0.23	0.20	3
Summer	CASTNet-Lye Brook	0.08	0.07	0.22	0.19	2
Summer	NADP-Bennington	0.10	0.09	0.19	0.23	12
Summer	NADP-Underhill	0.06	0.06	0.25	0.19	12
Fall	AIRMoN-Underhill	0.05	0.04	0.13	0.12	3
Fall	CASTNet-Lye Brook	0.06	0.08	0.16	0.25	2
Fall	NADP-Bennington	0.10	0.13	0.24	0.34	12
Fall	NADP-Underhill	0.06	0.08	0.17	0.19	12
Winter	AIRMoN-Underhill	0.10	0.13	0.26	0.17	3
Winter	CASTNet-Lye Brook	0.06	0.11	0.13	0.29	2
Winter	NADP-Bennington	0.13	0.20	0.28	0.35	12
Winter	NADP-Underhill	0.10	0.11	0.25	0.18	12

Seasonal Wet Deposition by Chemical 1997

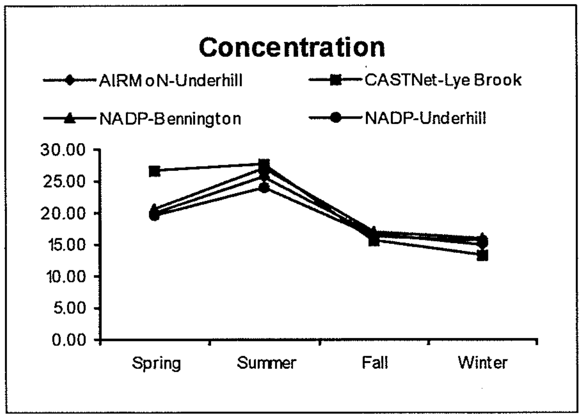
Chemical: Cond-field **Concentration Units:** uS/cm



		Concentration		Deposition (kg/ha)		
Season	Location	Current Year	Period of Record Average	Current Year	Period of Record Average	Years of Data
Spring	AIRMoN-Underhill	20.39	23.77			3
Spring	CASTNet-Lye Brook	27.11	30.76			2
Spring	NADP-Bennington	21.83	27.90			12
Spring	NADP-Underhill	20.69	21.91			12
Summer	AIRMoN-Underhill	26.50	23.28			3
Summer	CASTNet-Lye Brook	27.61	22.23			2
Summer	NADP-Bennington	26.77	34.34			12
Summer	NADP-Underhill	23.18	21.95			12
Fall	AIRMoN-Underhill	16.46	13.51			3
Fall	CASTNet-Lye Brook	16.22	13.42			2
Fall	NADP-Bennington	16.89	19.20			12
Fall	NADP-Underhill	16.08	18.18			12
Winter	AIRMoN-Underhill	14.14	18.88			3
Winter	CASTNet-Lye Brook	13.21	16.50			2
Winter	NADP-Bennington	16.12	22.14			12
Winter	NADP-Underhill	17.80	21.74			12

Seasonal Wet Deposition by Chemical 1997

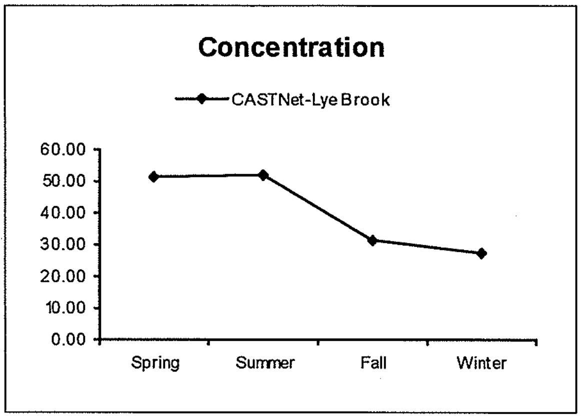
Chemical: Cond-lab **Concentration Units:** uS/cm



Season	Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
Spring	AIRMoN-Underhill	20.09	24.16			3
Spring	CASTNet-Lye Brook	26.76	30.43			2
Spring	NADP-Bennington	20.55	26.66			12
Spring	NADP-Underhill	19.62	20.37			12
Summer	AIRMoN-Underhill	25.66	23.57			3
Summer	CASTNet-Lye Brook	27.80	22.16			2
Summer	NADP-Bennington	27.12	29.69			12
Summer	NADP-Underhill	23.94	22.41			12
Fall	AIRMoN-Underhill	16.65	14.80			3
Fall	CASTNet-Lye Brook	15.75	13.18			2
Fall	NADP-Bennington	17.05	18.07			12
Fall	NADP-Underhill	16.20	17.57			12
Winter	AIRMoN-Underhill	14.97	20.86			3
Winter	CASTNet-Lye Brook	13.37	16.41			2
Winter	NADP-Bennington	16.03	19.76			12
Winter	NADP-Underhill	15.60	20.56			12

Seasonal Wet Deposition by Chemical 1997

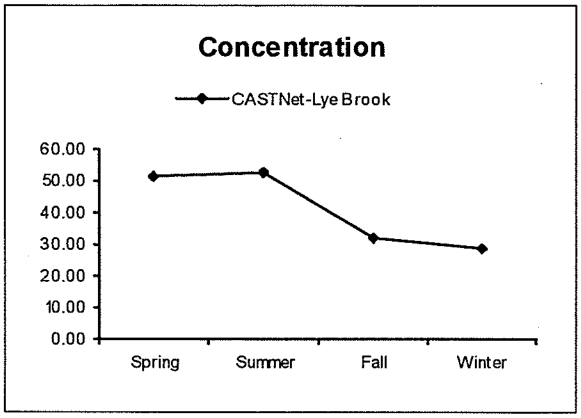
Chemical: H **Concentration Units:** ueq/l



Season	Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
Spring	CASTNet-Lye Brook	51.07	60.14			2
Summer	CASTNet-Lye Brook	51.78	43.89			2
Fall	CASTNet-Lye Brook	31.51	28.06			2
Winter	CASTNet-Lye Brook	27.22	37.63			2

Seasonal Wet Deposition by Chemical 1997

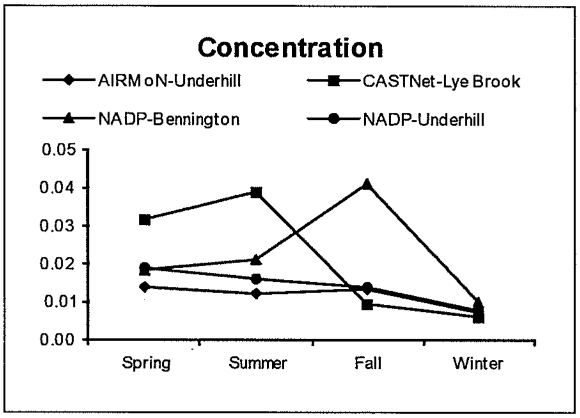
Chemical: H unfiltered **Concentration Units:** ueq/l

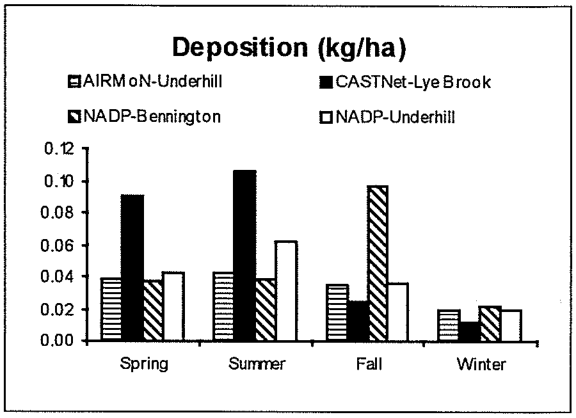


Season	Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
Spring	CASTNet-Lye Brook	51.51	60.36			2
Summer	CASTNet-Lye Brook	52.87	44.90			2
Fall	CASTNet-Lye Brook	32.33	28.30			2
Winter	CASTNet-Lye Brook	28.34	39.20			2

Seasonal Wet Deposition by Chemical 1997

Chemical: K **Concentration Units:** mg/l

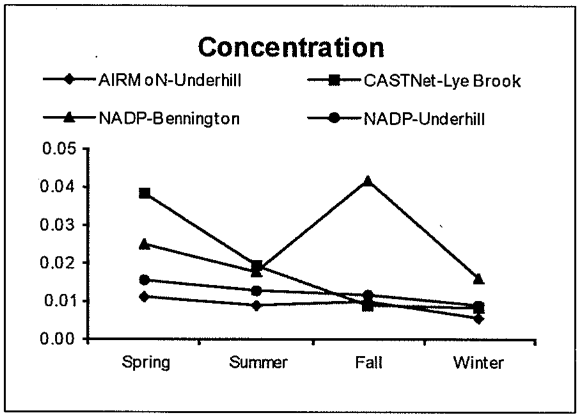


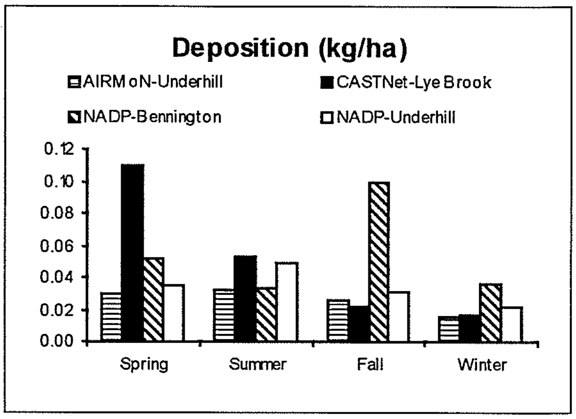


Season	Location	Concentration		Deposition (kg/ha)		Years of Data
		Current Year	Period of Record Average	Current Year	Period of Record Average	
Spring	AIRMoN-Underhill	0.01	0.02	0.04	0.06	3
Spring	CASTNet-Lye Brook	0.03	0.04	0.09	0.06	2
Spring	NADP-Bennington	0.02	0.03	0.04	0.06	12
Spring	NADP-Underhill	0.02	0.02	0.04	0.06	12
Summer	AIRMoN-Underhill	0.01	0.01	0.04	0.05	3
Summer	CASTNet-Lye Brook	0.04	0.03	0.11	0.07	2
Summer	NADP-Bennington	0.02	0.01	0.04	0.03	12
Summer	NADP-Underhill	0.02	0.02	0.06	0.04	12
Fall	AIRMoN-Underhill	0.01	0.01	0.04	0.03	3
Fall	CASTNet-Lye Brook	0.01	0.03	0.02	0.11	2
Fall	NADP-Bennington	0.04	0.02	0.10	0.06	12
Fall	NADP-Underhill	0.01	0.02	0.04	0.06	12
Winter	AIRMoN-Underhill	0.01	0.01	0.02	0.02	3
Winter	CASTNet-Lye Brook	0.01	0.01	0.01	0.02	2
Winter	NADP-Bennington	0.01	0.01	0.02	0.02	12
Winter	NADP-Underhill	0.01	0.01	0.02	0.02	12

Seasonal Wet Deposition by Chemical 1997

Chemical: Mg **Concentration Units:** mg/l

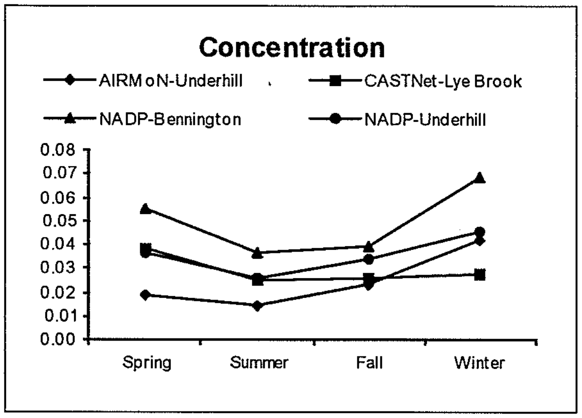


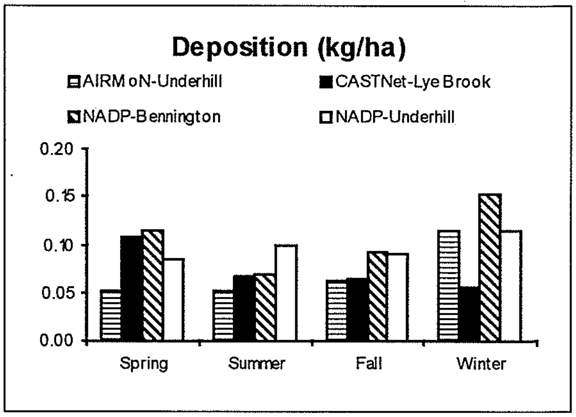


		Concentration		Deposition (kg/ha)		
Season	**Location**	**Current Year**	**Period of Record Average**	**Current Year**	**Period of Record Average**	**Years of Data**
Spring	AIRMoN-Underhill	0.01	0.01	0.03	0.04	3
Spring	CASTNet-Lye Brook	0.04	0.03	0.11	0.06	2
Spring	NADP-Bennington	0.03	0.03	0.05	0.06	12
Spring	NADP-Underhill	0.02	0.02	0.03	0.05	12
Summer	AIRMoN-Underhill	0.01	0.01	0.03	0.04	3
Summer	CASTNet-Lye Brook	0.02	0.02	0.05	0.04	2
Summer	NADP-Bennington	0.02	0.02	0.03	0.04	12
Summer	NADP-Underhill	0.01	0.01	0.05	0.04	12
Fall	AIRMoN-Underhill	0.01	0.01	0.03	0.02	3
Fall	CASTNet-Lye Brook	0.01	0.01	0.02	0.03	2
Fall	NADP-Bennington	0.04	0.02	0.10	0.05	12
Fall	NADP-Underhill	0.01	0.01	0.03	0.03	12
Winter	AIRMoN-Underhill	0.01	0.01	0.02	0.01	3
Winter	CASTNet-Lye Brook	0.01	0.01	0.02	0.03	2
Winter	NADP-Bennington	0.02	0.02	0.04	0.04	12
Winter	NADP-Underhill	0.01	0.01	0.02	0.02	12

Seasonal Wet Deposition by Chemical 1997

Chemical: Na **Concentration Units:** mg/l

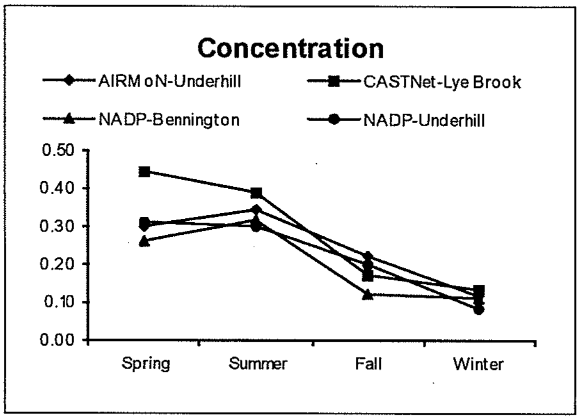


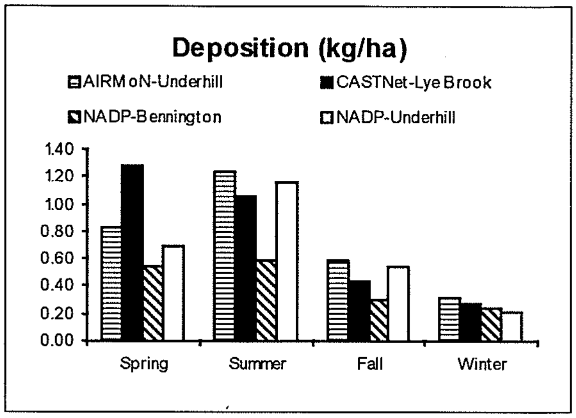


Season	Location	Concentration		Deposition (kg/ha)		Years of Data
		Current Year	Period of Record Average	Current Year	Period of Record Average	
Spring	AIRMoN-Underhill	0.02	0.02	0.05	0.06	3
Spring	CASTNet-Lye Brook	0.04	0.04	0.11	0.07	2
Spring	NADP-Bennington	0.05	0.06	0.11	0.16	12
Spring	NADP-Underhill	0.04	0.05	0.08	0.12	12
Summer	AIRMoN-Underhill	0.01	0.01	0.05	0.05	3
Summer	CASTNet-Lye Brook	0.02	0.02	0.07	0.05	2
Summer	NADP-Bennington	0.04	0.04	0.07	0.10	12
Summer	NADP-Underhill	0.03	0.03	0.10	0.09	12
Fall	AIRMoN-Underhill	0.02	0.02	0.06	0.05	3
Fall	CASTNet-Lye Brook	0.03	0.03	0.06	0.10	2
Fall	NADP-Bennington	0.04	0.08	0.09	0.20	12
Fall	NADP-Underhill	0.03	0.04	0.09	0.11	12
Winter	AIRMoN-Underhill	0.04	0.05	0.11	0.07	3
Winter	CASTNet-Lye Brook	0.03	0.06	0.06	0.15	2
Winter	NADP-Bennington	0.07	0.12	0.15	0.22	12
Winter	NADP-Underhill	0.05	0.06	0.11	0.10	12

Seasonal Wet Deposition by Chemical 1997

Chemical: NH4 **Concentration Units:** mg/l

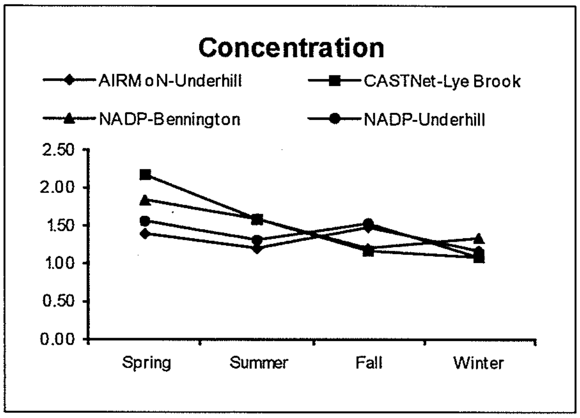


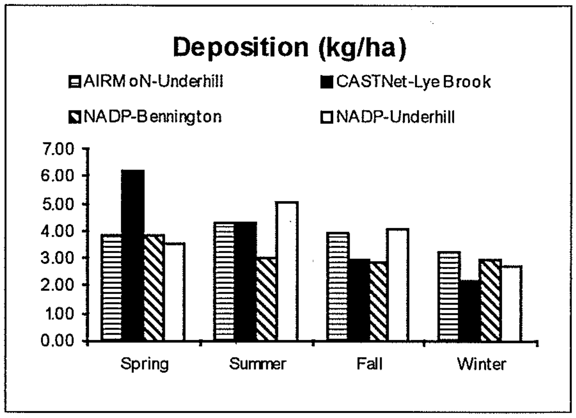


		Concentration		Deposition (kg/ha)		
Season	Location	Current Year	Period of Record Average	Current Year	Period of Record Average	Years of Data
Spring	AIRMoN-Underhill	0.30	0.37	0.82	1.00	3
Spring	CASTNet-Lye Brook	0.45	0.52	1.27	0.84	2
Spring	NADP-Bennington	0.26	0.33	0.54	0.78	12
Spring	NADP-Underhill	0.31	0.30	0.70	0.78	12
Summer	AIRMoN-Underhill	0.34	0.34	1.24	1.21	3
Summer	CASTNet-Lye Brook	0.39	0.30	1.05	0.84	2
Summer	NADP-Bennington	0.31	0.29	0.59	0.75	12
Summer	NADP-Underhill	0.30	0.25	1.16	0.78	12
Fall	AIRMoN-Underhill	0.22	0.16	0.59	0.43	3
Fall	CASTNet-Lye Brook	0.17	0.14	0.44	0.40	2
Fall	NADP-Bennington	0.12	0.13	0.30	0.33	12
Fall	NADP-Underhill	0.20	0.18	0.54	0.45	12
Winter	AIRMoN-Underhill	0.12	0.17	0.32	0.25	3
Winter	CASTNet-Lye Brook	0.14	0.13	0.27	0.32	2
Winter	NADP-Bennington	0.11	0.14	0.25	0.25	12
Winter	NADP-Underhill	0.08	0.17	0.20	0.25	12

Seasonal Wet Deposition by Chemical 1997

Chemical: NO3 **Concentration Units:** mg/l

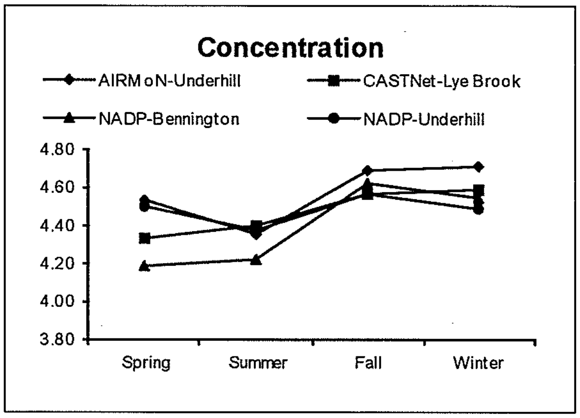




Season	Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
Spring	AIRMoN-Underhill	1.40	1.50	3.81	4.03	3
Spring	CASTNet-Lye Brook	2.17	2.35	6.17	3.96	2
Spring	NADP-Bennington	1.84	1.90	3.83	4.53	12
Spring	NADP-Underhill	1.55	1.44	3.51	3.86	12
Summer	AIRMoN-Underhill	1.19	1.09	4.27	3.95	3
Summer	CASTNet-Lye Brook	1.59	1.31	4.29	3.74	2
Summer	NADP-Bennington	1.60	1.59	2.98	4.04	12
Summer	NADP-Underhill	1.30	1.18	5.02	3.55	12
Fall	AIRMoN-Underhill	1.46	1.16	3.92	3.13	3
Fall	CASTNet-Lye Brook	1.18	0.98	2.95	2.94	2
Fall	NADP-Bennington	1.19	1.34	2.84	3.38	12
Fall	NADP-Underhill	1.53	1.34	4.07	3.39	12
Winter	AIRMoN-Underhill	1.17	1.93	3.21	2.63	3
Winter	CASTNet-Lye Brook	1.07	1.30	2.16	3.33	2
Winter	NADP-Bennington	1.32	1.72	2.94	3.05	12
Winter	NADP-Underhill	1.09	2.01	2.74	3.10	12

Seasonal Wet Deposition by Chemical 1997

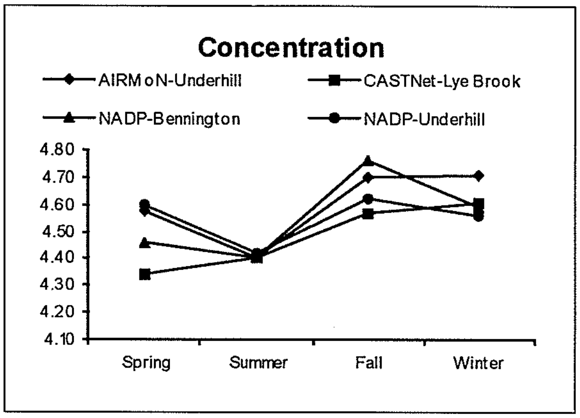
Chemical: pH-field **Concentration Units:**



Season	Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
Spring	AIRMoN-Underhill	4.54	4.43			3
Spring	CASTNet-Lye Brook	4.33	4.25			2
Spring	NADP-Bennington	4.19	4.32			12
Spring	NADP-Underhill	4.50	4.49			12
Summer	AIRMoN-Underhill	4.36	4.43			3
Summer	CASTNet-Lye Brook	4.41	4.46			2
Summer	NADP-Bennington	4.22	4.23			12
Summer	NADP-Underhill	4.37	4.43			12
Fall	AIRMoN-Underhill	4.69	4.72			3
Fall	CASTNet-Lye Brook	4.57	4.62			2
Fall	NADP-Bennington	4.62	4.52			12
Fall	NADP-Underhill	4.56	4.57			12
Winter	AIRMoN-Underhill	4.71	4.47			3
Winter	CASTNet-Lye Brook	4.59	4.46			2
Winter	NADP-Bennington	4.55	4.42			12
Winter	NADP-Underhill	4.49	4.46			12

Seasonal Wet Deposition by Chemical 1997

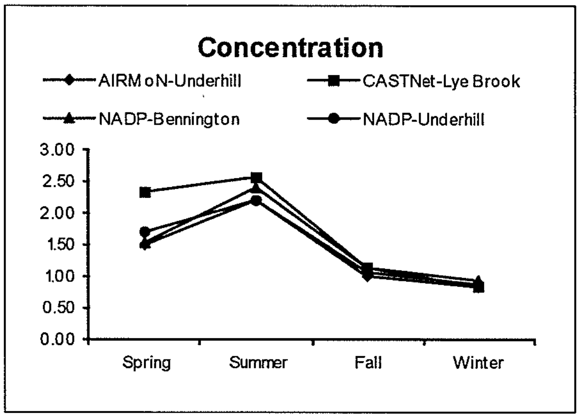
Chemical: pH-lab **Concentration Units:**

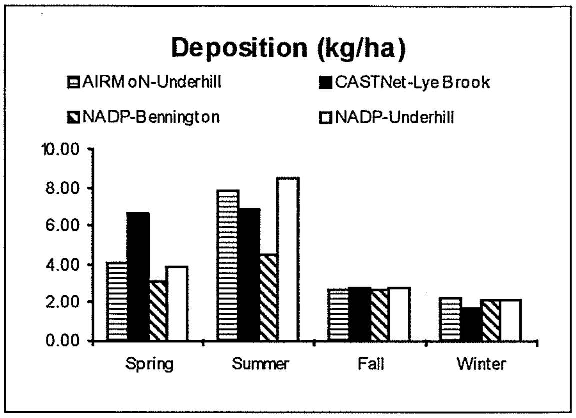


		Concentration		Deposition (kg/ha)		
Season	**Location**	**Current Year**	**Period of Record Average**	**Current Year**	**Period of Record Average**	**Years of Data**
Spring	AIRMoN-Underhill	4.58	4.48			3
Spring	CASTNet-Lye Brook	4.34	4.25			2
Spring	NADP-Bennington	4.46	4.39			12
Spring	NADP-Underhill	4.60	4.54			12
Summer	AIRMoN-Underhill	4.40	4.50			3
Summer	CASTNet-Lye Brook	4.40	4.46			2
Summer	NADP-Bennington	4.40	4.33			12
Summer	NADP-Underhill	4.42	4.44			12
Fall	AIRMoN-Underhill	4.70	4.75			3
Fall	CASTNet-Lye Brook	4.57	4.62			2
Fall	NADP-Bennington	4.76	4.61			12
Fall	NADP-Underhill	4.62	4.59			12
Winter	AIRMoN-Underhill	4.71	4.51			3
Winter	CASTNet-Lye Brook	4.61	4.48			2
Winter	NADP-Bennington	4.59	4.51			12
Winter	NADP-Underhill	4.56	4.49			12

Seasonal Wet Deposition by Chemical 1997

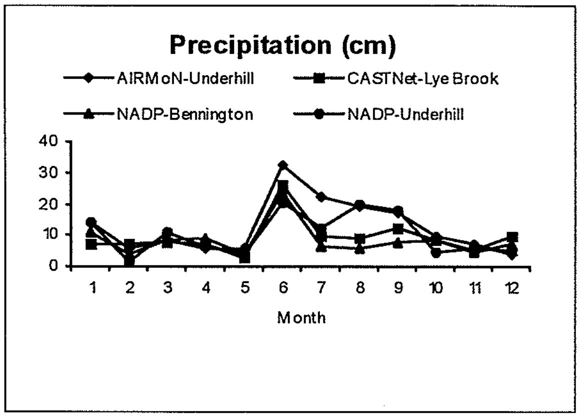
Chemical: SO4 **Concentration Units:** mg/l





		Concentration		Deposition (kg/ha)		
Season	Location	Current Year	Period of Record Average	Current Year	Period of Record Average	Years of Data
Spring	AIRMoN-Underhill	1.49	1.95	4.06	5.45	3
Spring	CASTNet-Lye Brook	2.33	2.74	6.65	4.40	2
Spring	NADP-Bennington	1.52	2.42	3.15	5.75	12
Spring	NADP-Underhill	1.69	1.88	3.84	5.07	12
Summer	AIRMoN-Underhill	2.18	2.07	7.86	7.57	3
Summer	CASTNet-Lye Brook	2.56	2.07	6.92	5.90	2
Summer	NADP-Bennington	2.42	2.80	4.51	7.16	12
Summer	NADP-Underhill	2.20	2.20	8.50	6.59	12
Fall	AIRMoN-Underhill	1.01	0.87	2.69	2.30	3
Fall	CASTNet-Lye Brook	1.12	0.94	2.82	2.84	2
Fall	NADP-Bennington	1.13	1.34	2.69	3.31	12
Fall	NADP-Underhill	1.06	1.32	2.82	3.34	12
Winter	AIRMoN-Underhill	0.83	1.03	2.28	1.58	3
Winter	CASTNet-Lye Brook	0.83	1.09	1.68	2.80	2
Winter	NADP-Bennington	0.95	1.30	2.11	2.25	12
Winter	NADP-Underhill	0.86	1.16	2.16	1.79	12

Monthly Wet Deposition: Precipitation 1997



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	13.72	7.24	3
February	5.94	4.34	3
March	8.18	7.39	2
April	5.75	10.23	2
May	5.50	8.77	3
June	32.31	10.59	3
July	21.95	13.77	3
August	18.95	14.18	3
September	17.32	9.67	3
October	9.80	9.52	3
November	7.12	9.64	3
December	3.67	8.44	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	7.16	3.33	1
February	6.76	7:39	1
March	7.65	10.77	1
April	7.19	12.52	1
May	2.39	12.27	1
June	25.96	5.22	2
July	9.50	16.32	2
August	8.84	6.06	2
September	11.91	10.01	2
October	8.33	10.54	2
November	5.08	9.36	2
December	9.25	12.97	2

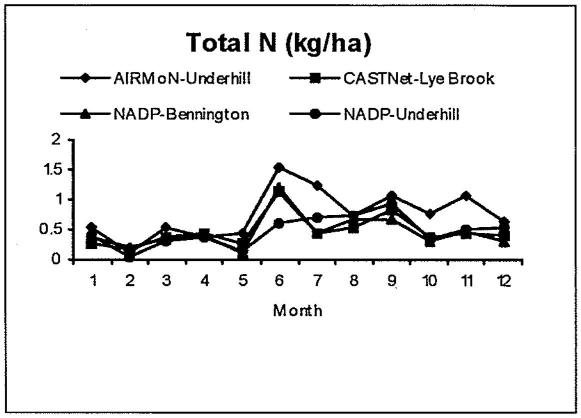
Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	10.72	6.74	12
February	4.11	3.89	12
March	8.13	6.87	12
April	8.61	8.48	12
May	3.90	7.76	12
June	23.32	7.95	12
July	6.12	9.07	12
August	5.91	10.49	11
September	7.32	7.62	11
October	8.53	9.07	12
November	4.50	9.00	12
December	7.14	7.28	11

Location NADP-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	14.15	6.58	12
February	1.40	4.06	12
March	10.72	6.67	12
April	6.07	8.67	12
May	3.53	8.79	12
June	20.55	8.97	12
July	11.86	9.48	12
August	19.89	12.05	12
September	17.73	10.10	12
October	4.60	11.36	12
November	5.65	7.14	12
December	4.94	5.97	12

Monthly Wet Deposition: Total Nitrogen Deposition 1997



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.52	0.30	3
February	0.10	0.31	3
March	0.54	0.53	2
April	0.36	0.66	2
May	0.44	0.53	3
June	1.53	0.79	3
July	1.23	0.79	3
August	0.74	0.60	3
September	1.06	0.47	3
October	0.75	0.34	3
November	1.08	0.31	3
December	0.65	0.34	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.27	0.34	1
February	0.18	0.14	1
March	0.38	0.81	1
April	0.42	0.69	1
May	0.26	0.98	1
June	1.14	0.73	2
July	0.43	0.71	2
August	0.54	0.28	2
September	0.82	0.42	2
October	0.35	0.40	2
November	0.44	0.24	2
December	0.41	0.40	2

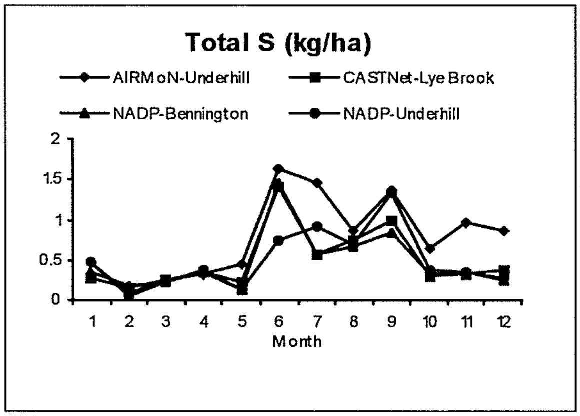
Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.36	0.27	12
February	0.20	0.31	12
March	0.34	0.41	12
April	0.40	0.55	12
May	0.12	0.49	12
June	1.19	0.60	12
July	0.42	0.53	12
August	0.65	0.65	11
September	0.68	0.32	11
October	0.30	0.41	12
November	0.45	0.30	12
December	0.30	0.31	11

Location NADP-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.41	0.30	12
February	0.05	0.29	12
March	0.32	0.35	12
April	0.37	0.52	12
May	0.13	0.43	12
June	0.59	0.51	12
July	0.70	0.46	12
August	0.73	0.48	12
September	0.94	0.48	12
October	0.35	0.43	12
November	0.49	0.30	12
December	0.53	0.35	12

Monthly Wet Deposition: Total Sulfur Deposition 1997



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.48	0.14	3
February	0.07	0.19	3
March	0.24	0.34	2
April	0.33	0.60	2
May	0.44	0.44	3
June	1.62	1.08	3
July	1.45	0.99	3
August	0.85	1.00	3
September	1.37	0.51	3
October	0.64	0.32	3
November	0.97	0.21	3
December	0.86	0.19	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.28	0.20	1
February	0.16	0.18	1
March	0.26	0.63	1
April	0.35	0.74	1
May	0.21	0.85	1
June	1.40	0.81	2
July	0.56	0.93	2
August	0.75	0.41	2
September	0.98	0.51	2
October	0.29	0.44	2
November	0.31	0.19	2
December	0.36	0.41	2

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.36	0.23	12
February	0.16	0.27	12
March	0.22	0.39	12
April	0.33	0.60	12
May	0.11	0.59	12
June	1.47	0.86	12
July	0.58	0.80	12
August	0.66	1.09	11
September	0.83	0.51	11
October	0.31	0.47	12
November	0.34	0.30	12
December	0.26	0.28	11

Location NADP-Underhill

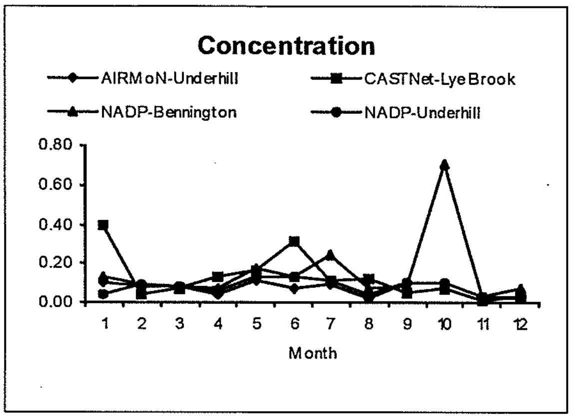
Month	Current Year	Period of Record Average	Years of Data
January	0.46	0.20	12
February	0.04	0.17	12
March	0.23	0.28	12
April	0.38	0.51	12
May	0.13	0.52	12
June	0.73	0.71	12
July	0.91	0.67	12
August	0.68	0.81	12
September	1.34	0.73	12
October	0.36	0.52	12
November	0.34	0.24	12
December	0.27	0.22	12

Monthly Wet Deposition by Chemical 1997

Chemical: Ca

Concentration

Units: mg/l



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.10	0.05	3
February	0.08	0.17	3
March	0.08	0.06	2
April	0.04	0.08	2
May	0.11	0.20	3
June	0.07	0.08	3
July	0.09	0.09	3
August	0.02	0.04	3
September	0.10	0.09	3
October	0.10	0.06	3
November	0.03	0.03	3
December	0.02	0.02	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.39	0.39	1
February	0.04	0.04	1
March	0.07	0.07	1
April	0.13	0.13	1
May	0.16	0.16	1
June	0.31	0.21	2
July	0.11	0.08	2
August	0.12	0.10	2
September	0.05	0.04	2
October	0.08	0.06	2
November	0.01	0.01	2
December	0.03	0.03	2

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.13	0.08	12
February	0.09	0.11	12
March	0.08	0.13	12
April	0.07	0.14	12
May	0.17	0.17	12
June	0.13	0.14	12
July	0.24	0.11	12
August	0.07	0.08	11
September	0.08	0.07	11
October	0.71	0.17	12
November	0.03	0.07	12
December	0.07	0.21	11

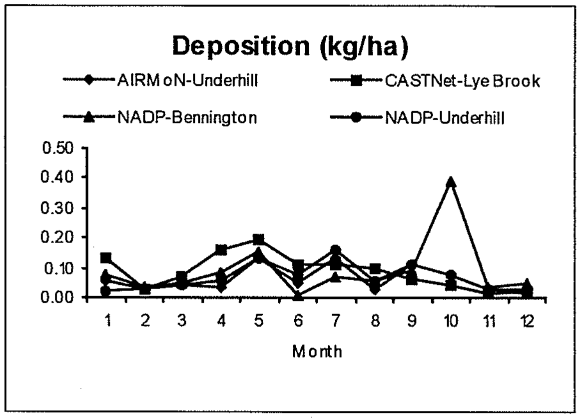
Location NADP-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.04	0.05	12
February	0.09	0.07	12
March	0.08	0.10	12
April	0.06	0.14	12
May	0.13	0.11	12
June	0.13	0.13	12
July	0.11	0.10	12
August	0.04	0.06	12
September	0.10	0.07	12
October	0.10	0.08	12
November	0.03	0.04	12
December	0.03	0.07	12

Monthly Wet Deposition by Chemical 1997

Chemical: Ca

Deposition



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.06	0.03	3
February	0.03	0.09	3
March	0.04	0.04	2
April	0.03	0.09	2
May	0.13	0.14	3
June	0.05	0.09	3
July	0.13	0.12	3
August	0.03	0.06	3
September	0.11	0.09	3
October	0.07	0.04	3
November	0.03	0.03	3
December	0.01	0.02	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.13	0.13	1
February	0.03	0.03	1
March	0.07	0.07	1
April	0.16	0.16	1
May	0.20	0.20	1
June	0.11	0.09	2
July	0.11	0.11	2
August	0.10	0.07	2
September	0.06	0.04	2
October	0.04	0.06	2
November	0.02	0.01	2
December	0.02	0.03	2

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.07	0.05	12
February	0.04	0.05	12
March	0.05	0.09	12
April	0.08	0.10	12
May	0.15	0.11	12
June	0.01	0.10	12
July	0.07	0.08	12
August	0.05	0.07	11
September	0.09	0.04	11
October	0.39	0.12	12
November	0.03	0.06	12
December	0.05	0.07	11

Location NADP-Underhill

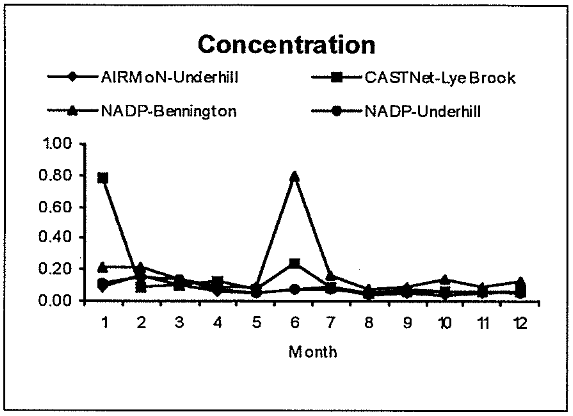
Month	Current Year	Period of Record Average	Years of Data
January	0.02	0.03	12
February	0.03	0.02	12
March	0.04	0.06	12
April	0.06	0.10	12
May	0.13	0.10	12
June	0.08	0.10	12
July	0.16	0.08	12
August	0.06	0.07	12
September	0.11	0.07	12
October	0.07	0.09	12
November	0.03	0.03	12
December	0.03	0.04	12

Monthly Wet Deposition by Chemical 1997

Chemical: Cl

Concentration

Units: mg/l



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.08	0.07	3
February	0.17	0.13	3
March	0.11	0.08	2
April	0.06	0.07	2
May	0.05	0.05	3
June	0.07	0.07	3
July	0.08	0.07	3
August	0.04	0.04	3
September	0.05	0.05	3
October	0.04	0.04	3
November	0.05	0.05	3
December	0.06	0.04	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.78	0.78	1
February	0.09	0.09	1
March	0.10	0.10	1
April	0.12	0.12	1
May	0.07	0.07	1
June	0.24	0.19	2
July	0.08	0.06	2
August	0.06	0.06	2
September	0.07	0.06	2
October	0.06	0.10	2
November	0.06	0.08	2
December	0.06	0.05	2

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.21	0.19	12
February	0.21	0.24	12
March	0.14	0.18	12
April	0.09	0.17	12
May	0.09	0.11	12
June	0.80	0.17	12
July	0.16	0.09	12
August	0.07	0.10	11
September	0.09	0.10	11
October	0.14	0.14	12
November	0.09	0.12	12
December	0.13	0.61	11

Location NADP-Underhill

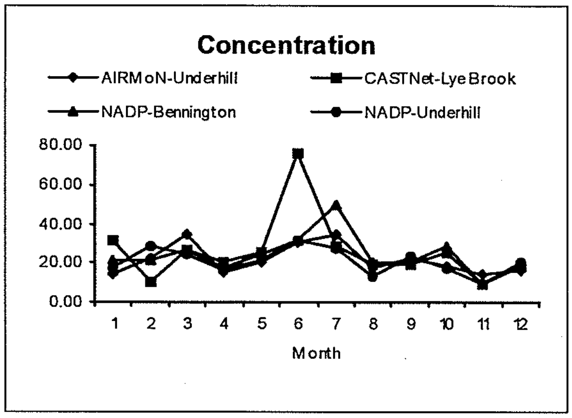
Month	Current Year	Period of Record Average	Years of Data
January	0.11	0.11	12
February	0.16	0.13	12
March	0.14	0.11	12
April	0.07	0.10	12
May	0.05	0.08	12
June	0.08	0.08	12
July	0.07	0.07	12
August	0.04	0.06	12
September	0.07	0.06	12
October	0.06	0.07	12
November	0.06	0.09	12
December	0.06	0.11	12

Monthly Wet Deposition by Chemical 1997

Chemical: Cond-field

Concentration

Units: uS/cm



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	14.44	11.59	3
February	22.73	19.60	3
March	34.27	27.18	2
April	14.69	21.97	2
May	19.88	15.71	3
June	30.77	32.43	3
July	34.34	27.99	3
August	17.00	22.29	3
September	22.26	18.28	3
October	17.86	17.30	3
November	14.66	10.25	3
December	15.73	14.30	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	31.82	31.82	1
February	10.36	10.36	1
March	26.49	26.49	1
April	19.83	19.83	1
May	25.80	25.80	1
June	75.70	55.05	2
July	28.71	21.11	2
August	18.97	22.05	2
September	19.41	18.58	2
October	25.75	18.94	2
November	9.41	10.45	2
December	18.63	15.59	2

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	20.96	18.71	12
February	21.41	32.68	12
March	26.21	23.02	12
April	16.92	31.49	12
May	24.37	29.24	12
June	31.36	35.03	12
July	49.52	33.85	12
August	20.63	34.84	11
September	20.21	25.76	11
October	27.97	22.44	12
November	9.05	16.03	12
December	19.97	25.11	11

Location NADP-Underhill

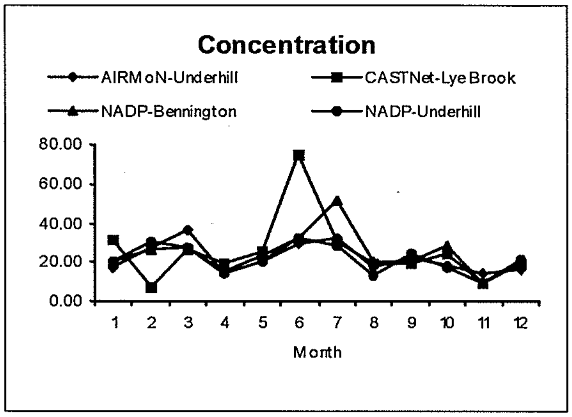
Month	Current Year	Period of Record Average	Years of Data
January	17.17	19.62	12
February	28.02	26.70	12
March	24.65	21.85	12
April	16.00	23.52	12
May	21.77	20.49	12
June	31.19	24.56	12
July	27.64	20.48	12
August	13.47	22.20	12
September	22.83	19.52	12
October	17.05	20.46	12
November	9.61	17.76	12
December	20.67	24.53	12

Monthly Wet Deposition by Chemical 1997

Chemical: Cond-lab

Concentration

Units: uS/cm



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	17.64	14.77	3
February	27.55	22.54	3
March	36.23	27.84	2
April	14.30	21.87	2
May	19.85	16.77	3
June	29.36	32.43	3
July	32.68	26.73	3
August	16.75	22.56	3
September	22.49	18.67	3
October	18.33	18.79	3
November	14.46	11.78	3
December	16.71	15.76	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	31.75	31.75	1
February	7.13	7.13	1
March	26.81	26.81	1
April	19.68	19.68	1
May	25.25	25.25	1
June	75.30	54.70	2
July	29.89	21.73	2
August	18.78	21.90	2
September	18.89	17.72	2
October	23.87	17.91	2
November	9.43	10.43	2
December	18.77	15.74	2

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	19.93	17.51	12
February	25.97	28.33	12
March	26.98	21.89	12
April	15.27	29.70	12
May	23.72	27.90	12
June	31.97	33.08	12
July	51.81	30.38	12
August	20.59	37.44	11
September	20.58	24.81	11
October	27.89	21.28	12
November	9.07	14.59	12
December	19.99	22.32	11

Location NADP-Underhill

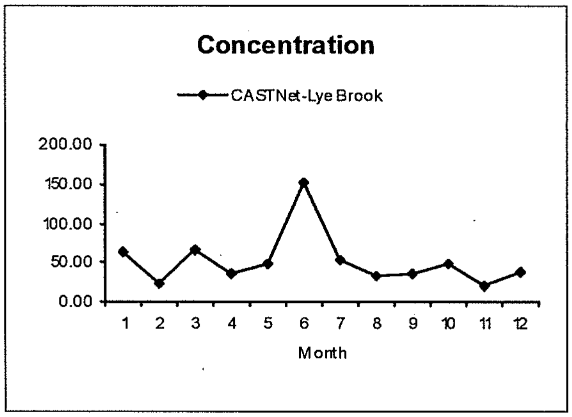
Month	Current Year	Period of Record Average	Years of Data
January	19.97	17.33	12
February	30.11	25.27	12
March	27.15	19.73	12
April	14.55	21.65	12
May	20.12	19.49	12
June	32.69	22.62	12
July	28.59	22.48	12
August	13.16	21.67	12
September	24.51	21.32	12
October	17.40	18.86	12
November	9.43	17.07	12
December	20.99	21.87	12

Monthly Wet Deposition by Chemical 1997

Chemical: H

Concentration

Units: ueq/l



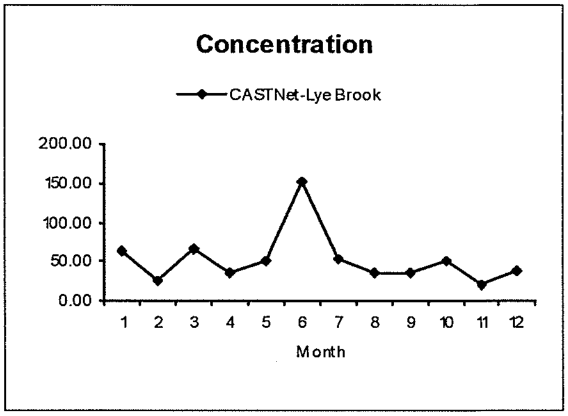
Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	64.12	64.12	1
February	21.57	21.57	1
March	65.49	65.49	1
April	36.68	36.68	1
May	49.00	49.00	1
June	151.49	110.34	2
July	52.63	40.76	2
August	33.86	44.07	2
September	35.78	37.45	2
October	47.45	36.02	2
November	19.46	24.08	2
December	38.52	35.04	2

Chemical: H unfiltered

Concentration

Units: ueq/l



Location CASTNet-Lye Brook

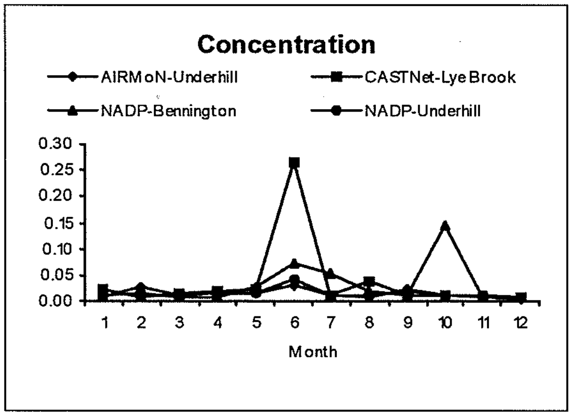
Month	Current Year	Period of Record Average	Years of Data
January	64.12	64.12	1
February	26.43	26.43	1
March	65.49	65.49	1
April	36.68	36.68	1
May	49.96	49.96	1
June	151.74	110.47	2
July	51.99	40.44	2
August	35.36	45.22	2
September	35.99	38.72	2
October	50.08	37.22	2
November	19.46	24.00	2
December	38.86	35.92	2

Monthly Wet Deposition by Chemical 1997

Chemical: K

Concentration

Units: mg/l



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.01	0.01	3
February	0.02	0.02	3
March	0.01	0.01	2
April	0.01	0.02	2
May	0.01	0.03	3
June	0.03	0.03	3
July	0.01	0.02	3
August	0.01	0.01	3
September	0.02	0.02	3
October	0.01	0.01	3
November	0.01	0.01	3
December	0.00	0.01	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.02	0.02	1
February	0.01	0.01	1
March	0.01	0.01	1
April	0.02	0.02	1
May	0.02	0.02	1
June	0.27	0.16	2
July	0.01	0.01	2
August	0.04	0.03	2
September	0.01	0.01	2
October	0.01	0.06	2
November	0.01	0.01	2
December	0.01	0.01	2

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.01	0.01	12
February	0.01	0.02	12
March	0.01	0.02	12
April	0.01	0.02	12
May	0.03	0.03	12
June	0.07	0.04	12
July	0.05	0.02	12
August	0.02	0.01	11
September	0.01	0.01	11
October	0.14	0.05	12
November	0.01	0.02	12
December	0.01	0.02	11

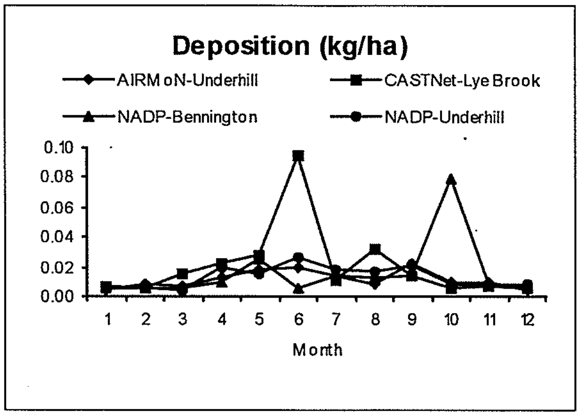
Location NADP-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.01	0.01	12
February	0.02	0.01	12
March	0.01	0.01	12
April	0.02	0.02	12
May	0.01	0.03	12
June	0.04	0.03	12
July	0.01	0.02	12
August	0.01	0.01	12
September	0.02	0.01	12
October	0.01	0.03	12
November	0.01	0.01	12
December	0.01	0.01	12

Monthly Wet Deposition by Chemical 1997

Chemical: K

Deposition



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.00	0.01	3
February	0.01	0.01	3
March	0.01	0.01	2
April	0.01	0.02	2
May	0.02	0.03	3
June	0.02	0.03	3
July	0.01	0.02	3
August	0.01	0.01	3
September	0.02	0.02	3
October	0.01	0.01	3
November	0.01	0.01	3
December	0.00	0.00	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.01	0.01	1
February	0.01	0.01	1
March	0.02	0.02	1
April	0.02	0.02	1
May	0.03	0.03	1
June	0.09	0.07	2
July	0.01	0.02	2
August	0.03	0.02	2
September	0.01	0.01	2
October	0.01	0.09	2
November	0.01	0.01	2
December	0.01	0.01	2

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.01	0.01	12
February	0.01	0.01	12
March	0.01	0.01	12
April	0.01	0.01	12
May	0.02	0.02	12
June	0.01	0.03	12
July	0.01	0.01	12
August	0.01	0.01	11
September	0.01	0.01	11
October	0.08	0.03	12
November	0.01	0.01	12
December	0.01	0.01	11

Location NADP-Underhill

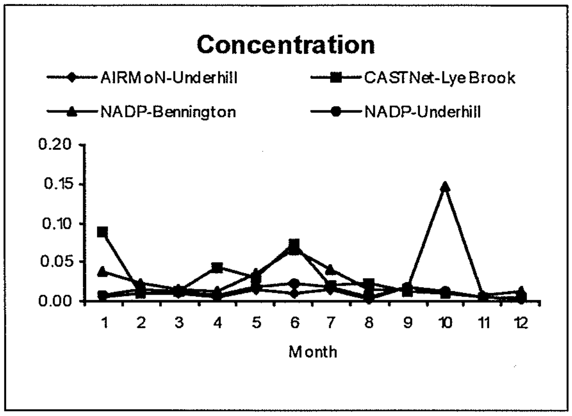
Month	Current Year	Period of Record Average	Years of Data
January	0.01	0.01	12
February	0.01	0.00	12
March	0.00	0.01	12
April	0.02	0.01	12
May	0.01	0.02	12
June	0.03	0.02	12
July	0.02	0.02	12
August	0.02	0.01	12
September	0.02	0.01	12
October	0.01	0.04	12
November	0.01	0.01	12
December	0.01	0.01	12

Monthly Wet Deposition by Chemical 1997

Chemical: Mg

Concentration

Units: mg/l



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.00	0.00	3
February	0.01	0.01	3
March	0.01	0.01	2
April	0.01	0.01	2
May	0.02	0.02	3
June	0.01	0.01	3
July	0.01	0.01	3
August	0.00	0.01	3
September	0.02	0.01	3
October	0.01	0.01	3
November	0.00	0.01	3
December	0.00	0.00	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.09	0.09	1
February	0.01	0.01	1
March	0.01	0.01	1
April	0.04	0.04	1
May	0.03	0.03	1
June	0.07	0.05	2
July	0.02	0.01	2
August	0.02	0.02	2
September	0.01	0.01	2
October	0.01	0.02	2
November	0.01	0.01	2
December	0.01	0.01	2

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.04	0.02	12
February	0.02	0.03	12
March	0.02	0.03	12
April	0.01	0.03	12
May	0.03	0.04	12
June	0.06	0.03	12
July	0.04	0.02	12
August	0.01	0.02	11
September	0.01	0.02	11
October	0.15	0.04	12
November	0.01	0.01	12
December	0.01	0.04	11

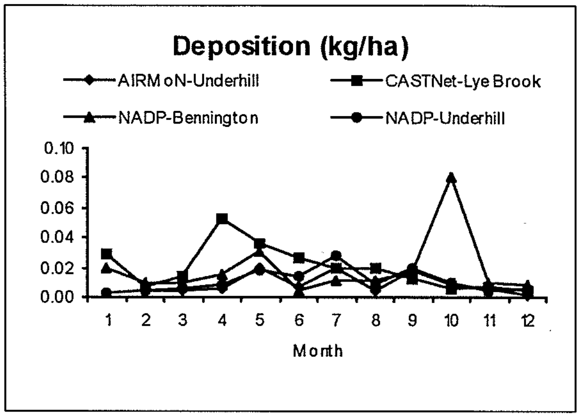
Location NADP-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.01	0.01	12
February	0.01	0.01	12
March	0.01	0.01	12
April	0.01	0.02	12
May	0.02	0.02	12
June	0.02	0.02	12
July	0.02	0.02	12
August	0.01	0.01	12
September	0.02	0.01	12
October	0.01	0.02	12
November	0.01	0.01	12
December	0.01	0.01	12

Monthly Wet Deposition by Chemical 1997

Chemical: Mg

Deposition



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.00	0.00	3
February	0.00	0.01	3
March	0.00	0.00	2
April	0.01	0.01	2
May	0.02	0.02	3
June	0.01	0.02	3
July	0.02	0.02	3
August	0.00	0.01	3
September	0.02	0.01	3
October	0.01	0.01	3
November	0.01	0.00	3
December	0.00	0.00	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.03	0.03	1
February	0.01	0.01	1
March	0.01	0.01	1
April	0.05	0.05	1
May	0.04	0.04	1
June	0.03	0.02	2
July	0.02	0.02	2
August	0.02	0.01	2
September	0.01	0.01	2
October	0.01	0.02	2
November	0.01	0.01	2
December	0.00	0.01	2

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.02	0.01	12
February	0.01	0.01	12
March	0.01	0.02	12
April	0.02	0.02	12
May	0.03	0.02	12
June	0.00	0.02	12
July	0.01	0.02	12
August	0.01	0.02	11
September	0.02	0.01	11
October	0.08	0.03	12
November	0.01	0.01	12
December	0.01	0.01	11

Location NADP-Underhill

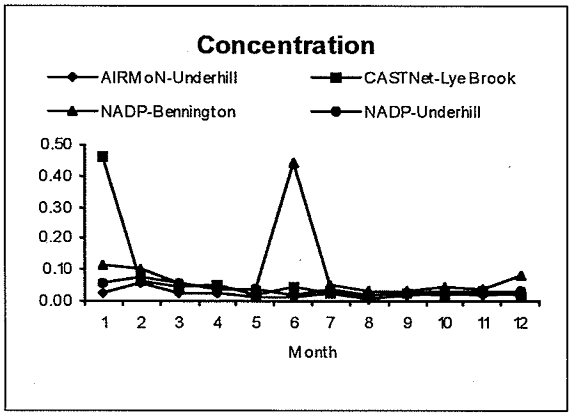
Month	Current Year	Period of Record Average	Years of Data
January	0.00	0.01	12
February	0.00	0.00	12
March	0.01	0.01	12
April	0.01	0.02	12
May	0.02	0.02	12
June	0.01	0.02	12
July	0.03	0.02	12
August	0.01	0.01	12
September	0.02	0.01	12
October	0.01	0.02	12
November	0.00	0.01	12
December	0.01	0.01	12

Monthly Wet Deposition by Chemical 1997

Chemical: Na

Concentration

Units: mg/l



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.03	0.02	3
February	0.06	0.05	3
March	0.03	0.03	2
April	0.02	0.03	2
May	0.01	0.02	3
June	0.01	0.02	3
July	0.02	0.02	3
August	0.00	0.01	3
September	0.02	0.02	3
October	0.02	0.02	3
November	0.02	0.02	3
December	0.03	0.02	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.46	0.46	1
February	0.06	0.06	1
March	0.04	0.04	1
April	0.05	0.05	1
May	0.02	0.02	1
June	0.05	0.04	2
July	0.03	0.02	2
August	0.02	0.02	2
September	0.02	0.02	2
October	0.02	0.04	2
November	0.03	0.04	2
December	0.02	0.02	2

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.11	0.11	12
February	0.10	0.15	12
March	0.06	0.11	12
April	0.04	0.09	12
May	0.04	0.05	12
June	0.44	0.08	12
July	0.05	0.04	12
August	0.03	0.04	11
September	0.03	0.05	11
October	0.05	0.10	12
November	0.04	0.07	12
December	0.08	0.40	11

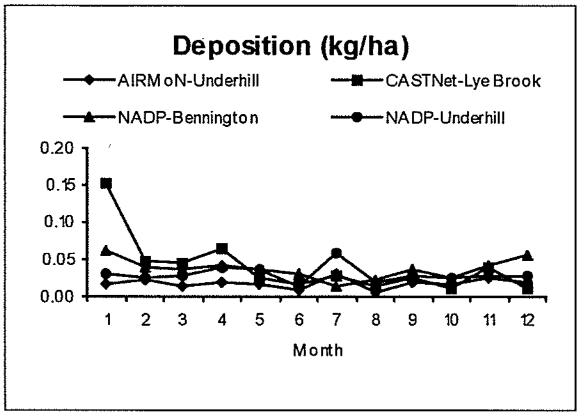
Location NADP-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.06	0.06	12
February	0.08	0.06	12
March	0.06	0.07	12
April	0.04	0.06	12
May	0.04	0.04	12
June	0.02	0.04	12
July	0.04	0.04	12
August	0.02	0.02	12
September	0.02	0.03	12
October	0.03	0.04	12
November	0.03	0.04	12
December	0.03	0.06	12

Monthly Wet Deposition by Chemical 1997

Chemical: Na

Deposition



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.02	0.02	3
February	0.02	0.02	3
March	0.01	0.02	2
April	0.02	0.03	2
May	0.02	0.01	3
June	0.01	0.02	3
July	0.03	0.03	3
August	0.01	0.01	3
September	0.02	0.02	3
October	0.02	0.01	3
November	0.02	0.02	3
December	0.02	0.01	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.15	0.15	1
February	0.05	0.05	1
March	0.05	0.05	1
April	0.06	0.06	1
May	0.03	0.03	1
June	0.02	0.02	2
July	0.03	0.03	2
August	0.01	0.01	2
September	0.03	0.02	2
October	0.01	0.05	2
November	0.04	0.03	2
December	0.01	0.02	2

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.06	0.08	12
February	0.04	0.06	12
March	0.04	0.08	12
April	0.04	0.06	12
May	0.04	0.04	12
June	0.03	0.04	12
July	0.01	0.03	12
August	0.02	0.04	11
September	0.03	0.04	11
October	0.03	0.08	12
November	0.04	0.06	12
December	0.06	0.09	11

Location NADP-Underhill

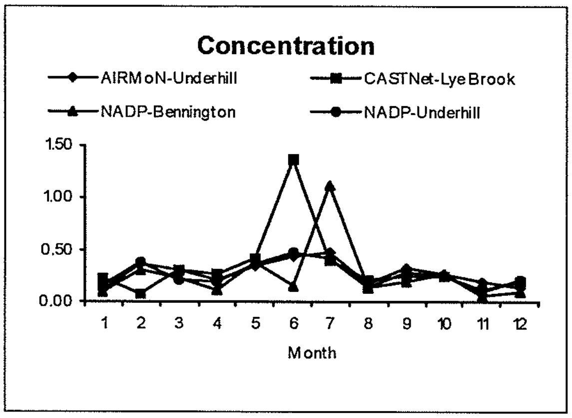
Month	Current Year	Period of Record Average	Years of Data
January	0.03	0.04	12
February	0.03	0.02	12
March	0.03	0.04	12
April	0.04	0.05	12
May	0.04	0.03	12
June	0.01	0.03	12
July	0.06	0.03	12
August	0.02	0.03	12
September	0.03	0.03	12
October	0.03	0.04	12
November	0.03	0.03	12
December	0.03	0.03	12

Monthly Wet Deposition by Chemical 1997

Chemical: NH4

Concentration

Units: mg/l



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.11	0.10	3
February	0.36	0.25	3
March	0.31	0.26	2
April	0.21	0.34	2
May	0.35	0.42	3
June	0.44	0.46	3
July	0.48	0.39	3
August	0.17	0.28	3
September	0.32	0.30	3
October	0.27	0.21	3
November	0.18	0.13	3
December	0.13	0.12	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.24	0.24	1
February	0.07	0.07	1
March	0.30	0.30	1
April	0.27	0.27	1
May	0.42	0.42	1
June	1.36	0.97	2
July	0.40	0.29	2
August	0.21	0.26	2
September	0.24	0.20	2
October	0.25	0.19	2
November	0.11	0.10	2
December	0.19	0.13	2

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.10	0.11	12
February	0.31	0.23	12
March	0.23	0.19	12
April	0.11	0.33	12
May	0.39	0.36	12
June	0.15	0.39	12
July	1.12	0.36	12
August	0.13	0.32	11
September	0.19	0.19	11
October	0.26	0.19	12
November	0.05	0.10	12
December	0.10	0.15	11

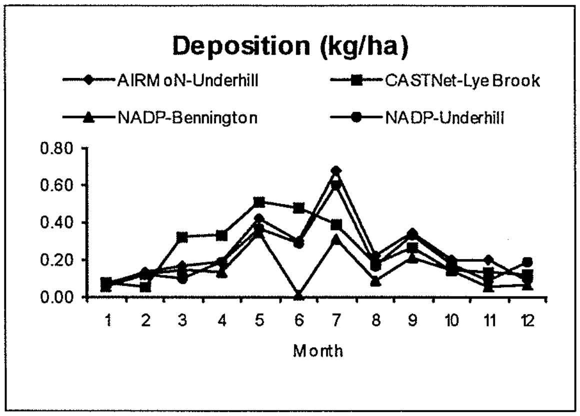
Location NADP-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.14	0.13	12
February	0.38	0.21	12
March	0.21	0.19	12
April	0.19	0.32	12
May	0.36	0.31	12
June	0.47	0.34	12
July	0.41	0.28	12
August	0.13	0.21	12
September	0.28	0.25	12
October	0.25	0.20	12
November	0.10	0.19	12
December	0.21	0.19	12

Monthly Wet Deposition by Chemical 1997

Chemical: NH4

Deposition



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.06	0.08	3
February	0.13	0.12	3
March	0.17	0.18	2
April	0.19	0.37	2
May	0.42	0.32	3
June	0.30	0.50	3
July	0.68	0.51	3
August	0.22	0.39	3
September	0.34	0.29	3
October	0.20	0.16	3
November	0.20	0.13	3
December	0.09	0.10	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.08	0.08	1
February	0.05	0.05	1
March	0.32	0.32	1
April	0.34	0.34	1
May	0.51	0.51	1
June	0.48	0.44	2
July	0.39	0.41	2
August	0.17	0.15	2
September	0.27	0.21	2
October	0.14	0.18	2
November	0.13	0.10	2
December	0.12	0.13	2

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.05	0.07	12
February	0.13	0.10	12
March	0.15	0.13	12
April	0.13	0.25	12
May	0.34	0.24	12
June	0.01	0.33	12
July	0.31	0.27	12
August	0.09	0.33	11
September	0.22	0.13	11
October	0.15	0.15	12
November	0.06	0.08	12
December	0.07	0.07	11

Location NADP-Underhill

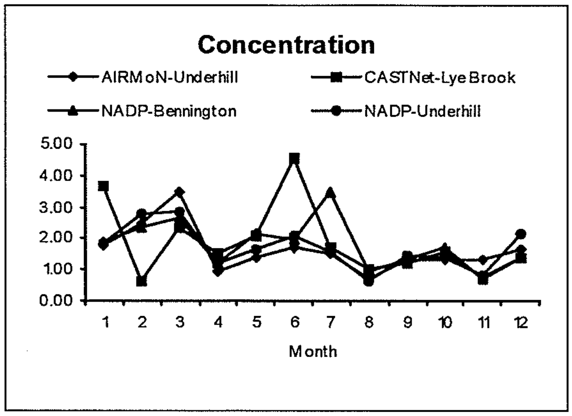
Month	Current Year	Period of Record Average	Years of Data
January	0.08	0.08	12
February	0.13	0.08	12
March	0.10	0.12	12
April	0.19	0.24	12
May	0.36	0.23	12
June	0.29	0.31	12
July	0.60	0.26	12
August	0.17	0.26	12
September	0.33	0.26	12
October	0.18	0.19	12
November	0.09	0.13	12
December	0.19	0.10	12

Monthly Wet Deposition by Chemical 1997

Chemical: NO3

Concentration

Units: mg/l



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	1.75	1.48	3
February	2.47	2.26	3
March	3.48	2.60	2
April	0.96	1.54	2
May	1.41	1.40	3
June	1.72	1.64	3
July	1.51	1.33	3
August	0.72	0.92	3
September	1.36	1.07	3
October	1.33	1.30	3
November	1.32	0.94	3
December	1.62	1.49	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	3.69	3.69	1
February	0.62	0.62	1
March	2.31	2.31	1
April	1.50	1.50	1
May	2.07	2.07	1
June	4.57	3.55	2
July	1.70	1.26	2
August	1.04	1.30	2
September	1.20	1.12	2
October	1.58	1.26	2
November	0.75	0.77	2
December	1.38	1.13	2

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	1.88	1.45	12
February	2.31	2.54	12
March	2.63	1.90	12
April	1.19	2.18	12
May	2.18	2.00	12
June	1.94	1.94	12
July	3.48	1.73	12
August	0.95	1.86	11
September	1.35	1.41	11
October	1.70	1.54	12
November	0.72	1.15	12
December	1.40	2.16	11

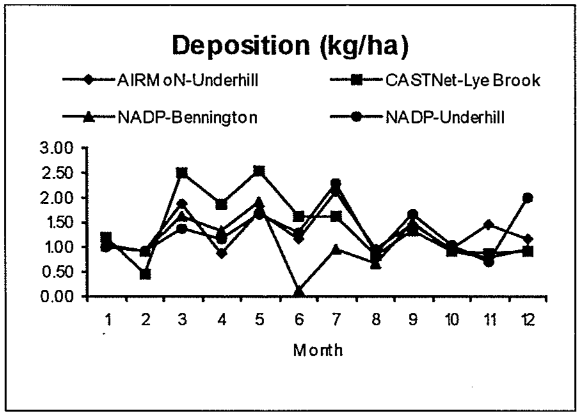
Location NADP-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	1.87	1.69	12
February	2.77	2.59	12
March	2.86	1.85	12
April	1.21	1.83	12
May	1.65	1.32	12
June	2.08	1.38	12
July	1.59	1.29	12
August	0.66	1.05	12
September	1.45	1.18	12
October	1.42	1.27	12
November	0.83	1.45	12
December	2.17	2.25	12

Monthly Wet Deposition by Chemical 1997

Chemical: NO3

Deposition



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	1.00	1.05	3
February	0.90	1.00	3
March	1.89	1.74	2
April	0.87	1.65	2
May	1.70	1.26	3
June	1.17	1.77	3
July	2.11	1.73	3
August	0.96	1.32	3
September	1.44	1.05	3
October	0.98	0.96	3
November	1.46	0.92	3
December	1.16	1.15	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	1.23	1.23	1
February	0.46	0.46	1
March	2.49	2.49	1
April	1.88	1.88	1
May	2.55	2.55	1
June	1.62	1.68	2
July	1.63	1.76	2
August	0.84	0.74	2
September	1.35	1.13	2
October	0.91	1.17	2
November	0.90	0.72	2
December	0.90	1.30	2

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	1.02	0.96	12
February	0.93	1.04	12
March	1.64	1.36	12
April	1.34	1.60	12
May	1.91	1.38	12
June	0.14	1.51	12
July	0.96	1.40	12
August	0.68	1.76	11
September	1.49	0.97	11
October	0.94	1.27	12
November	0.77	1.02	12
December	0.96	1.12	11

Location NADP-Underhill

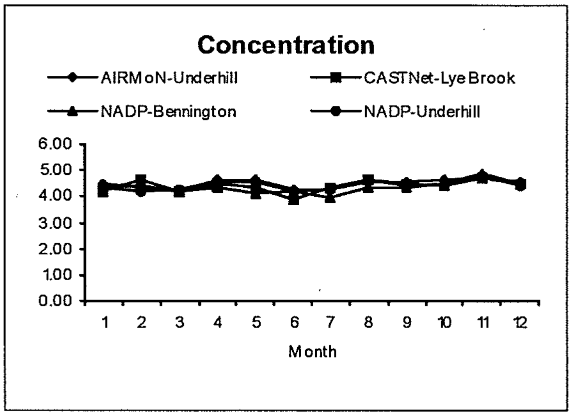
Month	Current Year	Period of Record Average	Years of Data
January	0.99	1.06	12
February	0.92	1.00	12
March	1.37	1.16	12
April	1.18	1.46	12
May	1.67	1.12	12
June	1.27	1.20	12
July	2.31	1.14	12
August	0.86	1.20	12
September	1.69	1.24	12
October	1.04	1.24	12
November	0.72	0.89	12
December	1.98	1.19	12

Monthly Wet Deposition by Chemical 1997

Chemical: pH-field

Concentration

Units:



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	4.46	4.56	3
February	4.29	4.39	3
March	4.16	4.40	2
April	4.62	4.46	2
May	4.64	4.78	3
June	4.22	4.26	3
July	4.22	4.37	3
August	4.55	4.43	3
September	4.56	4.59	3
October	4.65	4.65	3
November	4.73	4.80	3
December	4.59	4.61	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	4.21	4.21	1
February	4.61	4.61	1
March	4.20	4.20	1
April	4.47	4.47	1
May	4.31	4.31	1
June	3.88	4.02	2
July	4.33	4.46	2
August	4.62	4.48	2
September	4.48	4.47	2
October	4.37	4.52	2
November	4.73	4.68	2
December	4.52	4.54	2

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	4.36	4.47	12
February	4.44	4.28	12
March	4.15	4.36	12
April	4.30	4.27	12
May	4.09	4.39	12
June	4.21	4.27	12
July	3.97	4.19	12
August	4.33	4.18	11
September	4.30	4.37	11
October	4.47	4.49	12
November	4.88	4.58	12
December	4.47	4.43	11

Location NADP-Underhill

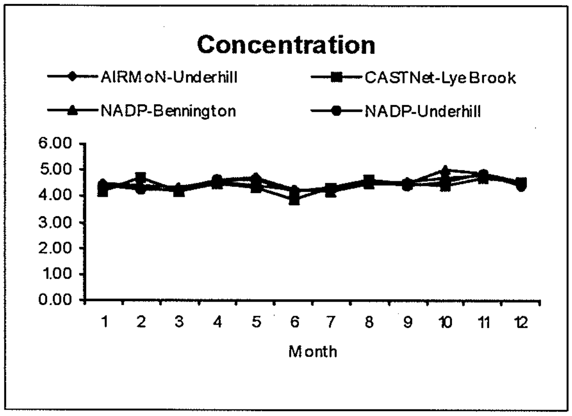
Month	Current Year	Period of Record Average	Years of Data
January	4.35	4.52	12
February	4.19	4.35	12
March	4.24	4.48	12
April	4.57	4.43	12
May	4.53	4.55	12
June	4.20	4.47	12
July	4.28	4.46	12
August	4.60	4.43	12
September	4.37	4.44	12
October	4.49	4.56	12
November	4.81	4.58	12
December	4.43	4.42	12

Monthly Wet Deposition by Chemical 1997

Chemical: pH-lab

Concentration

Units:



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	4.49	4.65	3
February	4.33	4.51	3
March	4.18	4.40	2
April	4.64	4.48	2
May	4.70	4.89	3
June	4.27	4.27	3
July	4.26	4.48	3
August	4.59	4.47	3
September	4.55	4.62	3
October	4.68	4.69	3
November	4.76	4.84	3
December	4.57	4.63	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	4.21	4.21	1
February	4.72	4.72	1
March	4.20	4.20	1
April	4.47	4.47	1
May	4.31	4.31	1
June	3.88	4.02	2
July	4.31	4.45	2
August	4.60	4.47	2
September	4.49	4.48	2
October	4.38	4.52	2
November	4.73	4.67	2
December	4.53	4.55	2

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	4.46	4.53	12
February	4.44	4.34	12
March	4.32	4.49	12
April	4.53	4.31	12
May	4.41	4.38	12
June	4.27	4.31	12
July	4.19	4.31	12
August	4.47	4.21	11
September	4.50	4.43	11
October	4.99	4.58	12
November	4.85	4.72	12
December	4.54	4.55	11

Location NADP-Underhill

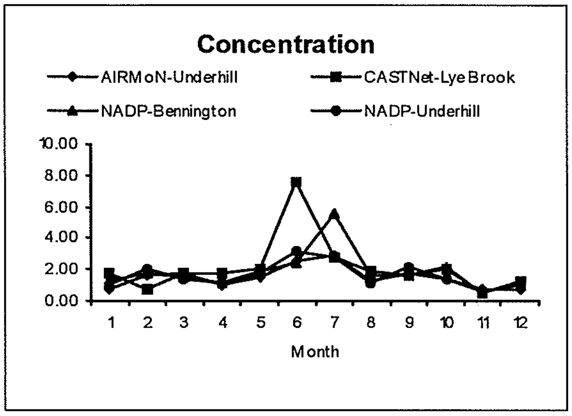
Month	Current Year	Period of Record Average	Years of Data
January	4.41	4.55	12
February	4.27	4.39	12
March	4.29	4.54	12
April	4.64	4.51	12
May	4.66	4.61	12
June	4.21	4.50	12
July	4.32	4.47	12
August	4.66	4.43	12
September	4.44	4.46	12
October	4.56	4.56	12
November	4.88	4.59	12
December	4.41	4.46	12

Monthly Wet Deposition by Chemical 1997

Chemical: SO4

Concentration

Units: mg/l



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.79	0.61	3
February	1.67	1.27	3
March	1.82	1.47	2
April	0.98	1.66	2
May	1.58	1.35	3
June	2.48	2.86	3
July	2.86	2.33	3
August	1.32	2.02	3
September	1.79	1.54	3
October	1.34	1.26	3
November	0.77	0.66	3
December	0.76	0.72	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	1.77	1.77	1
February	0.74	0.74	1
March	1.74	1.74	1
April	1.78	1.78	1
May	2.08	2.08	1
June	7.64	5.39	2
July	2.74	2.01	2
August	1.84	2.12	2
September	1.60	1.53	2
October	2.04	1.50	2
November	0.51	0.65	2
December	1.24	1.05	2

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	1.23	1.16	12
February	1.77	1.86	12
March	1.49	1.59	12
April	1.08	2.62	12
May	1.95	2.64	12
June	2.41	3.22	12
July	5.59	2.95	12
August	1.71	3.52	11
September	1.66	2.17	11
October	2.11	1.70	12
November	0.45	1.02	12
December	1.31	1.37	11

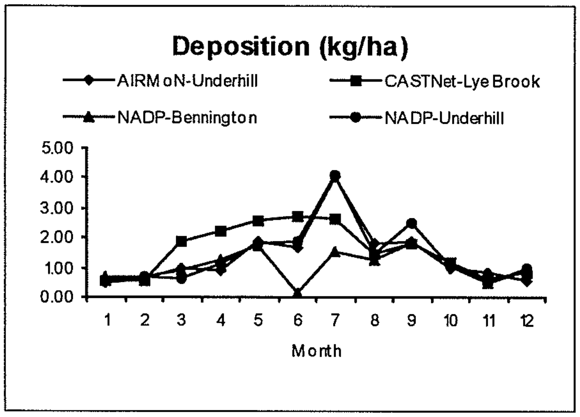
Location NADP-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	1.05	0.95	12
February	2.02	1.36	12
March	1.36	1.32	12
April	1.12	1.93	12
May	1.75	1.87	12
June	3.10	2.32	12
July	2.80	2.23	12
August	1.12	2.11	12
September	2.12	2.03	12
October	1.40	1.56	12
November	0.57	1.19	12
December	1.08	1.23	12

Monthly Wet Deposition by Chemical 1997

Chemical: SO4

Deposition



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.45	0.43	3
February	0.61	0.58	3
March	0.99	1.02	2
April	0.88	1.78	2
May	1.90	1.33	3
June	1.69	3.25	3
July	4.01	2.95	3
August	1.78	3.01	3
September	1.90	1.52	3
October	0.99	0.96	3
November	0.85	0.63	3
December	0.54	0.55	3

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.59	0.59	1
February	0.55	0.55	1
March	1.87	1.87	1
April	2.23	2.23	1
May	2.56	2.56	1
June	2.72	2.44	2
July	2.64	2.79	2
August	1.48	1.23	2
September	1.80	1.54	2
October	1.18	1.33	2
November	0.61	0.57	2
December	0.81	1.24	2

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.67	0.70	12
February	0.71	0.80	12
March	0.93	1.15	12
April	1.22	1.79	12
May	1.71	1.78	12
June	0.17	2.56	12
July	1.54	2.39	12
August	1.24	3.27	11
September	1.83	1.52	11
October	1.16	1.40	12
November	0.48	0.91	12
December	0.90	0.84	11

Location NADP-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.56	0.60	12
February	0.67	0.52	12
March	0.65	0.85	12
April	1.09	1.53	12
May	1.78	1.57	12
June	1.90	2.13	12
July	4.08	2.00	12
August	1.45	2.44	12
September	2.47	2.19	12
October	1.03	1.57	12
November	0.50	0.73	12
December	0.98	0.65	12

Vermont Acid Precipitation Monitoring Program

Data Summary Report 1980-1997 for Underhill and Mt. Mansfield

Heather Pembrook
Vermont Department of Environmental Conservation
Biomonitoring and Aquatic Studies Section

Cooperators:

UVM Proctor Maple Research Center: Joanne Cummings and Mim Pendleton
WCAX-TV Mt. Mansfield Transmitter Station: Michael Rainey
Stowe Mountain Resort and Simon Operating Systems: Michael Bernadine

Abstract:

The VMC monitoring stations located at Underhill and Mt. Mansfield are included in the Vermont Acid Precipitation Monitoring Program (VAPMP). The majority of bulk precipitation in Vermont is unquestionably acidic. Forty-three percent of all events occur between the pH of 4.1 - 4.6. Ninety-four percent of all precipitation events have a pH of less than 5.60, the theoretical pH of unpolluted rain. Typically, both sites have lower volume-weighted pH means in the summer than in the winter. Mt. Mansfield, Underhill and a site located in Morrisville were examined for elevational and spatial variations. The sites can be characterized from lowest to highest pH; Mt. Mansfield, Underhill and Morrisville. In addition, a lower pH can be expected on the west side of the Green Mountains due to storm fronts moving west to east.

Introduction:

The Department of Environmental Conservation (DEC) began monitoring precipitation events via the Vermont Acid Precipitation Program (VAPMP). The program was initiated in 1980 to assess the impact of the 1970 Clean Air Act, which mandated the improvement of air quality in the vicinity of midwestern and southeastern fossil fuel burning plants. Precipitation samples are collected on an event basis by dedicated volunteers at five sites throughout Vermont (Mt. Mansfield, Underhill, Morrisville, Holland, and St. Johnsbury).

Methods:

Bulk precipitation is collected and measured on an event basis. Precipitation amount and pH are measured for each event. The pH is measured with a Cole Parmer digital pH meter model 5987 and a Cole Parmer combination electrode with a calomel reference.

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

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

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

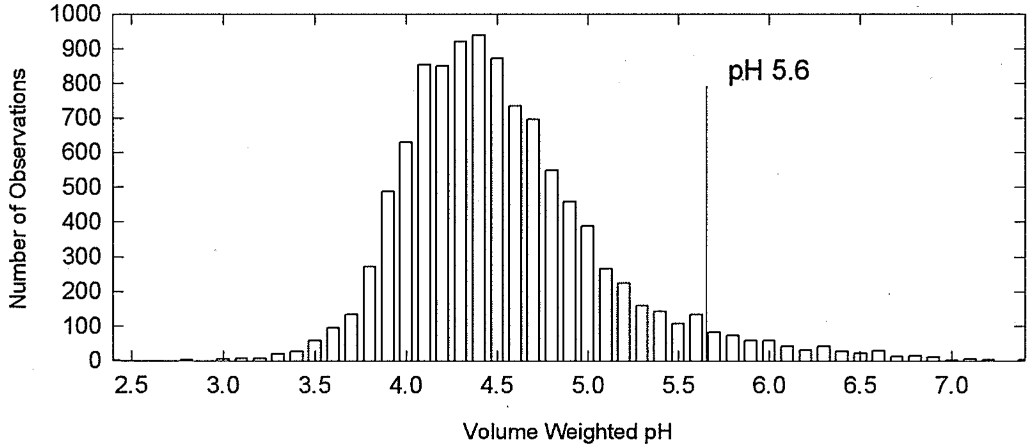
The pH meters are calibrated with buffers 4.00 and 7.00 prior to each use. To ensure that the electrodes are working properly, the monitors are supplied with a check sample of pH 4.70+/-0.10 at 25°C. The pH meters are professionally calibrated every year and the electrodes are replaced when they show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

Results:

Frequency of Distribution

The highest frequency of precipitation pH occurrence falls between 4.1 - 4.6. Ninety-four percent of all precipitation events from July 1980 to December 1997 are less than pH 5.60, the theoretical pH for unpolluted precipitation. Eighty-four percent of all precipitation events are between 3.00 - 5.00. The most extreme pH observations, both high and low, appear to be associated with low-volume precipitation events while high-volume events tend to have pH's toward the median of the distribution (Graph 1).

Graph 1. VAPMP Frequency Distribution for all stations, 1980-1997. 10,545 Observations



Mt. Mansfield recorded substantially lower annual volume-weighted pH in 1980, 1981, 1991, 1992 and 1994 (Table 1). In comparison to other VAPMP sites, Underhill and Mt. Mansfield usually have the lowest annual volume weighted pH.

Seasonal Variation

Summer volume-weighted means tend to be slightly lower than the winter volume-weighted means (Table 2). However, there is not a significant trend indicating that the summer means are consistently lower than the winter means.

Discussion:

The majority of bulk precipitation in Vermont is unquestionably acidic. However, based on this network there has been no clear trend indicating a statistical change in pH since 1980 in Vermont. It has been suggested that if sulfur emissions decreased, then pH would increase. The VAPMP data does not support this hypothesis. This may be due to the importance of nitrate in atmospheric chemistry, which has not been regulated as strictly as sulfur emissions. In addition, there has been a reduction of base cations in the atmosphere, which provides an atmospherically deposited buffer. This is due in part to the removal of dust particulates from emissions. With the implementation of Phase II of the 1990 Clean Air Act, nitrate emissions will be reduced, possibly improving the pH of precipitation. However, Utility Restructuring may have a profound effect on Vermont's precipitation chemistry. Older coal-powered utility plants which were grandfathered in the Clean Air Act may begin to run at full capacity. These plants are able to produce cheap energy without installing pollution prevention devices.

Although the summer volume weighted means tend to be slightly lower than the winter volume weighted means, there is no significant trend. In addition, from 1989-1994, summer means appear to be higher than the winter means. Summer data fromMt Mansfield 1997 was reamrkably low. This may be due to incomplete data. In general, a lower pH is expected in the summertime due to increases in sunlight, temperature, humidity and photochemical oxidants which enhance the chemical transformation of sulfur dioxide (SO_2) into sulfuric acid (H_2SO_4) (Allan and Mueller, 1985; Bowersox and Stensland, 1985).

Several spatial relationships have been suggested in reference to precipitation and pH in Vermont.
1) There is a decrease in pH with increasing elevation, mainly due to acidic fog; 2) a lower pH is expected to occur west of the Green Mountains as a result of storm fronts moving west to east, depositing more acidic and concentrated pollutants as they rise over the mountains (Scott, 1987).
The VAPMP data support these suggested relationships.

Future plans:

After 17 years as a monitor at the Morrisville Treatment Plant, Don Ward has retired. A new station has been created in Hyde Park, which we feel will be comparable to the Morrisville site. In addition, we have a new monitor in Holland, which replaces the Canaan/Concord site.

We continue to work out problems with the Mount Mansfield station. Inconsistent collection and processing have resulted in an incomplete data set. We are attempting to create a more consistent reporting system for the site with greater communication between the collectors (WCAX transmitter engineers) and the processor (Simon Operating Services).

References:

1. Allan, M.A., and P.K. Mueller, 1985. Precipitation chemistry in the Eastern United States. Air Pollution Control Association 78th Annual Meeting, Detroit, MI.

2. Bowersox, V.C., and G.J. Stensland, 1985. Seasonal variation in the chemistry of precipitation in the United States. Air Pollution Control Association 78th Annual Meeting, Detroit, MI.

3. Schamaun, C., 1994. Vermont acid precipitation monitoring program, data summary report, 1980-1991. Vermont Department of Environmental Conservation, Waterbury, VT.

4. Scott, J.M., 1987. Vermont acid precipitation monitoring program 1980 to 1986 results. Vermont Agency of Environmental Conservation, Waterbury, VT.

5. United States Environmental Protection Agency, 1991. Air and Radiation. Allowance system proposed acid rain rule.

Ecology

A Model of the Integrated Forest Inventory: Combining Conservation and Commodity Values using the Natural Community Classification System and the Forest Examination Inventory.

Demain J. McKinley

Evaluators
Rick Paradis, Natural Areas Manager, The Environmental Program
Walter Poleman, Teaching Associate, The Field Naturalist Program
Alicia Daniel, Associate Director, The Field Naturalist Program

Abstract

The current trend in forest management toward an ecosystem approach warrants a revision in forest inventory methods. In Vermont it has been suggested that the more traditional Forest Examination (FOREX) inventory system could benefit from being combined with the Natural Heritage Program's "natural community" inventory system, which could supply more comprehensive information about regional biological diversity. A field test was conducted on Mt. Mansfield to decide if combining the two is practical and informative. The concept of "a sense of place" is then explored in relation to the management shift to an ecosystem perspective, out of which the need for integrated inventories, such as the above, has arisen.

Introduction: The evolution, description, and creation of the integrated forest inventory

Historical changes in forest management philosophy

The philosophy of resource management in the United States has changed drastically from its beginnings in the late 19th century. Originally, Federally owned land was distributed freely to citizens, encouraging them to pick up their belongings and move westward to seek their fortune. Land management under the Homestead Act of 1862 was absent, and private use of lands was almost completely unrestricted (Loomis 1993). The creation of the United States Forest Service 1905 began a philosophy of active land management. In an age of industrial expansion, managers intervened in the rapid privatization of public lands, worried that the resources on them would eventually be depleted if no action were taken (Loomis 1993).

In the post-World War II era, the nation found itself growing more interested in public lands for their recreation value. "Increasingly in the 1950's and 1960's wilderness preservationists [were] faced with the problem of too much popularity for wilderness..." (Nash 1967:323) As awareness of the public lands grew, so did the concern for how they were being managed. The public and a faction of the scientific community became dissatisfied with the widespread logging that occurred at the expense of wildlife habitat and wild lands used for recreation. The legislative responses to this public and scientific discontent included the Multiple Use, Sustained Yield Act (MUSY) of 1960 and the National Forest Management Act in 1976 (Loomis 1993). These acts changed the mandate of the Forest Service from managing single, separate uses, to managing multiple-uses on public lands in a way that would sustain their productivity over time. The types of values in National Forests broadened to include outdoor recreation, wildlife, fisheries, and wilderness.

Both of these management policies focused too much on achieving certain amounts of forest uses at the expense of the resources themselves. "Emphasis on the use aspect of multiple use can lead to unsustainable commodity production levels that jeopardize native species of flora and fauna." (Wood 1994:7) As a result, forests have been overcut, and rangelands have been overgrazed among other emerging problems. A new idea of forest management has evolved out of the failures of the previous management philosophies.

The latest management philosophy, called ecosystem management, doesn't completely discard the frameworks or values of the previous systems, but builds on them, adding a new context to forest management. The novel element in this philosophy is its recognition of the actual place forest uses occur- the ecosystem (Wood 1994). The rationale for focusing less on particular uses and more on the environment where they occur is rather simple. The human uses and values (recreation, timber, wilderness, etc.) are inseparable from the forests where they occur and if the integrity of the forest (aquatic, grassland, etc.) ecosystem is compromised, so too are the uses that depend on the forest. Another important addition of ecosystem management recognizes that ecosystem boundaries overlap political and social boundaries. Consequently this framework encourages cooperation among the people and the political institutions affected by management decisions.

What we see is an evolution in management philosophy toward acknowledging the intricacies of the land and the inherent interconnectedness of all managed resources within the ecological, social, and political context of a certain place. As resource management philosophy exchanges the view of the landscape as fragmented individual uses for one of forest uses as integrated and inseparable from the forest out of which the originate, revised views of how to partition the landscape into management units arise.

Elements of an integrated forest inventory

Emerging thought in forestry has moved toward a model of management called "forest zoning" which includes three types of forest management areas (Hunter 1990). First, forests of special ecological significance or high biodiversity value are preserved. Second, high productivity forests with no special ecological significance are managed in a way analogous to intensive agriculture, placing value on the lumber yield. Third, and most challenging, are the "working landscapes" which integrate both economic and ecological values on the same pieces of land. This third type, where multiple uses occur together, is much more widespread than the other two types of forest (Poleman 1996a). It is therefore important to define a responsible management planning process for these working landscapes that integrates different, and sometimes conflicting, values.

Poleman (1996a) identifies 5 stages of the forest management planning process: 1. determining objectives, 2. assessing current forest condition, 3. determining desired forest condition, 4. designing and implementing a management plan, and 5. monitoring results of the management plan. Of these five, this study focuses on the second, assessing current forest condition: the forest inventory. It is an important step since a forest management plan designed without knowledge of a forest's biological, ecological and physiographical character lacks a foundation on which to stand.

As management perspectives evolve, so must the types of information gathered in forest inventories. Since management practices are tending toward the integration of various values, forest inventories necessarily are shaped to inform this goal. This study explores a model of forest inventory that informs integrated management in what Poleman (1996b) has termed an "integrated forest inventory."

An integrated inventory informs management by combining various values in a forest ecosystem. "Integration implies more than just employing different approaches side by side; it is the merging of objectives so that (1) information gathering activities inform both conservation and commodity perspectives (and are therefore cost-effective), and (2) management prescriptions promote both objectives simultaneously" (Poleman 1996a). In order to construct an integrated inventory, one must choose which values to focus on, whether human use values or conservation values. It is important to understand the components of a forest inventory before delving into specific examples and then trying to construct an integrated inventory out of them.

The forest inventory

At the basis of any inventory is a value judgment of what is important in a forest. Different types of data are collected depending on the lens one chooses to look through. If timber is important, then tree girth, height, and quality will be measured. If conservation of biological diversity is the focus, then species composition and distribution will be emphasized.

Two tools are used to describe the forest. First is a classification system that draws boundaries around relatively homogenous patches of vegetation that recur across a landscape called "landscape elements" (Poleman 1996a). The criteria for classification is commonly the dominant vegetation, whether that means the plants that dominate the canopy, or are the most abundant in non-forest ecosystems (Noss 1987). Bailey (1996:1) summarizes the purpose of this tool well "Land classification is the process of arranging or ordering information about land units so we can better understand their similarities and relationships." It can give context to an individual tract of forest within a larger landscape.

The second tool is a detailed inventory of the landscape element composition (Poleman 1996a). The inventory does not attempt to measure and describe every square inch of each landscape element, an endeavor that would be extremely time consuming and virtually impossible.

Data is collected in a systematic fashion from representative samples across a tract of land. The results are then generalized to the rest of the parcel as an estimate of its actual composition.

Because of budget and time constraints, it is important that an inventory be carried out as efficiently as possible. One doesn't want to gather too much relevant information or gather excessive information that ultimately doesn't inform the original goals of the inventory. Doing either of these could make the inventory procedures too cumbersome and/or expensive to implement (Poleman 1996a).

Ideas for the creation of an integrated forest inventory can be drawn from systems that already exist; there is no need to start from scratch since the best of existing inventories can be combined. First, the values that are going to be integrated must be chosen, Poleman (1996a) posed the question, can the two primary ways the public views forests, as an economic entity for the extraction of products and as habitat for plants and wildlife be integrated? These commodity and conservation values will be the goals integrated in this inventory. The Forest Examination inventory of the Vermont Parks and Recreation Department, a modified timber cruise, informs the timber value of a forested parcel and will be the first inventory used in this study. The Natural Heritage Program's inventory of the "elements of diversity" is specifically tailored to locate biodiversity and inform conservation decisions, and therefore is an appropriate system to assess the conservation value for this integrated inventory.

Forest Examination (FOREX)

Forest Examination (FOREX) is modeled after a traditional approach to inventory called a timber cruise, focusing on the volume, type and quality of lumber on a forested parcel (Vile 1989). It classifies the dominant vegetation using the Society of American Forester's *cover type*. The advantage of cover type is that it is easy to identify and delineate using aerial photographs. The detailed inventory utilizes both a variable plot method (using a 10 factor prism) to assess basal area, augmented with optional fixed radii plots for understory analysis (Vile 1989), FOREX represents a step toward the integrated inventory by incorporating information about wildlife habitat and significant physiographic features on an assessed parcel of land. However, FOREX doesn't collect enough information on biodiversity to inform conservation decisions. Biodiversity data includes information on some game species such as deer and the understory vegetation data gathered is oriented toward plant species that may inhibit the regeneration of commercially important tree species (Poleman 1996b). Therefore it serves as an effective analysis of standing timber, but not the ideal tool for biodiversity inventory.

The Natural Heritage Program's "Elements of Diversity" inventory

The "elements of diversity" inventory system used by the Natural Heritage Program is designed to inventory and catalogue biological diversity and therefore could serve as a valuable supplementary tool for FOREX. It was created by The Nature Conservancy in 1974 with the goal of standardizing conservation inventory attempts which previously had been localized, short term, and unconnected (Jenkins 1978). This new inventory system included an ongoing state by state inventory that focused on the "Elements of Diversity" rather than on specific sites (Jenkins 1978). These elements are at two different levels of biological organization, individual species and natural communities, and also include significant physiographic features that influence biological patterns across the landscape (Noss 1987). The advantage of this approach is that the abundance and rarity of each element can be compared across its range. Since this system is an ongoing inventory, the status of each element can be monitored over time and conservation energies can be redirected as the condition of certain elements change. The scope of this inventory system is now expanding from statewide to a regional and eventually national system do that rarity can be assessed over much larger areas.

It is a hierarchical classification system that utilizes a "dual filter" approach. The "coarse filter" searches for natural communities which are characterized by the dominant plant species that recur in recognizable patterns across a landscape. By preserving a full range of natural communities that occur in a particular region, other species associated with the dominant plants will be conserved as well. In this way, this system serves as a "filter" or net catching the dominant and associated species together. The Nature Conservancy estimates that 85-90% of the species can be conserved this way (Hunter et al. 1988). This inventory system is an iterative process by which natural community designations are refined and further delineated as more time is spent in the field identifying them. Simultaneously, a second filter or "fine filter" approach is used which catalogues and indexes rare and endangered species that may have been missed by the coarse filter approach.

Within this classification system, as stated above, natural communities are the fundamental units, delineated by the Natural Heritage Program for each state using secondary sources such as scientific literature, herbaria and museums, knowledgeable people, and new fieldwork (Noss 1987). The inventory is conducted by outlining potential communities on aerial photos, then visiting the sites and adjusting the boundaries of the natural communities using a quadrat methodology.

The Integrated Inventory - combining conservation and commodity values

In order to make this integrated inventory worthwhile, I selected the aspects of each of these two systems that were most useful, and eliminated the aspects though to overly burden fieldwork. Since one goal of this inventory is to supply information about the economic potential of a forest parcel, the two tools of FOREX, inventory and classification system, are necessary. The other goal, to provide information for biodiversity conservation, can be addressed by using the natural community classification system. Since this integrated inventory is designed for use by anybody from landowners to state foresters, the detailed inventory of the natural community system using quadrats would be, I hypothesize, too time consuming to implement and therefore will be excluded. The estimation of natural communities can be done comparing site characteristics to the community descriptions summarized in the guide by Liz Thompson (1996) called Natural Communities of Vermont: Uplands and Wetlands.

The information gathered in this integrated inventory, I hypothesize, will reveal more than if FOREX and the natural community classification inventory were conducted separately. The value of the natural community classification lies in the relative rarity ranking, from 51- 5S (51 being the most rare and 5S the most common; S stands for State) which allows the managers of a forest parcel, whether public or private, to make decisions based on this rarity rather than just on the economic value of an area. In addition to information on the rarity of natural communities are the "element occurrence rankings" or an assessment of the quality of individual occurrences. This is designated by the community's 1)"quality" or representativeness, 2) "condition" or degree of naturalness, 3) long term survival based on surrounding natural buffers 4) *how* imperiled a community is by current human activity (The Nature Conservancy, date unknown). This is difficult to incorporate into the integrated forest inventory since it requires more research and mapping, and has not been included for the sake of efficiency. The rest of the study is spent answering the following three questions: 1) Are natural communities relevant evolutionary and ecological units? 2) Is this integrated inventory practical and useful? 3) What is a "sense of place" and *how* does it relate to new management perspectives?

Literature Review: The evolutionary and ecological relevance of Natural Communities

Natural communities defined

Sperduto (1996) justifies using natural communities as conservation inventory units for two reasons: 1) A combination of physical factors and disturbance agents in a certain region create recognizable vegetation patterns, and 2) In order to preserve biodiversity conservationists need a way to sort out these ecological patterns in a logical and understandable manner. Despite their obvious utility as a conservation unit, the following question must be asked: What is the ecological and evolutionary relevance of natural communities?

Natural communities are "recurring assemblages of organisms found in particular physical environments" (Sperduto 1996). Human influences are small or absent, hence the term natural, but may have affected the area in the past (Thompson 1996). Thompson (1996) outlines the subtle differences among the terms "natural community", "ecosystem", and "plant community". An "ecosystem" is much like a natural community and includes all the plants and animals within their physical environment, but this is not limited by scale. An ecosystem can occur under a pebble or can encompass a whole mountain range. A "plant community" includes only plants in its definition to the exclusion of animals and physical setting. The "communities" used in natural community classification include both natural and plant communities depending on how dependent the community's occurrence is on its physical environment (Noss 1987).

There are some similarities between ecosystems and natural communities that can illuminate important characteristics of the latter. Rowe and Barnes (1994) attempt to clarify the word "ecosystem" offering a division into two categories, one based on landform (soil, aspect, topography, hydrology) and one based on biotic associations. The former is referred to as "geo-ecosystems" and the latter are "bio-ecosystems". Since natural communities emphasize the plants and animals that occupy a given site, they would fall into the category of bio-ecosystems.

Whether geo-ecosystems or bio-ecosystems are used as the basis of a land classification unit depends on the managers' goals since both ways of framing ecosystems are valuable. A geo-ecosystem will emphasize a much more static unit of land, but will take the emphasis off immediate associations of biodiversity. In contrast, using a bio-ecosystem definition will do the opposite-focus on the plants and animals on a given site while taking the emphasis off the more permanent physiographic characteristics.

The evolutionary significance of natural communities

Hunter *et al.* (1988) do not believe that natural communities are a relevant unit on an evolutionary time scale. They recognize and agree with the basic premise of the natural community system: "Our concern is in identifying the best strategies for maintaining a high level of species diversity" (Hunter *et al.* 1988:382) but find three problems with natural communities:

1. They are transitory assemblages of plant and animal species.
2. They are impractical for predicting the distribution of very rare, patchily distributed species.
3. Community dominant species may not be as sensitive to environmental change as the associated species are.

Concerning the first problem, Hunter et al. (1988) use the paleoecological record (determined from pollen frequency in bog cores) as a confirmation that natural communities shouldn't be the units of conservation. Instead, ecosystems based on physiographic characteristics should since natural communities have changed their composition many times over the last 10,000 years with the end of the Wisconsonian glacial period (Davis 1981). For example, the oak-chestnut forests of the Appalachian mountains have contained chestnut as a dominant species for 5,000 years, while the oak-chestnut forests of Connecticut have included chestnut for only 2,000 years (Davis 1981). Metaphorically speaking, the justification for using geo-ecosystems is that the theater should be preserved, not the theatrical production that occurs within it. There is an immediacy to conservation efforts, though, that makes utilizing a geo-ecosystem approach problematic. Wilson (1986) describes an unprecedented fragmentation of habitats and loss of biodiversity occurring in the modern world. The time scale that we are working with is much shorter than the scale at which geo-ecosystems function, and if preserving biodiversity is the goal, a natural community approach is better suited.

The second problem raises the concern that the coarse filter method is too coarse, and rare species will go extinct through habitat loss because they were not found in time. The Nature Conservancy admits these species oversights by the very name they gave to this system: the "coarse filter". The system is meant to preserve a majority of species and then, to the degree that is possible, rare species will be found and protected by the "fine filter" approach using special conservation attention, such as the Endangered Species Act and/or private conservation efforts such as land trusts (Noss 1987).

The third problem involves situations where the dominant plant species grow in areas with different environmental characteristics that would change the understory plant species For example a red spruce/balsam fir community in the Northeast can occur at high elevation in well drained soils or within lowlands in poorly drained soils, conditions which may change the understory composition (Hunter *et al.* 1988). If this pattern is initially missed, an inconsistent community description, when discovered, can be split into two or more communities to account for new found variation.

The ecological significance of natural communities

Noss (1987) questions the actual ecological significance of natural communities because of the sampling methods used. Sampling occurs in relatively uniform homogenous areas of vegetation and therefore avoids forest edges and other heterogeneous community types. He argues that each natural community is part of a larger landscape and therefore doesn't contain ecological processes that take place on a larger spatial scale across these uniform patches of vegetation. Whole disturbance regimes are not necessarily included (depending on the type and scale), and a single community may not be connected to other community types that, when combined, are important for the life history and foraging of certain animals species.

The developers of the natural community system admit to its shortcomings. It was never meant as the definitive land classification system. Communities shift based on natural disturbance (fire, flood, blowdown), human land use (tree harvesting), and successional stage. Although natural communities are not enduring entities, this system is useful for identifying and cataloging biological diversity at various scales.

Methodology

To assess the potential benefits of combining the natural community approach with FOREX a study integrating the two was conducted in a forest managed by the Vermont Monitoring Cooperative (VMC) on the west side of Mt. Mansfield in Underhill, Vermont (Figure 1). The 210 acre parcel is located just south of Stevensville Brook and extends from about 1400 ft to

2500 ft in elevation. The relatively small size of the parcel was an asset considering the short time frame in which the study was conducted. FOREX inventory data was previously gathered by a VMC researcher during the summers of 1995 and 1996. Therefore the data gathered in this study was only of the natural communities occurring within the parcel. If this integrated inventory were actually employed in a real situation, data collection for FOREX and the natural community classification would be conducted simultaneously.

Preestablished systematic plots were laid out on the parcel for the FOREX inventory by the VMC. Each FOREX plot was revisited taking compass bearings from the Butler Lodge Trail, which vertically divides the parcel. A natural community designation was given at each plot using the Natural Communities of Vermont: Uplands and Wetlands (Thompson 1996). Revisiting these plots made comparing the FOREX data and the gathered natural community data easier since there was an actual area with which to compare the two data sets. The decision of what natural community was present was a subjective measure, whereby site characteristics were compared with community descriptions in the natural community guide.

Natural communities were designated during the "leaf off" season since many forest inventories are conducted during the winter months for maximum tree visibility (Poleman 1996 pers. comm.) This will help address the question of whether the natural community approach is viable when combined with FOREX and conducted in winter. The potential problem with a winter inventory is that the herbaceous ground layer is mostly covered by snow, and therefore cannot contribute to field identification of communities.

Results

Within the study area, five stands were outlined by the VMC using the FOREX inventory. Generally, timber was of low quality and not currently harvestable. Specific stand descriptions and management prescriptions are summarized in Appendix 1.

Two natural communities were found on the parcel. Mesic northern hardwoods forest community (Appendix 2) began at the lower extent of the parcel at 1400 ft and made a transition into a high-elevation hardwoods-spruce forest community (Appendix 3) between 2100 and 2300 ft. The mesic northern hardwood forest carries a 54 ranking while the high-elevation hardwoods-spruce forest is ranked S3. In Natural Communities of Vermont: Uplands and Wetlands, Liz Thompson (1996:32) writes,

> S3 - High quality examples are uncommon in the state, but are not rare; the community is restricted in distribution for reasons of climate, geology, soils, etc., or many high quality examples have been severely altered.
>
> S4 - The community is widespread in the state, but the number of high quality examples is low or the total acreage is relatively small.

Figure 2 shows the relationship between the stand and natural community boundaries on the Stevensville Brook parcel. The transition of the mesic northern hardwoods to transitional hardwoods occurs between the 2100 and 2300 ft. and seems related to, but doesn't exactly mirror, the boundary drawn between Stands 3 and 4.

Discussion

Advantages of natural community classification

The natural community classification provides a different way to look at forests than through a timber cruise lens. I found that my attention to communities heightened my awareness of the different layers of the forest. I noticed tree species, the understory, any animal tracks left in the snow and how these factors combined to express the character of the place.

The next step in making the natural community classification system a valuable management tool is to specify how the rarity designations should affect management prescriptions. What does it mean that the mesic northern hardwoods community is an S4 or that the transitional hardwoods is an S3 community? When should a rarity designation make a landowner cautious about cutting? Is an S4 community common enough that one should not worry about its fate? The S3 and S4 communities found within the Stevensville parcel pose some gray area in how management decisions are affected by them. In general, an S1 or S2 designation are both rare enough that managers should be cautious about altering them.

The Nature Conservancy and the Heritage Programs select their conservation priorities based on a combination of both the state and individual occurrence rankings. In light of this, introducing natural community occurrence rankings into this integrated inventory may lessen the ambiguity surrounding the meaning of the "S" rankings. For example, if a community has a S2 ranking, but is a poor example of one, then managers should be more willing to change the character of the area than if the community occurrence was of a high quality. As mentioned above, introducing occurrence rankings would require more work by the organization conducting the inventory, so an efficient system that assesses occurrence quality would need to be developed.

There are many advantages to using this natural community approach to assessing biodiversity on a parcel. First of all the classification system already exists, therefore saving the time and effort of assembling a new biodiversity classification system from scratch. Secondly, it has proven effective at cataloguing biodiversity and setting conservation priorities. Thirdly, it is an efficient, low technology system, which doesn't require any excess equipment besides the natural community guidebook and/or a working knowledge of natural communities in a particular region. Fourth, the system is an evolving inventory that grows in value as information about natural communities is updated and refined (Jenkins 1986). Lastly, many community descriptions provide information about associated wildlife species (both game and nongame) and substrate, and provide more information for managers to consider.

Another possible advantage to using the natural community classification system in this integrated inventory is it's potential to help the Vermont Nongame and Natural Heritage Program (VNNHP) add information to their ongoing database. The VNNHP ecologist, Eric Sorenson (1996 pers. comm.) mentioned that having another source of information that helps update their database on community occurrences in Vermont would be extremely valuable. Their staff of five can only do so much fieldwork and research, so if coordinated and applied correctly, the integrated inventory could supplement the VNNHP's efforts.

Difficulties and drawbacks of natural community classification

An obvious point, but one that needs to be stated, is that in order for the natural community system to work, the correct community designations need to be applied to communities in the field. From my personal observations, there are some difficulties that may affect applying the proper designations. While identifying natural communities within the Stevensville Brook parcel, I was usually second guessing myself, as no area on the parcel seemed to completely fit any one

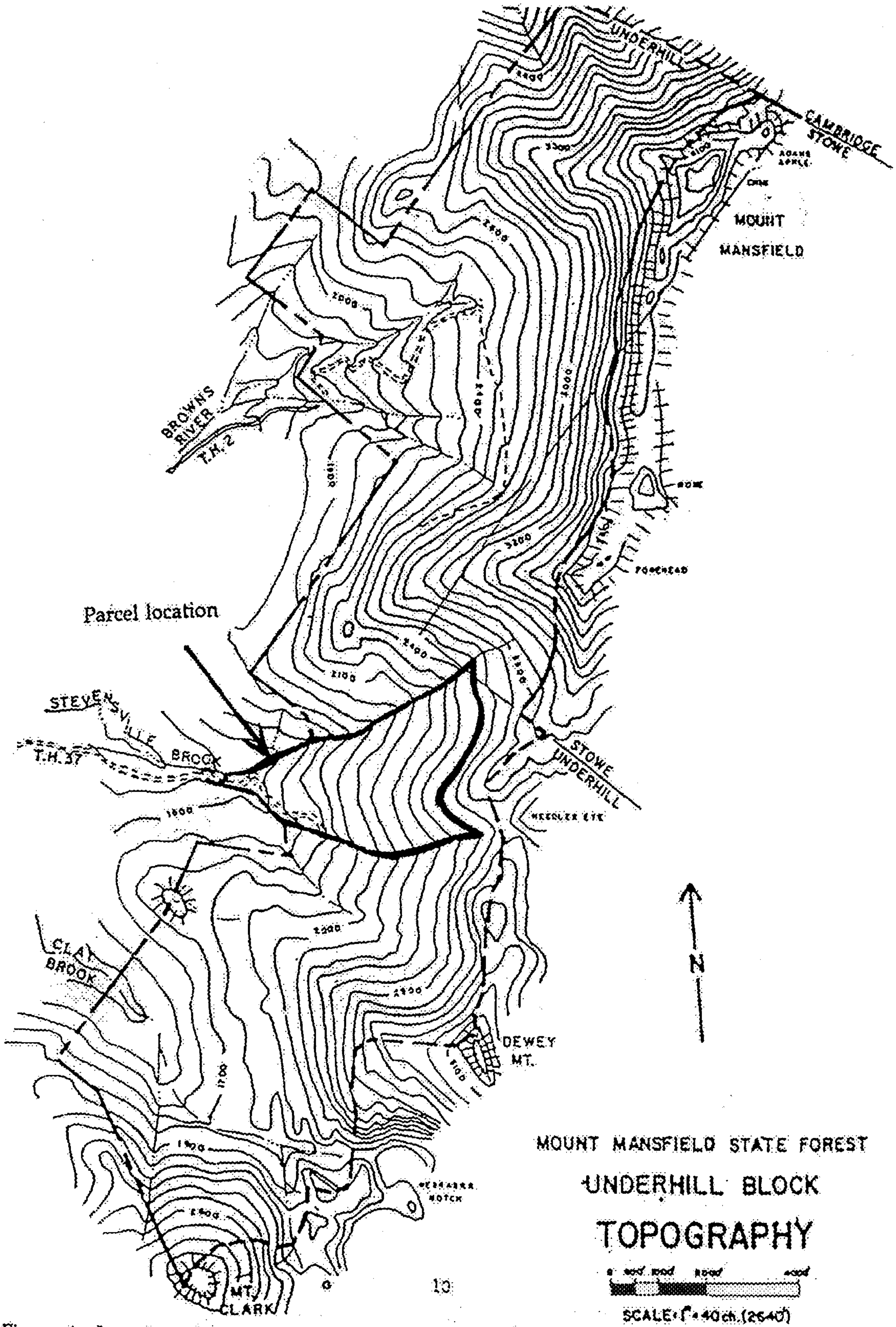


Figure 1. Location of the Vermont Forest Ecosystem Monitoring (VForEM) parcel on Mt. Mansfield. Underhill, Vermont.

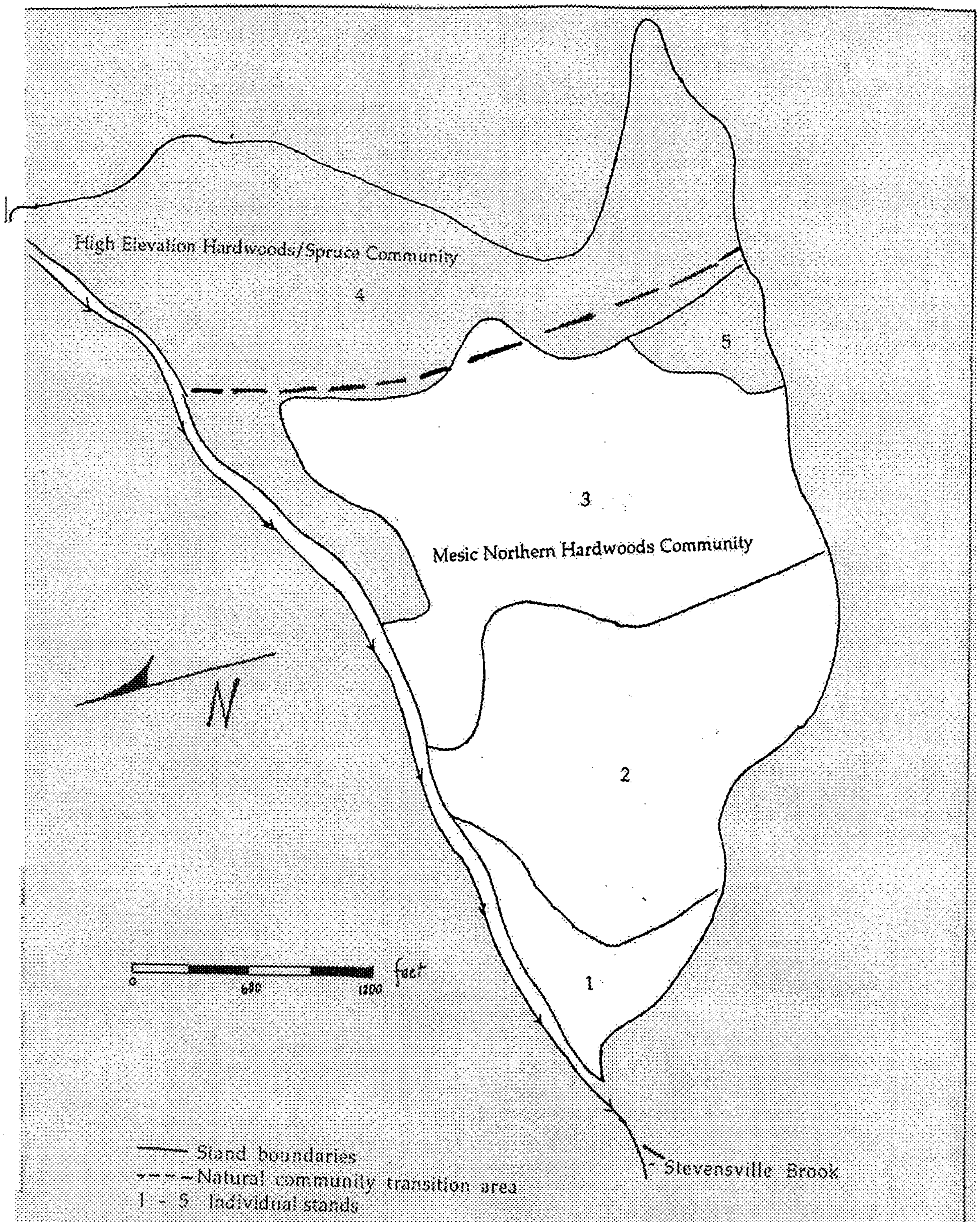


Figure 2. The stands and natural communities within the Stevensville Brook Parcel on Mt. Mansfield, Underhill, Vermont.

community designation. I can think of two reasons for this.

First is the difference between a "stand" and a natural community. A stand is "a forested landscape element with uniform cover type and uniform age and size classes, often reflecting cutting (or other disturbance) history" (Poleman 1996a:8). A stand will therefore emphasize the age and size of trees while communities will emphasize the plant associations regardless of age and physical quality. That natural communities are not defined by vegetation age structure made it possible for Tetreault (1996) to develop a system of classifying potential upland and wetland natural communities in a portion of New Hampshire. Hypothetically, all one would need to know to classify potential communities are the landform (cliff, river terrace, etc. for uplands, and basin, seep or floodplain for wetlands), parent material, the physiognomy for wetlands and soil depth, drainage, and aspect for uplands, and to have all of these factors correlated with existing natural communities in a particular region.

Each physical occurrence of a natural community can contain different concentrations of its component species and I found this internal variation confusing at first. Using qualitative observations, Stand 1 includes Sugar maple *(Acer saccharum),* American beech *(Fagus grandifolia)* , red maple *(A. rubrum),* and yellow birch *(Betula allegheniesis),* whereas Stand 3 is dominated largely by mature sugar maple with some large yellow birch and a few beech, yet they both receive the same community designation of Mesic Northern Hardwoods (See Figure 2). A more rigid protocol that outlines how communities are identified in the field needs to be developed so that it is less of a subjective measure.

The second problem encountered is related to the fundamental problem of any classification system. Thompson (1996:3) illuminates this by recognizing we are trying to draw boundaries in forests where naturally there aren't any, "The use of this or any classification must recognize that natural communities intergrade with one another in sometimes imperceptible ways, and that any place on the landscape is unique. These truths about nature make classification difficult." Any classification system will force a given area in the landscape into categories that already exist. Noss (1987:12) writes about the necessity for any classification system to be as thorough as possible: "It is especially important that a classification system be comprehensive. If important combinations or patterns of vegetation are missed in the classification, they will not be inventoried, and hence may not be protected." This is an unavoidable limitation of the natural community system. It necessarily homogenizes places that seem similar, but fails to expose the subtle differences that make individual forests unique in a landscape.

It would be wrong to assume that we should not classify forests, since classification systems help us in our attempt to understand vegetation patterns and ultimately to be good forest stewards. We should recognize the utility of classification systems, but also understand the inherent limitations. The weakness of the natural community system is therefore its strength. It doesn't try to fully describe the uniqueness of each site, but in doing so, gains the ability to compare and contrast the abundance of natural communities across a larger area. It therefore has the potential to fulfill its purpose of informing conservation values within this integrated inventory when the rarity designations are further defined and become meaningful to managers.

A slight bias exists in the natural community system. Both the Vermont Nongame and Natural Heritage Programs and The Nature Conservancy have a vested interest in identifying rare or endangered species or communities in landscapes. Because of limited resources, classification efforts are focused on identifying and protecting rare elements of diversity, and not necessarily refining descriptions of more common community types. A slight bias in classification results so that rare communities are described with more detail and divisions, while more abundant ones, such as the mesic northern hardwood community, ones are "lumped" together so that some

Table 1. Annual Volume-Weighted Mean pH for 3 Sites.

SITE	1980	1981	1982	1983	1984	1985	1986	1987	1988
Mt. Mansfield	3.86	4.09	4.28	4.41	4.30	4.35	4.43	4.42	4.49
Underhill	ND	ND	ND	4.37	4.29	4.27	4.36	4.32	4.32
Morrisville	4.78	ND	4.37	4.51	4.44	4.49	4.51	4.37	4.39

SITE	1989	1990	1991	1992	1993	1994	1995	1996	1997
Mt. Mansfield	4.26	4.28	4.14	4.03	4.25	4.13	ND	ND	3.73*
Underhill	4.34	4.46	4.41	4.46	4.28	4.31	4.38	4.52	4.38
Morrisville	4.44	4.38	4.49	4.64	4.50	4.47	4.54	4.63	4.47

ND = No Data, *= based on incomplete data set

Table 2. Seasonal Volume-Weighted pH 1981-1997.

SITE	1981		1982		1983		1984		1985		1986	
	W	S	W	S	W	S	W	S	W	S	W	S
Mt.Mansfield	4.32	4.00	4.37	4.25	4.45	4.40	4.21	4.21	4.20	4.24	4.52	4.39
Underhill	ND	ND	ND	ND	ND	4.25	4.44	4.14	4.30	4.25	4.37	4.32

SITE	1987		1988		1989		1990		1991		1992	
	W	S	W	S	W	S	W	S	W	S	W	S
Mt. Mansfield	4.53	4.42	4.38	4.51	4.36	4.29	4.22	4.24	4.32	4.29	3.69	4.60
Underhill	4.40	4.36	4.12	4.23	4.12	4.50	4.35	4.53	4.44	4.50	4.33	4.62

SITE	1993		1994		1995		1996		1997	
	W	S	W	S	W	S	W	S	W	S
Mt. Mansfield	4.24	4.31	4.27	4.14	4.38	ND	ND	ND	ND	4.21*
Underhill	4.25	4.25	4.41	4.19	4.36	4.36	4.37	4.46	4.39	4.35

W = Winter, S = Summer, ND = No Data, *= based on incomplete data set

Elevational and Spatial Variation

In comparing Mt. Mansfield (3800') with Underhill (1300'), and Morrisville (700') there appears to be a pattern of decreasing pH with increasing elevation. In comparing spatial relationships, Underhill, located to the west of Mt. Mansfield, has a lower yearly mean weighted pH than does Morrisville, located on the east side of Mt. Mansfield. (Table 1.)

variation may be missed (Thompson 1997 pers. comm.)

In this case study, there were fewer natural communities than stands. Hypothetically, there may be cases where the opposite is true— more natural communities present than stands. For example, if the ground flora reflects a change in the substrate, but the dominant canopy species remain the same, then the cover type classification system would fail to pick this subtlety up, but a natural community classification (if one exists for the transitional community) would reveal this change. Few, if any, Vermont forested natural communities are defined solely by a change in the herbaceous layer composition. Because of this, it is unlikely that conducting this inventory in the winter months would make identifying natural communities harder.

Conclusions

The integrated inventory combining the natural community classification system and the FOREX inventory is a potentially useful tool for Vermont State and private forestry operations. It provides a more detailed classification system that locates a given parcel within the context of a state's natural communities. The rarity designation attached to natural community descriptions is the potentially useful element for managers. This designation will be useful when the specific rankings of S1 and S5 are modified to include suggestions and details of how management prescriptions should be changed in light of a certain community's abundance. The Vermont Forests, Parks and Recreation Department is the most obvious organization to coordinate and further refine the methods of this system since it already processes the data collected in its own and private timber cruises employing the FOREX methodology.

Using this system in winter may pose problems to selecting natural communities defined by the herbaceous vegetation layer which is largely dead and covered by snow in this season. In Vermont, there doesn't appear to be any forested communities that are solely characterized by the ground layer at this time, but as communities are further defined, this may become a consideration during winter inventories (Thompson 1996).

A sense of place

I hypothesize that the desire to manage ecosystems rather than individual resources is, at least in part, a product of an increasing "sense of place", or simply, of where we live. The problem with previous management philosophies has not been the selection of resources from forests for human use, which is necessary for a society's physical and cultural survival. "From the many objects and organisms around them, people identify a certain subset as 'resources' things to be drawn into the human community and turned to useful ends" (Cronin, date unknown). The problem lies in the failure to acknowledge the relationships between the useful and non-useful parts of ecosystem integrity. By trying less to filter out the useful from the non-useful and by inquiring about the unique ecological relationships of specific places through scientific questioning and description, we are beginning a process of rediscovering where we live.

Americans evolved out of a tradition that imposed its ideas and way of life on the previously unknown ecology and people of this continent. "Our trouble with the New World— a world that was intended to refuel an Old World which had in some sense grown effete— has been that from the beginning we have imposed, not proposed. We never said to the people or the animals or the plants or the rivers or the mountains: What do you think of this? We said what <u>we</u> thought, and bent to our will whatever resisted" (Lopez 1990:17). We are now opening a dialogue with natural world we should have begun long ago.

Changing the type of information collected in forest inventories is part of this process of fostering a sense of place. In an ecosystem framework, a forest inventory collects information about the biotic and environmental elements of an ecosystem, and the processes that govern them. Its ultimate goal is to define the uniqueness of individual places in order to conduct effective management. In our search to discover a sense of place, natural community classification is a useful tool. It provides a more thorough description of forest composition than the traditional *cover type* classification. The long term usefulness of any inventory information is limited, though "[An inventory of] existing ecosystem capabilities determine what is possible in a human time frame, say a generation to a century. Any longer than that the basic capabilities of ecosystems may change and our ability to predict outcomes is rather poor" (Salwasser and Pfister 1992:151). Places change over time, and so does our knowledge of them.

An integrated ecosystem inventory could contain parts of the natural community classification, the ecosystem classification approach using geo- ecosystems (ECOMAP) being developed by the US Forest Service (USFS 1993), and FOREX. It could include information on landform, soils, geology, topography, overstory composition, size and quality of trees, commercial regeneration, ground flora, wildlife habitat, natural communities and cruise information. Any such inventory will be more labor intensive and time consuming to implement, but the information is extremely valuable and will help define responsible management practices.

Ecosystem management is not a remedy for our trespassings, nor does it necessarily embrace a new ethic of land stewardship. Its focus, at least in the realm of public land management, is to sustain human use of forest ecosystems over time, not to recognize the intrinsic value of a place.

While management perspectives shift, we are given a new opportunity to investigate society's relationship with ecosystems. "A sense of place must include at the very least, knowledge of what is inviolate about the relationship between a people and the place they occupy, and certainly, too, how the destruction of this relationship, or the failure to attend to it, wounds people" (Lopez 1990:40). As we seek to define this healthy relationship with places, we are coming to realize that it is not only management practices that need to change, but also our expectations of how much ecosystems can provide for us.

Our relationship to place is coming to include more than just a utilitarian ethic, which regards the land as a passive source of wealth and resources for humans. In the writings of Aldo Leopold, Wendell Berry, and Gary Snyder a new ethical relationship is fostered in which we recognize that we have an obligation to the land, to treat it with care and maintain its heath. This new tendency may be mistaken for romanticism, but it has a very practical and understandable basis, "And the wisdom of [addressing the land], the ineffable and subtle intertwining of living organisms on Earth, is confirmed today by molecular biology and atmospheric chemistry. To acknowledge the interdependence is simply a good and wise habit of mind" (Lopez 1990:18). The first law of ecology is "everything is connected", which includes us and what we are managing. Therefore we should be careful in our treatment and use of ecosystems, and mindful of the mystery that surrounds their very existence. Hopefully, as we understand more about where we live through an increasing sense of place, we will be able to define what a "healthy relationship" with the natural world is, and pursue it wholeheartedly.

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Soils

SOIL TEMPERATURE GRADIENTS IN A NORTHERN HARDWOOD FOREST

1997

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

Cooperators:

Deane Wang, Joanne Cummings, and Miriam Pendleton
UVM School of Natural Resources

ABSTRACT

A study was initiated in January 1993 to continuously monitor soil temperature, at several depths, in a northern hardwood forest located at the Proctor Maple Research Center in Underhill, VT. In 1993-97 treatments applied to these plots were designed to examine the effects of snow cover on soil temperature within a hardwood forest. Overall seasonal trends were similar in all four years with soil temperatures decreasing with increasing soil depth in spring and summer and increasing with increasing soil depth during fall and winter. That is, in winter soil temperatures were generally warmer at -30 cm than at -15 or -5 cm. When snow accumulated early in the winter (Dec.) and remained at a depth of 30 cm or greater throughout winter, soil temperatures gradually drifted down, but remain above freezing at all soil depths. When snow-cover was absent, daily average soil temperatures dropped below freezing at all soil depths and reached -2° C at -30 cm between mid January and late March. When snow was present, minor changes in soil temperatures in response to changes in ambient temperatures sometimes occurred, but these responses were delayed by as much as a day or more due to the insulating properties of snow. Soil temperatures under snow-free conditions changed more rapidly and dramatically in response to ambient air temperatures, although, there was still a slight delay in soil temperature responses. Under both conditions responses to changes in ambient temperatures were generally greater at more shallow depths. When actual differences between the two treatments were calculated, by subtracting daily average soil temperatures for snow-free plots from those of snow-covered plots, for each day, and each soil depth, differences were greater at more shallow soil depths. For example, at -5 cm daily average soil temperatures were as much as 12° C warmer, while at -30 cm they were 4° C warmer when snow cover was present. This study showed that the presence, timing, and amount of snow cover does influence winter soil temperatures. In addition, changes in snowfall patterns may be a reality of Global Warming, and will affect soil temperatures and influence the entire forest ecosystem.

Surface Waters

Streamflow and water quality monitoring
West slope of Mt. Mansfield

1997 Annual Report

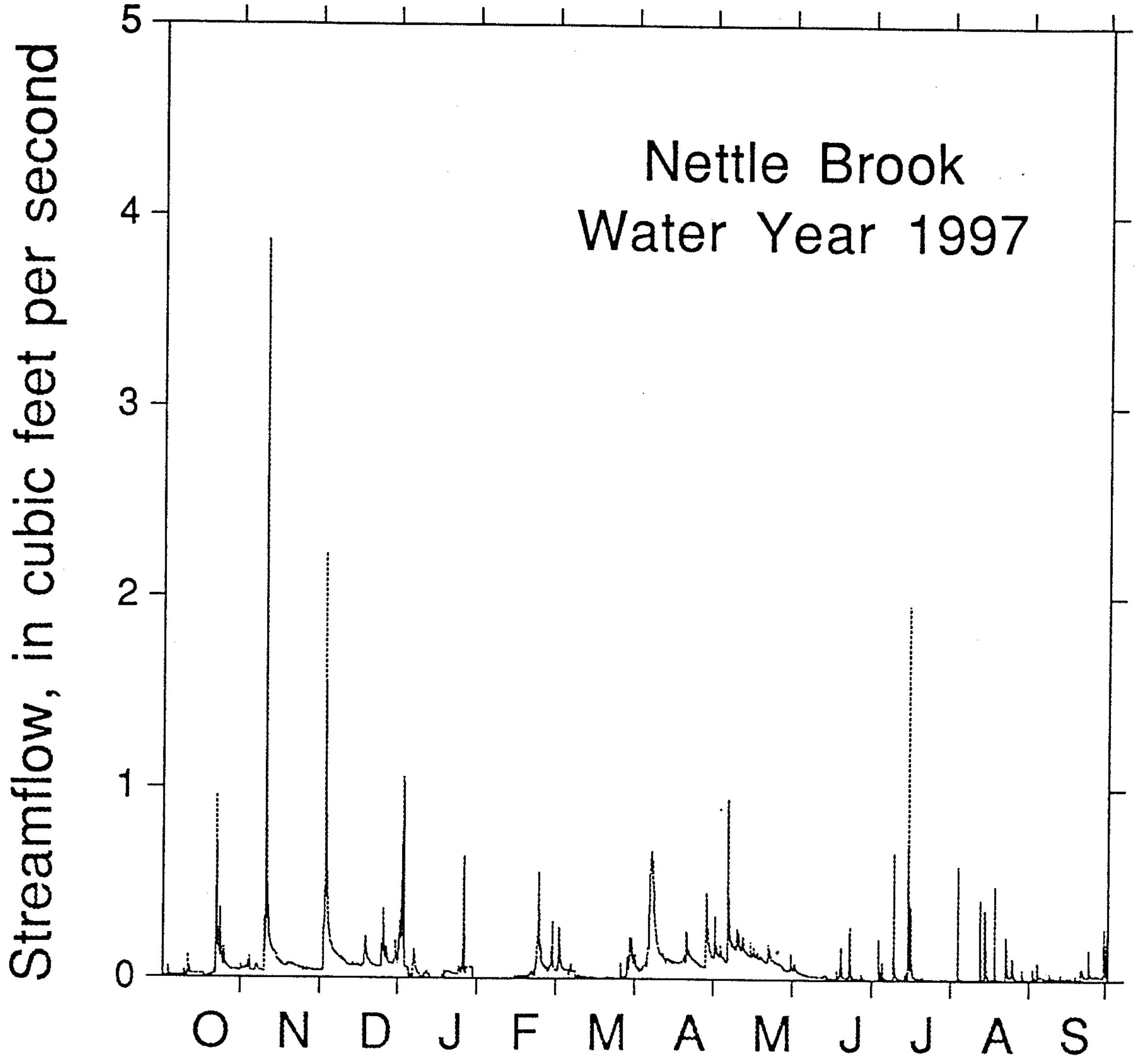
James B. Shanley and Jon C. Denner
U.S. Geological Survey
Montpelier, VT

The USGS, in collaboration with the VMC, established a stream gage at Nettle Brook on the west slope of Mt. Mansfield in September 1993. A 90-degree V-notch weir was installed in the stream channel. Water levels are tracked by a float in a stilling well in hydraulic contact with the pool behind the weir. The rise and fall of the float drives a potentiometer which electronically records the pool level at 5-min intervals. Pool level is converted to disharge by a theoretical equation which has been validated by volumetric measurements. Streamflow data are collected continously by datalogger and archived after each monthly site visit.

The 11-hectare catchment has been used for water quality studies, including nitrogen cycling and mercury biogeochemistry. Data quality is generally very good, but editing for the inevitable occurrences of backwater from ice and vegetative debris is performed on an "as needed" basis by standard USGS techniques.

The 1997 water year (October 1996 through September 1997) was slightly wetter than average in northern Vermont. Some heavy fall rain events culminated in a very wet December. The winter was quiet, lacking the large January thaws of the 2 prior years. A minor thaw in late February preceded a slow, prolonged snowmelt period. The melt started in late March as usual but extended well into May as a series of late season storms brought varying mixtures of snow and rain to the mountains and temperatures remained well below average. The summer was perhaps on the dry side of average, with no notable high-flow events.

The record is excellent from 1 April through the end of the water year as it was edited in support of some ongoing mercury work by Andrea Donlon. Approximately 30 samples of streamwater under various flow conditions were analyzed for Hg. In addition, Andrea collected soil water from shallow and deep points in the unsaturated zone for Hg analysis. The results confirmed earlier findings that Hg transport in streamwater tends to occur predominately at high flow. The new insight from Andrea's soil water monitoring is that Hg movement toward the stream occurs primarily in the shallow organic-rich soil in association with dissolved organic carbon.


Nettle Brook
Water Year 1997
Streamflow, in cubic feet per second
5
4
3
2
1
0
O
N
D
J
F
M
A
M
J
J
A
S

Terrestrial Fauna

Amphibian Monitoring in the Lye Brook Wilderness Region of the Green Mountain National Forest
April - October 1997

James S. Andrews, Biology Department
Middlebury College, Middlebury, Vermont 05753

Update

Background

An inventory of amphibians in the Lye Brook Region of the Green Mountain National Forest in Bennington County was begun in 1993 and completed in 1995. Monitoring of selected amphibian species began in 1994. The goals of the monitoring are to (1) establish a baseline data set of abundance indices for the amphibian species caught in the fences, (2) monitor year-to-year changes in their abundance indices, (3) compare population changes between this site and other monitoring locations in the Green Mountains, (4) look for correlations between amphibian populations and other data gathered at this site, (5) monitor changes in the number or type of obvious external deformities, (6) gather inventory data for the Vermont Herp Atlas, and (7) gather basic natural history information on the species present. Five species of salamander (Eastern newt, Northern two-lined salamander, Redback salamander, Spotted salamander, Spring salamander) and five species of frog (American toad, Green frog, Pickerel frog, Spring peeper, Wood frog) are monitored using drift-fences, egg-mass counts, and stream surveys. Four years of monitoring data have been gathered using egg-mass counts and stream surveys. Any trends suggested at this point will need to be confirmed as the number of years spent monitoring increases. For details on methods and locations see previous VForEM and VMC annual reports.

Stream surveys

The stream surveys continue to show decreasing pH, however, numbers of Spring and Two-lined salamanders were up slightly from last year. The egg-mass counts show no clear trends in populations of Wood frogs or Spotted salamanders but the pH of their breeding ponds appears to be declining.

Upper drift-fences

Three years of monitoring data have been gathered at the upper drift-fences. Indices for each species continue to show considerable annual variability but the relative abundances of each species are still maintained. Eastern newt continues to be the most frequently caught salamander, followed in order both years by Spotted salamander, Redback salamander and Northern two-lined salamander. The big surprise this year is the very unexpected occurrence of a single member of the Blue-spotted salamander group at the southernmost of the upper drift-fences. This species had not been located during surveys of this or any other mid- to high-elevation Green Mountain site. I would have predicted that it did not occur above 1200 ft. or outside of the major valleys and surrounding low-elevation hills. Since no historic data are available from the Green Mountains, it is not known whether this species was once more plentiful here than it is now or if it has existed in very low numbers for some time. In Vermont it is listed as an S3 species. Some large populations have been located in the Lake Champlain Valley. The term Blue-spotted salamander group is used since this species frequently contains genetic material from the closely related Jefferson salamander. The large size and broad head of the individual caught suggest that it is a hybrid. Wood frogs continue to be the most frequently caught frog, followed in the same order as the previous two years by Green frog, American toad, and Spring peeper.

Lower drift-fence

At the lower drift-fence Eastern newt numbers more than doubled while Redback numbers were cut to less than half of last years catch. This reverses their relative abundance at this fence from last year with eastern newt now being the most frequently caught salamander species. This may be the result of the many new beaver ponds in the area. Spring peepers were the most frequently caught frog compared to fourth in relative abundance last year. Five times as many were caught this year than last.

Malformities and deformities

One of the 51 American toads caught was missing its left year leg and one of the 47 Redback salamanders caught was missing its right hind foot. These may have been either developmental (malformities) or traumatic (deformities) in origin. No other malformities were seen out of a total of 837 (counting all nights) amphibians caught. Signs of fresh trauma were seen, usually with the probable traumatizer (shrews) still in the bucket. Most of these amphibians were dead (14), but a few survived with injuries (3). As reported in the 1995 report, newts in ponds near the upper fences have shown signs of disease.

Tables

This year's drift-fence, egg-mass count, and stream survey results are shown in Tables 1-5.

Acknowledgments

Funding for this monitoring was provided through a cost-share agreement with the Green Mountain National Forest. Colleen Jones and Maureen Rice were the local field technicians.

Table 1. Monitoring results from the upper two drift-fences in the Lye Brook Wilderness Region during 1997. The three most successful trappings per month are included (15 out of 22 trappings). Data used are from May 10,20,31; June 13,18,19; July 4,9,16; Sept. 3,12,14,29; and Oct. 15,16.

Species name	**# of all ages**	**# of young of the year**[1]	**% young of the year**	**date of first meta-morph**[2]	**largest adult (total length in mm)**	**# per trapping**[3]	**% of group**	**% of total catch**
Salamanders								
Eastern newt	291	179[4]	62%	Sept. 3	86	19.4	72%	49%
Spotted salamander	86	17	20%	Sept. 3	206	5.7	21%	14%
Redback salamander	23	1	4%	Oct. 15	93	1.5	6%	4%
Northern two-lined	5	1	20%	Sept. 29	86	0.3	1%	1%
Blue-spotted group	1	0	0%	N/A	147	0.1	<1%	<1%
Group totals	406	198	49%	---	---	27.1	100%	68%
Frogs and Toads								
Wood frog	90	33	37%	May 20	60	6.0	47%	15%
Green frog	46	40	87%	July 16	81	3.1	24%	8%
American toad	30	5	17%	June 13	72	2.0	16%	5%
Spring peeper	27	4	15%	Sept. 3	35	1.8	14%	5%
Group totals	193	82	42%	---	---	12.8	100%	32%
Amphibian totals	599	280	47%	---	---	39.9	---	100 %

[1] For each species, individuals under a given total length were considered potential young of the year. The chosen length was based on the timing of their appearance, gaps in their size continuum, and records in the literature. The cutoff sizes used were *A. maculatum* (70 mm), *E. bislineata* (60 mm), *N. viridescens* (45 mm), *P. cinereus* (32 mm), *B. americanus* (32 mm), *P. crucifer* (20 mm), *R. clamitans* (44 mm), *R. palustris* (34 mm), and *R. sylvatica* (33 mm). In addition, it was necessary to examine the minimum possible development time for each species. Individuals shorter than the cutoff lengths clearly overwinter (possibly as larvae for *N. viridescens* and *A. maculatum*) and show up in very early spring. These are not counted as young of the year.

[2] No trapping took place in August.

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

[4] *N. viridescens* metamorphs below the 45 mm cut-off length were caught as early as May. This suggests that they either overwintered at a very small size or overwintered as larvae and metamorphosed in the spring. Three were caught in May, one in June, and one in July. On September 3, 19 metamorphs were caught and on Sept. 12, 133 metamorphs were caught. I suspect that Sept. 3 is actually the first trapping of metamorphs developed from eggs laid in 1997.

Table 2. Monitoring results from the lower drift-fence in the Lye Brook Wilderness Region during 1997. The three most successful trappings per month are included (18 out of 28 trappings). Data used were from April 13,18,29, May 2,14,31; June 13,18,25, July 4,10,16, Sept. 3,12,14; and Oct. 4,15,16.

Species name	**# of all ages**	**# of young of the year**[1]	**% young of the year**	**date of first meta-morph**[2]	**largest adult (total length in mm)**	**# per trapping**[3]	**% of group**	**% of total catch**
Salamanders								
Eastern newt	84	28	33%	Sept. 3	92	4.7	78%	51%
Redback salamander	19	0	0%	N/A	91	1.1	18%	11%
Spotted salamander	5	1	20%	Sept. 12	212	0.3	5%	3%
Group totals	108	29	27%	---	---	6.0	100%	65%
Frogs and Toads								
Spring peeper	20	3	15%	May 14	35	1.1	34%	12%
Wood frog	13	4	31%	June 13	65	0.7	22%	8%
American toad	12	5	42%	June 25	94	0.7	21%	7%
Pickerel frog	12	2	17%	May 31	52	0.7	21%	7%
Green frog	1	0	0%	N/A	---	0.1	2%	1%
Group totals	58	14	24%	---	---	3.2	100%	35%
Amphibian totals	166	43	26%	---	---	9.2	---	100%

[1] For each species, individuals under a given total length were considered potential young of the year. The chosen length was based on the timing of their appearance, gaps in their size continuum, and records in the literature. The cutoff sizes used were *A. maculatum* (70 mm), *E. bislineata* (60 mm), *N. viridescens* (45 mm), *P. cinereus* (32 mm), *B. americanus* (32 mm), *P. crucifer* (20 mm), *R. clamitans* (44 mm), *R. palustris* (34 mm), and *R. sylvatica* (33 mm). In addition, it was necessary to examine the minimum possible development time for each species. Individuals shorter than the cutoff lengths clearly overwinter (possibly as larvae for *N. viridescens* and *A. maculatum*) and show up in very early spring. These are not counted as young of the year.

[2] No trapping took place in August.

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

[4] *N. viridescens* metamorphs below the 45 mm cut-off length were caught as early as June. This suggests that they either overwintered at a very small size or overwintered as larvae and metamorphosed in the spring. One was caught in June, and one in July. In September, 13 metamorphs were caught. I suspect that Sept. 3 is actually the first trapping of metamorphs developed from eggs laid in 1997.

Table 3. A comparison of data from the upper two drift-fences in Lye Brook Wilderness, Sunderland, Bennington County, Vermont, Data are taken from the 1995, 1996, and 1997 field seasons. Fences were opened at least three times per month.

Species name	**Common name**	**# per trapping[1]**			**% of total**		
		95	**96**	**97**	**95**	**96**	**97**
Caudates (Salamanders)							
Ambystoma laterale group	Blue-spotted salamander group	0.0	0.0	0.1	0%	0%	<1%
Ambystoma maculatum	Spotted salamander	8.7	4.7	5.7	20%	9%	14%
Eurycea bislineata	Northern two-lined salamander	0.8	0.3	0.3	2%	6%	1%
Notophthalmus viridescens	Eastern newt	12.7	29.5	19.4	29%	57%	49%
Plethodon cinereus	Redback salamander	2.0	3.3	1.5	5%	7%	4%
Group totals		24.2	37.1	27.1	56%	74%	68%
Anurans (Frogs and Toads)							
Bufo americanus	American toad	4.3	2.7	2.0	10%	5%	5%
Pseudacris crucifer	Spring peeper	0.8	1.2	1.8	2%	2%	5%
Rana clamitans	Green frog	6.8	2.9	3.1	15%	6%	8%
Rana sylvatica	Wood frog	8.2	6.3	6.0	18%	13%	15%
Group totals		20.0	13.1	12.8	45%	26%	32%
	Totals	44.2	50.2	39.9	100 %	100 %	100 %

[1] Number per trapping are rounded to the nearest 0.1. All other figures are rounded to the nearest whole number. There were a total of 18 trappings counted in 1995, 15 in 1996, and 15 in 1997. Fence-nights counted are those nights where the upper traps were opened under appropriate weather conditions for amphibian movement.

Table 4. Maximum counts of egg masses from monitoring locations in the Lye Brook Wilderness region from 1994 through 1997. At the site near Benson Pond the entire pond is surveyed. At North Alder Dam a four-meter strip around all of the pond except the swampy north end is surveyed. At the Pond Near Drift-fence #2, a four-meter strip around the entire pond is surveyed.

Site	**Spotted salamander**	**Wood frog**	**Mean pH** [2]
Near Benson Pond			
1994 count dates: 4/26, 5/10, 5/25	10	67 [1]	7.3 (N = 1)
1995 count dates: 4/24[2], 5/12	3	19	6.8 (N = 1)
1996 count dates: 4/24, 4/27, 5/7, 5/8, 5/15	73	2	6.9 ± 0.4 SD (N = 3)
1997 count dates[3]: 4/27, 5/5, 5/12	16	97	6.1 ± 0.1 SD (N = 3)
North Alder Dam			
1994 count dates: 5/11, 5/25, 6/8	97	225	5.0 ± 0.3 SD (N = 2)
1995 count dates: 4/24[2], 5/12, 6/9	292	3	5.1 ± 0.4 SD (N = 2)
1996 count dates: 5/8, 5/15, 5/25	176	3	5.0 ± 0.4 SD (N = 3)
1997 count dates[4]: 5/20, 5/27, 6/3	0	44	4.2 ± 0.2 SD (N = 3)
Pond Near Drift-fence #2			
1994 count dates: 5/11, 5/25, 6/9	6	3	5.7 ± 0.3 SD (N = 2)
1995 count dates: 4/24[2], 5/12, 6/9	70	152	5.6 ± 0.4 SD (N = 2)
1996 count dates: 5/8, 5/15, 5/25	78	62	5.2 ± 0.6 SD (N = 3)
1997 count dates: 5/20, 5/27, 6/3	55	77	5.0 ± 0.8SD (N = 3)

[1] Hatched by May 10

[2] All readings taken on April 24, 1995 were believed to be erroneus and are not included in the mean. All pH measurments taken during 1996 at the site near Benson Pond were taken in May. Each reading used in the average is itself composed of three measurements taken from different areas of the ponds. All pH means have been rounded to the nearest 0.1.

[3] Site has been flooded over. Three newly created adjacent puddles were included in the count along with the original site.

[4] Water level much higher due to new beaver activity. Visibility poor.

Table 5. Results of three 50-meter stream-transects in Branch Pond Brook in the Lye Brook Wilderness Region from 1994-1997. Only adult *Gyrinophilus porphyriticus* (Spring salamander) and *Eurycea bislineata* (Two-lined salamander) are included in the table.

Year	**Spring salamander**	**Two-lined salamander**	**pH^1**	**Water temp. in °C^1**	**Max. water depth^2 in cm**
1994					
(7/18/94)	10	11	4.9 ± 0.2 (N = 3)	17.4	20
1995					
(7/24/95)	6	1	4.4 ± 0.5 (N = 5)	17.4	26
1996					
(8/6/96)	3	0	4.0 ± 0.2 (N = 3)	16.1 ± 0.2 (N = 3)	21
1997					
(7/11/97)	7	3	3.8 ± 0.1 (N = 2)	15.6 ± 0.6 (N = 3)	27

[1] Temperature and pH were taken two meters downstream from the downstream end of the first transect.

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

Amphibian Monitoring on Mt. Mansfield, Vermont
1993-1997

James S. Andrews
Biology Department
Middlebury College, Middlebury Vermont 05753

Update

Populations of amphibian species are monitored annually on Mount Mansfield using drift-fences. The goals of the monitoring are to (1) establish a baseline data set of abundance indices for the amphibian species caught in the fences, (2) monitor year-to-year changes in their abundance indices, (3) monitor changes in the number or type of obvious external deformities, (4) gather inventory data for the Vermont Herp Atlas, and (5) gather basic natural history information on the species present. Amphibians are targeted for this kind of study because their multiple habitat usage and permeable skin make them especially sensitive to changes in environmental conditions. Five years of data have now been gathered at this site. This is the longest running set of amphibian monitoring data in the state. Three fences are opened and checked up to four times per month during rain events throughout the field season (April through October excluding August). The population indices are generated using the three most successful trap-nights per month.

An analysis of the data gathered to date suggest that seven of the eight species abundant enough to monitor have increased over the five years: American toad, Green frog, Pickerel frog, Wood frog, Eastern newt, Redback salamander, and Spotted salamander. Spring peeper is the only species whose numbers have dropped over the five-year period. However, because of the amount of annual variation in amphibian populations, eight to ten years of data will more reliably show long-term population trends. Last year (1996) I reported that among the species monitored were two groups whose populations oscillated synchronously. Eastern newt, Spring peeper, Green frog, and Pickerel frog populations all increased or decreased in the same years. Populations of Spotted salamanders and Wood frogs (both early spring breeders) were also synchronized with each other. Redback salamanders, I reported, varied in direct opposition to the Eastern newt group. None of these apparent groupings held for the fifth year of monitoring. Spring peepers continued to decline while all the others in its group increased. Spotted salamander started to decline while Wood frog continued to increase in number. No young of the year Spotted salamanders were caught, suggesting poor breeding success this year for this species. Unlike the previous four years, both Redback salamanders and Eastern newts increased in number during the same year.

As was reported last year, the malformity rate at this site is very low. None of the 217 amphibians caught during 1997 at these three fences showed any obvious external malformities. Baseline malformity rates at relatively pristine sites such as this one are tremendously important for purposes of comparison with less pristine locations.

Two tables follow. Table 1 gives the specifics of this year's trapping effort. Table 2 shows the population indices generated for all eleven amphibian species trapped over the past five years.

This years monitoring effort was supported by the Lintilhac Foundation. Field personnel (Aaron Decker, Nate Harlow, Dave Keller, Julie Longstreth, and volunteers) were under the direction of Betsy Chapek.

Table 1. Monitoring results from the two drift-fences at 1,200 ft. and one at 2,200 ft. on Mt. Mansfield, Underhill, Vermont during 1997. Traps were opened whenever conditions were appropriate for amphibian movement. Three trappings per month in April, May, June, July, September, and October are the goal. Appropriate conditions did not occur until May. Data used are from May 12,13,31; June 13,19; July 3,5,8; September 18; and October 15, November 2, and 3. Data from 12 of 17 trap-efforts are used. Trapping in early May (through May 13) was possible at the lower two drift-fences only.

Species name	**# of all ages**	**# of young of the year[1]**	**% young of the year**	**date of first meta-morph[2]**	**largest adult (total length) in mm**	**# per trapping[3]**	**% of group**	**% of total catch**
Salamanders								
Redback salamander	40	2	5%	Nov. 3	102	3.3	49%	18%
Eastern newt	22	1	5%	Sept. 18	80	1.8	27%	10%
Spotted salamander	17	0	0%	N/A	203	1.4	21%	8%
Northern two-lined	2	0	0%	N/A	73	0.2	2%	1%
Group totals	81	3	4%	---	---	6.8	100%	37%
Frogs and Toads								
Wood frog	84	34	40%	May 31	63	7.0	62%	39%
American toad	30	6	20%	Sept. 18	82	2.5	22%	14%
Green frog	15	10	67%	July 5	N/A	1.3	11%	7%
Spring peeper	4	2	50%	June 13	33	0.3	3%	2%
Pickerel frog	3	0	0%	N/A	63	0.3	2%	1%
Group totals	136	52	38%	---	---	11.3	100%	63%
Amphibian totals	217	55	25%	---	---	18.1	---	100%

[1] For each species, individuals under a given total length were considered potential young of the year. The chosen length was based on the timing of their appearance, gaps in their size continuum, and records in the literature. The cutoff sizes used were *A. maculatum* (70 mm), *E. bislineata* (60 mm), *N. viridescens* (45 mm), *P. cinereus* (32 mm), *B. americanus* (32 mm), *P. crucifer* (20 mm), *R. clamitans* (44 mm), *R. palustris* (34 mm), and *R. sylvatica* (33 mm). In addition, it was necessary to examine the minimum possible development time for each species. Individuals shorter than the cutoff lengths clearly overwinter (possibly as larvae for *N. viridescens* and *A. maculatum*) and show up in very early spring. These are not counted as young of the year.

[2] No trapping took place in August.

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

Table 2. A comparison of drift-fence data from the 1993 through 1997 field seasons at Mt. Mansfield, Underhill, Vermont. Data used are from two fences at 1,200 ft. and one fence at 2,200 ft. elevation.

Species name	# per trapping[1]									
	93	94	95	96	97	93	94	95	96	97
Caudates (Salamanders)										
Ambystoma maculatum	1.7	1.0	1.4	2.0	1.4	12%	10%	9%	12%	8%
Desmognathus fuscus	0.3	0.3	0.3	0.0	0.0	2%	3%	2%	0%	0%
Eurycea bislineata	0.5	0.1	0.2	0.1	0.2	4%	1%	1%	1%	1%
Gyrinophilus porphyriticus	< 0.1	0.0	0.0	0.1	0.0	< 1%	0%	0%	< 1%	0%
Notophthalmus viridescens	1.3	1.2	1.7	1.4	1.8	10%	12%	11%	8%	10%
Plethodon cinereus	1.2	4.2	1.3	2.5	3.3	9%	40%	9%	14%	18%
Group totals	5.1	6.8	4.9	6.1	6.8	38%	66%	32%	36%	37%
Anurans (Frogs and Toads)										
Bufo americanus	0.7	0.6	1.5	2.2	2.5	5%	5%	10%	13%	14%
Pseudacris crucifer	1.7	1.1	2.2	0.9	0.3	13%	10%	14%	5%	2%
Rana clamitans	< 0.1	0.2	0.9	0.6	1.3	< 1%	2%	6%	3%	7%
Rana palustris	0.1	0.0	1.1	0.3	0.3	1%	0%	7%	2%	1%
Rana sylvatica	5.6	1.7	4.4	6.8	7.0	42%	16%	29%	40%	39%
Group totals	8.2	3.6	10.1	10.8	11.3	62%	33%	66%	64%	63%
Amphibian totals	13.4	10.4	15.0	16.8	18.1	100%	100%	100%	100%	100%

[1] Number per trapping are rounded to the nearest 0.1. All other figures are rounded to the nearest whole number. There were a total of 15 trappings counted in 1993, 14 in 1994, 18 in 1995, 17 in 1996, and 12 in 1997. Trappings counted were on those nights when at least two of the three traps were opened under appropriate weather conditions for amphibian movement.

Terrestrial Flora

Annual Assessment of Forest Health in the Lye Brook Wilderness Area
1997

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

Cooperators

Brent Teillon, Jay Lackey, Brad Greenough, Ron Wells, and Lars Lund, Department of Forests, Parks & Recreation; Florence Peterson, USDA Forest Service-Forest Health Protection.

Introduction

Annual assessments of crown condition, mortality, and damages are conducted on permanent plots located at two elevations, 1400 and 2200 feet. The purpose of these plots is to document changes in tree health over time and to aid in the identification of causes for declines, if they occur.

Materials and Methods

Five long-term monitoring plots using the design and measurement variables of the National Forest Health Monitoring Program (NFHM) (Tallent-Halsell, N.G. 1994)are used to represent forest health in the Lye Brook Wilderness Area. Data collected to assess forest health includes mensuration, crown condition and tree damages. In 1990, one plot was established at 2300' as part of the NFHM Program grid. One additional plot at the same elevation and 2 plots at 1400' were established in 1994. An additional high elevation plot was added in 1995 to improve the hardwood sample size. These elevations were chosen for comparison with plots on Mt. Mansfield, the northern Vermont VMC study site.

Results and Discussion

Many tree health indicators improved in 1997. At 1400 foot plots, overstory trees had lower dieback and slightly denser foliage than in 1996 (Tables 1-4). Compared to the 4 year baseline of tree health on 1400 foot elevation plots, trees had significantly less dieback in 1997 (Figures 1-3). There was a significant improvement in black cherry health over previous years, with lower average dieback (6.0%), higher crown density (48.5%), lower foliage transparency (25.5 %) and more healthy trees (100%). Other species at this elevation also showed improved tree health, especially lower average dieback ratings.

At 2200 foot plots overstory trees had lower dieback than the previous year. Although crown density and foliage transparency was worse than in 1996, foliage density was significantly better than the 4 year average (Figures 1-3). All species at this elevation showed improvement in average dieback. In 1997, good tree health can be attributed to good growing conditions (plenty of precipitation) and low incidence of major insect and disease problems.

Many damages are persistent on trees, and may result in long-term tree health problems. Detecting and recording those damages that are significant to tree health and survival provides information that can explain unexpected tree declines in the future. Injury and damages present on tree boles, exposed roots, crown stem, branches and foliage are recorded when above a threshold established as "significant to tree health".

In 1997, 44% of trees on 1400 foot plots and 32% of trees on 2200 foot plots had damages that could be important to future health (Table 5). Paper birch had the most damages. Indicators of internal decay on tree boles was the most common type of damage.

Table 1. Trend in average crown dieback measurements for overstory trees growing on monitoring plots at different elevations in the Lye Brook Wilderness Area, 1994 - 1997.

Species	Elevation	1994	1995	1996	1997
Balsam Fir	2200	1.0	1.8	2.9	2.2
Black Cherry	1400	6.5	12.5	12.5	6.0
Paper Birch	1400	*	*	4.5	1.5
Red Maple	1400	3.8	5.4	5.4	2.9
	2200	6.0	6.4	6.9	4.1
Red Spruce	2200	1.0	2.6	4.3	1.9
All Species	1400	5.2	7.1	6.7	3.5
	2200	3.4	4.2	5.1	3.2

* Sample size <10 trees.

Table 2. Trend in average crown density measurements for overstory trees growing on monitoring plots at different elevations in the Lye Brook Wilderness Area, 1994 - 1997.

Species	Elevation	1994	1995	1996	1997
Balsam Fir	2200	48.3	44.2	50.6	51.8
Black Cherry	1400	45.5	42.5	38	48.5
Paper Birch	1400	*	*	54	51.5
Red Maple	1400	55.2	52.3	51.5	51.0
	2200	46.7	50.2	56.4	54.5
Red Spruce	2200	51.0	51.4	58.6	56.2
All Species	1400	53.0	52.4	50.3	51.8
	2200	48.3	48.7	55.2	53.7

Table 3. Trend in average foliage transparency measurements for overstory trees growing on monitoring plots at different elevations in the Lye Brook Wilderness Area, 1994 - 1997. *indicates < 10 trees

Species	Elevation	1994	1995	1996	1997
Balsam Fir	2200	18.3	24.4	16.7	19.3
Black Cherry	1400	25	*	26.5	25.5
Paper Birch	1400	*	*	20.5	17.5
Red Maple	1400	14.2	19.6	15	16.5
	2200	20.9	24.8	16.0	16.0
Red Spruce	2200	16.6	22.1	12.9	15.6
All Species	1400	17.0	23.1	18.2	17.9
	2200	18.9	24.1	15.3	17.0

Table 4. Trend in percent of trees healthy for overstory trees growing on monitoring plots at different elevations in the Lye Brook Wilderness Area, 1994 - 1997. *indicates < 10 trees

Species	Elevation	1994	1995	1996	1997
Balsam Fir	2200	100	100	91.7	100
Black Cherry	1400	100	*	80	100
Paper Birch	1400	*	*	100	100
Red Maple	1400	100	100	100	95.8
	2200	93.1	96.8	90	100
Red Spruce	2200	100	100	100	100
All Species	1400	98.1	92.2	94.0	94.6
	2200	98.6	97.6	92.7	100

Figure 1-3. Overstory tree health in 1997 compared to 4 year averages (baseline) for survey plots at 2 elevations in the Lye Brook Wilderness Area. Tree health indicators include: crown density (Figure 1), crown dieback (figure 2), and foliage transparency (Figure 3). Letters show statistically significant differences between elevations, "*" shows significant differences between baseline and 1997 averages.

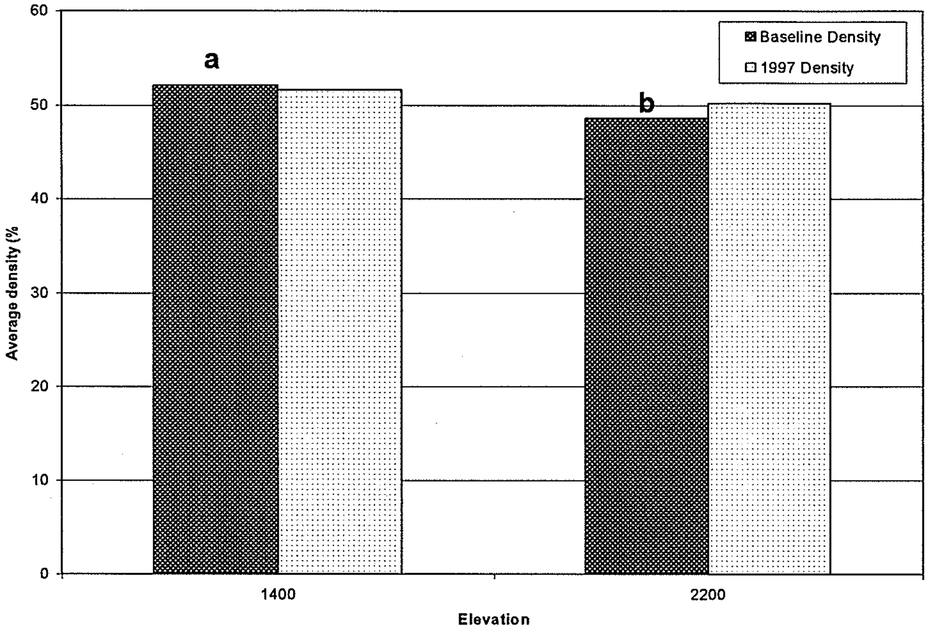


Figure 1. Crown Density

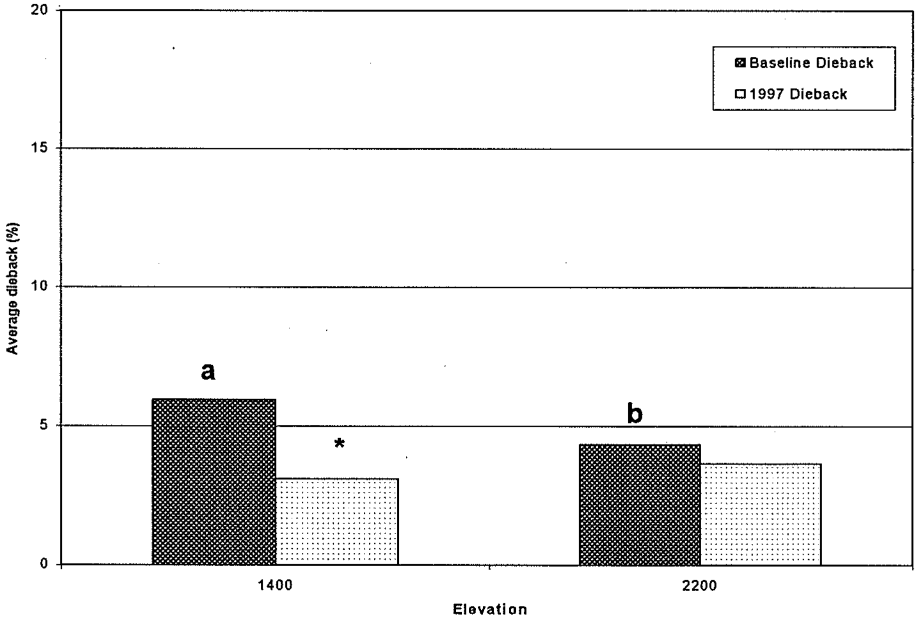


Figure 2. Crown Dieback

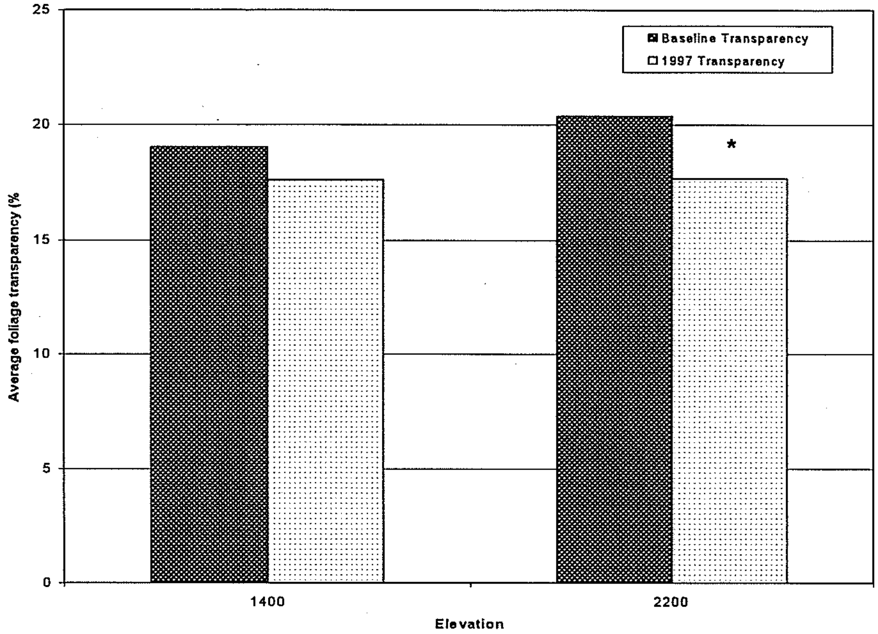


Figure 3. Foliage Transparency

Table 5. Percent of trees affected by different types of tree damages in 1997.

Species	Elevation	Percent of trees and type of damage
Balsam Fir	2200	7 % with indicators of decay
Black Cherry	1400	18 % with indicators of decay 9 % with broken/dead branches
Paper Birch	1400	30 % with indicators of decay 10 % with open wounds (size > 20% of circumference) 10 % with dead terminal
Red Maple	1400	28 % with indicators of decay 4 % with open wounds
	2200	4 % with cankers 21 % with indicators of decay 2 % with broken/dead branches
Red Spruce	2200	3 % with open wounds

References

Tallent-Halsell, N.G. (ed.). 1994. Forest Health Monitoring 1994 Field Methods Guide. EPA/620/R-94/027. U.S. Environmental Protection Agency, Washington, D.C. 1997 version.

ANNUAL ASSESSMENT OF FOREST HEALTH ON MOUNT MANSFIELD
1997

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

Cooperators

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

Introduction

Annual assessments of crown condition, mortality, and damage are conducted on permanent plots located at four elevations and two aspects. The purpose of these plots is to document changes in tree health over time and to aid in the identification of causes for declines, if they occur.

Two types of plot designs and measurements are used: one plot at low elevations is part of the North American Maple Project (NAMP) plot system; 14 additional plots use the design and measurement variables of the National Forest Health Monitoring Program (NFHM).

NAMP Plot Methods

One 5-point cluster plot was established in an operating sugarbush at the Proctor Maple Research Center in 1988. Plot establishment, site characterization and annual tree evaluations follow standardized NAMP protocols (Cooke et al, 1995) and are comparable to the other 39 plots in Vermont, and over 200 plots in the U.S. and Canada. Annual evaluations of tree condition and foliage damage require two - three visits to the plot to determine extent of injury from early-, mid-, and late-season defoliators: one in mid-to-late June, July, and early September. Evaluators are trained and certified with other state and provincial field crews to maintain high Quality Control. Between-crew and between-state remeasurements are done on 10 % of the plot-clusters and with each field crew. Data entry is completed in-state, and statewide data is acquired following quality check by the NAMP data analyst at SUNY in Syracuse, NY. Metric units are used for data collection and analysis.

NAMP Plot Results and Discussion

Sugar maple trees examined as part of the North American Maple Project continue to maintain a generally healthy condition. Over 94.9% of overstory sugar maples were considered healthy in 1997, slightly fewer than in 1996. Other indicators of health likewise fluctuated towards less healthy this year: average dieback was 8.1% and average foliage transparency was 10.8%. Although these indicators show a less healthy condition, they are within the range of normal for healthy sugar maple. There was no new mortality in 1997.

Forest Health Plot Methods

Eight permanent plots are used to monitor the health of forests on the west slope of Mount Mansfield, annually. Two plots at each of four elevations (1400, 2200, 3000 and 3800 feet) were established following the design and measurement variables of the NFHM program (Tallent-Halsell 1994). At each elevation, except 3800 ft, paired plots were located in each of the two watersheds: Browns River and Stevensville Brook. In the Stevensville Brook watershed, no canopy trees were present at the 3800 foot elevation, so the paired plots at this elevation are in the Browns River watershed. English units are used for data collection and analysis.

In 1997, 6 additional plots were established on the east slope of the mountain, in the Ranch Brook watershed. Paired plots at three elevations (1400, 2200, and 3000 feet) provide an opportunity to compare tree health between west and east aspects.

Forest Health Plot Results and Discussion

West slope plot results

An analysis of the health of major tree species at each elevation showed that species at all elevations improved in average dieback this year (Figure 1), while crown density remained stable (Figure 2). Foliage transparency was also stable, except for an increase in balsam fir transparency on trees monitored at 3800 feet elevation (Figure 3).

When comparing tree health in 1997 to the 5 year baselines for each health indicator (dieback, transparency and density), there was a significant improvement in dieback at the 1400 and 2200 foot plots in 1997 (Figure 4). Other indicators of crown condition, foliage transparency and crown density (Figure 5-6) showed no change in foliage and crown density in 1997, despite the good growing conditions.

In general, trees at lower elevations are healthier than at higher elevations. For all indicators (dieback, foliage transparency and crown density) trees at 1400 feet are healthier than at 3800 feet (Figures 4-6). Trees at 3800 feet have remained in poor condition since monitoring began in 1992. The percentage of healthy trees is low (58.5%), and average dieback is high (20.7%). There was no new mortality in 1997 in any of the plots.

Damages to trees can play a significant role in tree health. Trees in the 1400 foot elevation plots had fewer damages than at the other elevations (Table 2). The most common type of damage at the 1400, 2200, and 3000 foot elevation plots was indicators of decay (past wounds that have begun to decay). At the 3800 foot elevation plots, broken or dead tops was the most common damage, probably due to severe winter weather that includes heavy ice loads and strong winds.

East slope results and comparison with west slope

Tree composition at each elevation is similar on the east and west slopes with a few exceptions. At the 1400 foot elevation plots, sugar maple is the predominant species, but nearly half the trees in the west slope plots are this single species, while east slope plots have a better mix of sugar maple, beech and yellow birch (Table 3). At the 2200 foot elevation plots both aspects have a dominance of yellow birch. Paper birch comprises 23% of trees on the east slope, but is not present on west slope plots. At 3000 feet, west slope plots have an equal abundance of balsam fir and paper birch, but the east slope plots have a dominance of paper birch (53% of trees).

Trees on the west slope plots are healthier than on the east slope. Average dieback and transparency are lower, and crown density is higher on the west slope plots at all elevations (Table 3). Likewise, a higher percent of trees have less than 15% dieback (healthy category) on the west slope than on the east slope, with the exception of the 2200 foot elevation, where 96% of trees are healthy on the east slope compared to 93% on the west slope. Transparency and crown density differences could be explained by the difference in species composition. Although there is higher average dieback and fewer trees healthy on the east slope plots, the 1400 and 2200 foot values are still considered healthy (over 90% of trees healthy). Relatively high dieback (11%) and low percent of trees healthy (78%) at the 3000 foot elevation on the east slope indicates a recent stress event affecting tree health. Since half the trees on these plots are paper birch, which is susceptible to environmental stresses such as drought or ice damage, this may account for the difference between east and west slope tree health.

References

Cooke, R., D., Lachance, W. Burkman & D. Allen. 1995. North American Sugar Maple Decline Project: organization and field methods. Updated from: Gen. Tech. Rep NE-154. Radnor, PA: U.S. Dept. of Agr., Forest Service, Northeastern Forest Experiment Sta. 22 p.

Tallent-Halsell, N.G. (ed.). 1994. Forest Health Monitoring 1994 Field Methods Guide. EPA/620/R-94/027. U. S. Environmental Protection Agency, Washington, D.C. 1997 version.

Figure 1. Trend in ***average dieback*** *of overstory trees for species at different elevations on the west slope of Mount Mansfield, 1992-1997.*

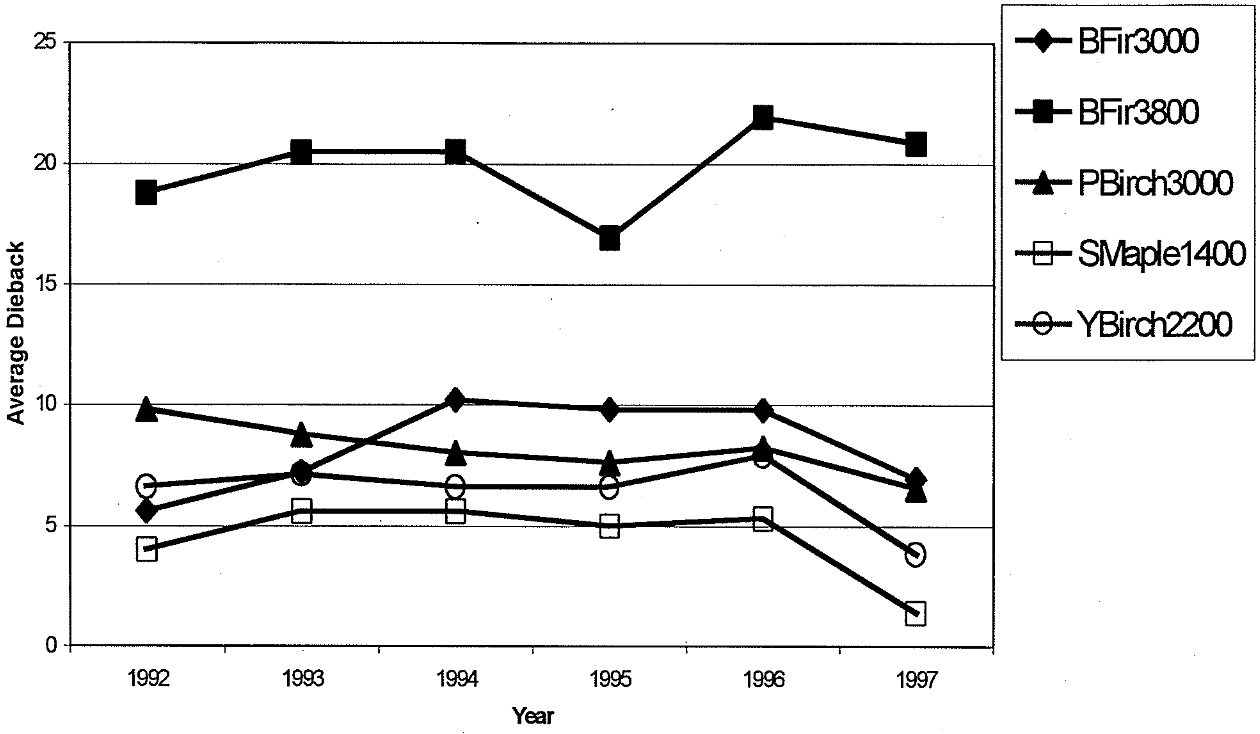


Figure 2. Trend in average ***crown density*** *of overstory trees for species at different elevations on the west slope of Mount Mansfield, 1992-1997.*

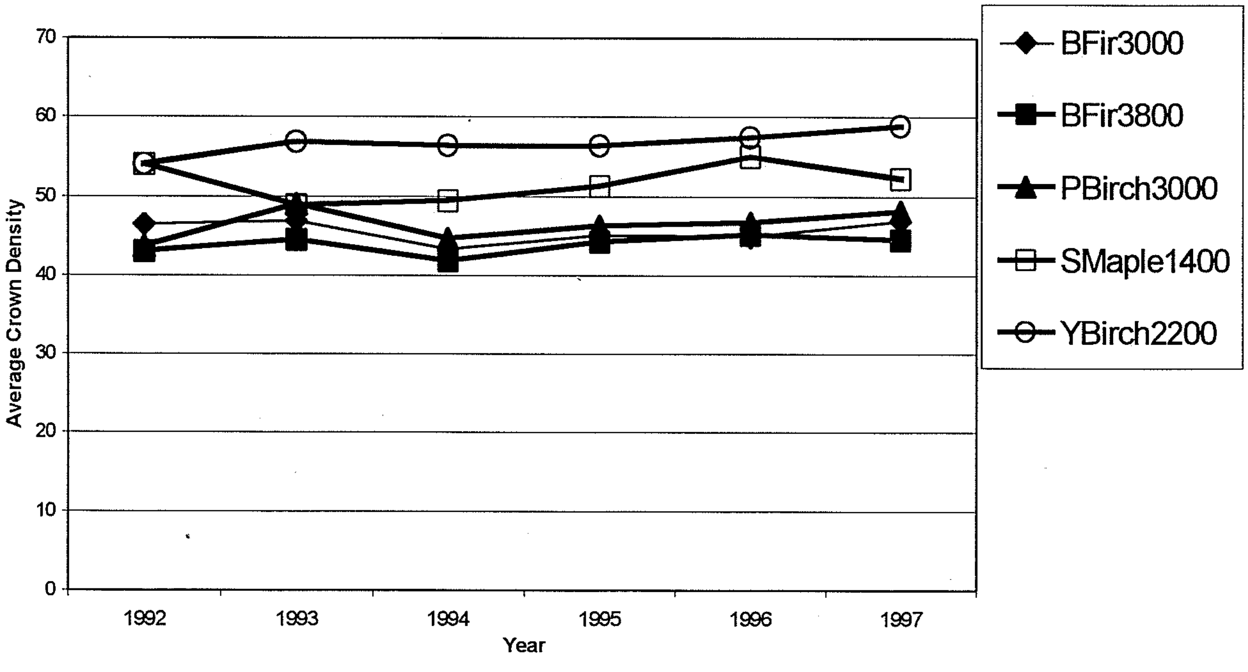


Figure 3. Trend in ***foliage transparency*** *of species at different elevations on the west slope of Mount Mansfield, 1992-1997.*

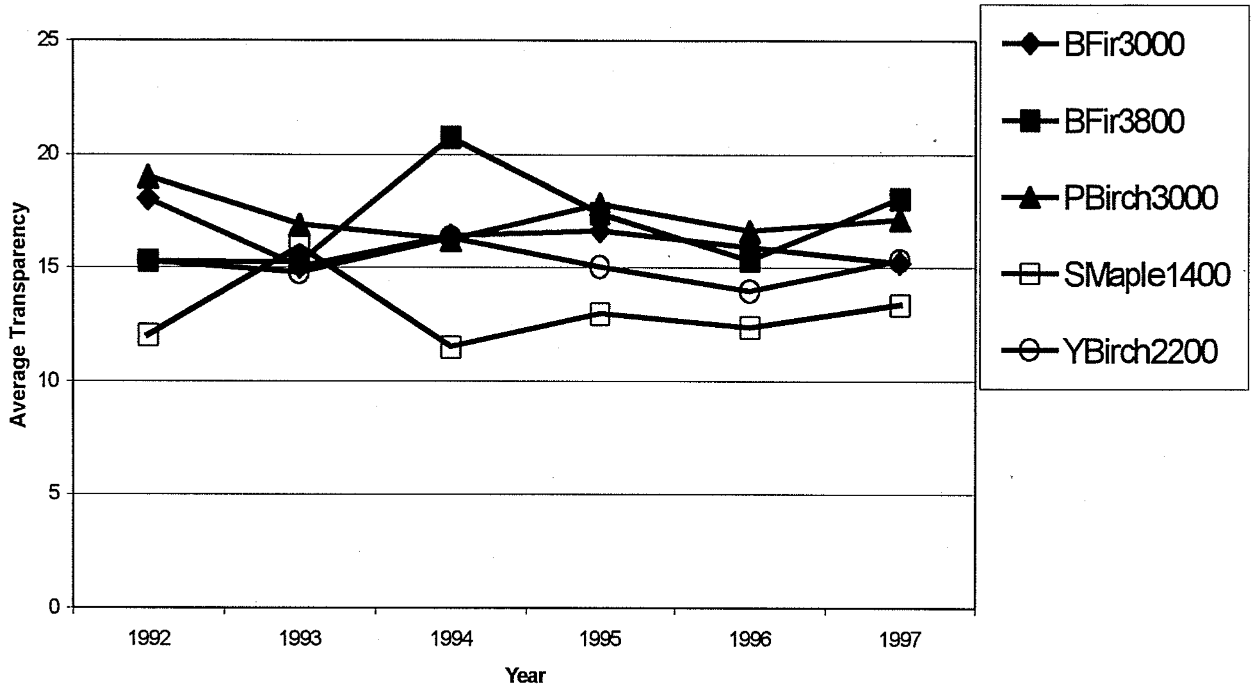


Figure 4. Overstory tree health in 1997 compared to the 5 year average (baseline) for ***crown dieback*** *at 4 elevations on the west slope of Mount Mansfield.*

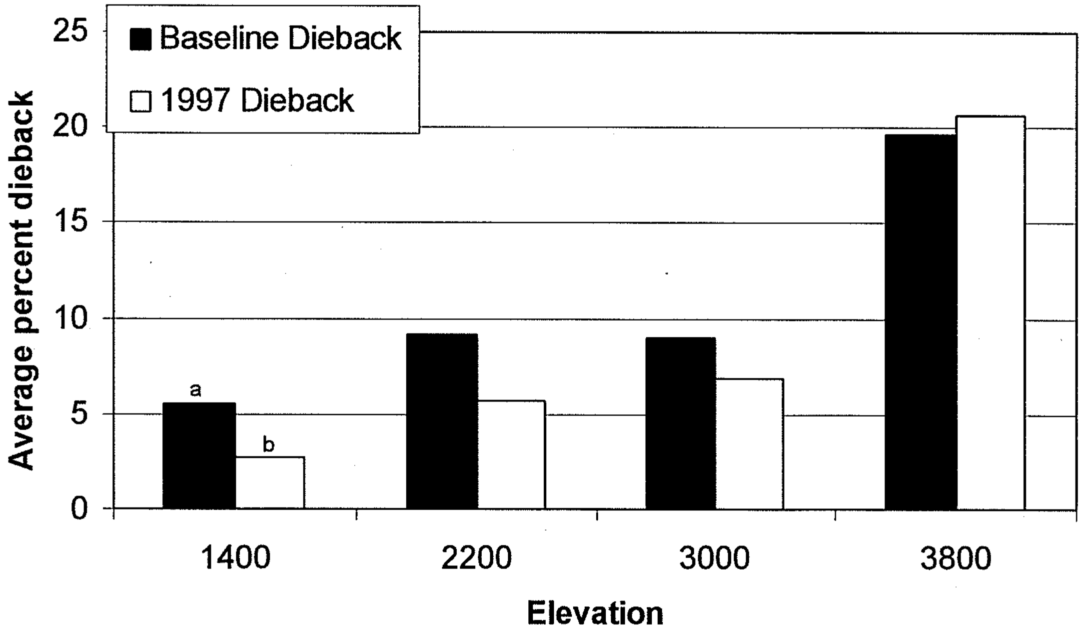


Figure 5. Overstory tree health in 1997 compared to the 5 year average (baseline) for ***foliage transparency*** *at 4 elevations on the west slope of Mount Mansfield.*

Figure 6. Overstory tree health in 1997 compared to the 5 year average (baseline) for ***crown density*** *at 4 elevations on the west slope of Mount Mansfield.*

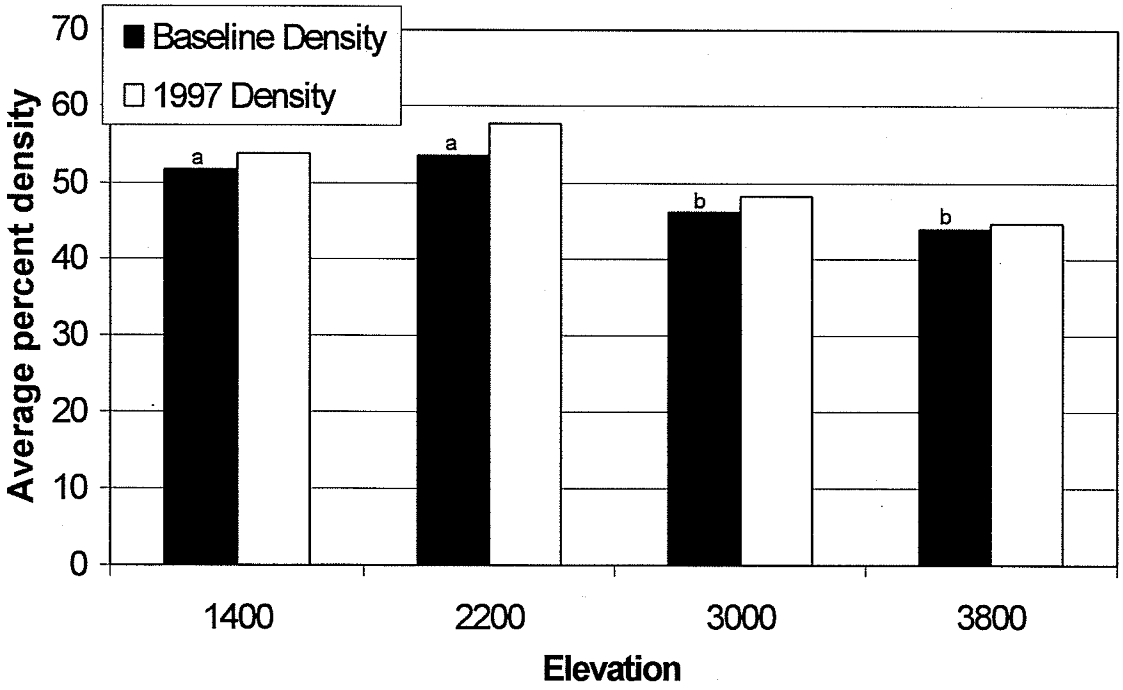


Table 1. Tree health results for the NAMP plot at 415 m (1360 ft) at the Proctor Maple Research Center, Mount Mansfield, Vermont. Average crown dieback, average foliage transparency (the amount of light coming through the foliated portions of the crown), mortality, and percent of trees healthy are all used to assess the health of dominant and codominant sugar maple trees in this plot.

YEAR	DIEBACK (%)	TRANSPARENCY (%)	MORTALITY (%)	HEALTHY TREES (%)
1988	11.3	27.3	0	88.6
1989	7.1	23.0	0	91.4
1990	7.6	14.0	0	91.4
1991	3.0	10.9	0	97.1
1992	8.1	14.3	0	94.3
1993	8.2	14.3	0	91.5
1994	7.6	10.4	0	95.8
1995	7.3	11.3	0	95.8
1996	6.9	9.5	0	95.7
1997	8.1	10.8	0	94.9

Table 2. Percent of trees on west slope plots affected by significant damages in 1997. Minimum thresholds for each type of damage are those considered significant for tree growth and vigor. Protocols follow those of the National Forest Health Monitoring Program.

Elevation (feet)	Percent of trees with damage	Percent of trees affected by each type of damage
1400	20.4%	18.2% Indicator of decay
		6.8% Canker
		2.3% Dead or broken top
2200	40.5%	44.2% Indicator of decay
		7.0% Canker
		7.0% Open wound
		4.6% Dead or broken top
3000	33.3%	20.8% Indicator of decay
		6.9% Canker
		4.2% Open wound
		2.8% Dead or broken top
		2.8% Broken branches
		2.8% Other
3800	36.8%	27.6% Dead or broken top
		11.8% Indicator of decay
		10.5% Broken branches
		5.3% Open wounds
		5.3% Broken bole or roots
		2.6% Other

Table 3. Species composition differences between plots on the west and east slope of Mount Mansfield.

Elevation	**Species**	**West slope percent of trees**	**East slope percent of trees**
1400	Sugar Maple	48.6	37.8
	Beech	40.8	24.4
	Yellow Birch	21.6	22.2
	Red Maple	13.5	8.9
	Other	5.4	6.6
2200	Yellow Birch	63.0	48.9
	Sugar Maple	22.2	17.0
	Beech	11.1	8.5
	Other	3.7	2.1
	Paper Birch	0	23.4
3000	Balsam Fir	41.3	28.8
	Paper Birch	41.3	53.4
	Red Spruce	11.1	16.4
	Other	6.3	1.4

Table 4. Comparison of tree health on the west and east slope of Mount Mansfield using dieback, foliage transparency, crown density and the percent of trees healthy as health indicators.

Health indicator	**West Slope**			**East Slope**		
	1400	**2200**	**3000**	**1400**	**2200**	**3000**
Dieback	2.7	5.7	6.9	5.0	6.8	11.2
Transparency	14.6	15.2	16.2	16.8	16.6	18.8
Density	53.8	57.8	48.3	51.2	49.3	44.7
Percent healthy	100	92.6	96.6	97.8	95.7	78.1

Forest damage assessment at Mt. Mansfield and the Lye Brook Wilderness Area

1997

Sandra Wilmot, Thomas Simmons and Trish Hanson
Vermont Department of Forests, Parks & Recreation

Abstract

Annual monitoring of pest population trends and tree damage is conducted on a statewide basis to understand trends in stress agent occurrence in relation to forest health. More recently, concerns about the role of air pollutants in forest health have prompted monitoring of plants sensitive to ground level ozone.

Monitoring efforts on Mount Mansfield include conducting aerial surveys to detect areas of defoliation or decline, ground plot evaluations of tree damages, and monitoring of forest pest population trends. At the Lye Brook Wilderness Area (LBW) aerial surveys and ground plot evaluations are used to detect defoliation and declines.

The objective of this monitoring effort is to detect trends in the populations of major insect pests, and to document the occurrence, location and severity of damage to the forests on Mount Mansfield and the LBW.

At Mount Mansfield, populations of major forest insect pests were relatively low, with significant defoliation occurring only to birch trees in localied areas from birch leaf miner defoliation. Forest tent caterpillar populations remain below detection limits. Spruce budworm populations seem to be increasing, but no defoliation has resulted. Pear thrips defoliation was light on sugar maple regeneration, and light on scattered trees. A patch of birch defoliation and browning was detected in the Browns River drainage from aerial surveys. In the Lye Brook Wilderness Area site, areas of spruce browning and hardwood decline were detected from aerial surveys. Surveys of ozone sensitive bioindicator plants in both northern and southern Vermont continue to detect plants with symptoms of ozone injury.

Introduction

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

Monitoring efforts on Mount Mansfield include conducting aerial surveys to detect areas of defoliation or decline, ground plot evaluations of tree damages, and monitoring of forest pest population trends. At the Lye Brook Wilderness Area (LBW) aerial surveys and ground plot evaluations are used to detect defoliation and declines.

The objective of this monitoring effort is to detect trends in the populations of major insect pests, and to document the occurrence, location, and severity of damage to the forests on Mount Mansfield and the LBW from detectable stress agents.

Mount Mansfield Monitoring Methods

There are many different methods for measuring forest pest populations. Some forest pests do not yet have reliable, meaningful survey methods developed. In 1997, the forest pests monitored on Mount Mansfield included: pear thrips (PT), forest tent caterpillar (FTC), and spruce budworm (SBW). Defoliation and declines are monitored on ground plots and from the aerial survey.

FOREST TENT CATERPILLAR AND SPRUCE BUDWORM

These pests are monitored using pheromone traps (multipher traps with a biolure and a vaportape insecticide), which attract male moths during their flight period, indicating relative population levels in the area. FTC trapping is done using a 5 trap cluster in northern hardwood stands. SBW trapping uses a 3 trap cluster placed in spruce and fir stands. Protocols for these surveys are consistent with those of other statewide surveys for these pests making results comparable across the state (Teillon et al, 1997).

Each trap type is deployed during the adult moth flight period. FTC traps are active between June 10 and August 16. SBW traps are deployed between June 18 and August 16. Trap catches are returned to the Vermont Department of Forests, Parks & Recreation (FPR) Forest Biology Laboratory in Waterbury for identification and counting of target and non-target species.

PEAR THRIPS

Pear thrips are a relatively new pest to Vermont sugar maple trees, and therefore lack the depth of understanding in relating trap catches to population densities and subsequent damage. At present 2 different population assessment methods are in use for monitoring this pest: soil samples for fall and winter population estimates, and yellow sticky traps for adult population estimates and flight period. Both methods are used at the Proctor Maple Research Center [1360 ft. (415 m) elevation]. Additional soil sample plots were established in 1995 at 3 elevations in the Stevensville Brook watershed as part of the planned Forest Management Study. Here, the sampling transects are located at 1500, 2000 and 2500' elevations off the Butler Lodge Trail.

Soil samples are collected annually in the fall to estimate the overwintering pear thrips population. Field and laboratory protocols previously established for statewide and regional PT surveys are used (Parker et al, 1990). Basically, 5 sugar maple trees at each sampling site are used as reference points for soil sampling, using a bulb planter collecting tool, and in the following spring are assessed for defoliation.

Yellow sticky traps are used to monitor the timing and duration of adult PT activity above ground, as well as to monitor trends in adult populations over time. Standard protocols were developed under the CAPS program (Cooperative Agricultural Pest Survey Program) and consisted of placement of 4 yellow sticky traps at a 1-m height off the ground in the vicinity of 8 sugar maple trees to be used for monitoring bud phenology and PT damage. Weekly trap collections are made from April 1 through June 13, with trap catch counts conducted at the VT FPR Forest Biology Laboratory.

Mount Mansfield and Lye Brook Wilderness Area Methods

AERIAL SURVEY OF FOREST DAMAGE

Aerial surveys conducted by trained FPR staff during the summer months are used to detect areas of defoliation, discoloration, heavy dieback or mortality, and determine the cause of this injury, if possible. Two observers sketch damaged areas onto topographic maps, indicate a possible cause, then later conduct ground surveys to verify location, extent, severity and possible cause of injury. Procedures are standardized statewide and remeasurement is conducted on 10% of the area evaluated (Teillon et al, 1997). Information is later digitized into a Geographic Information System.

OZONE BIOINDICATOR PLANTS

Plants sensitive to ground level ozone are surveyed as part of the National Forest Health Monitoring Program (NFHM)(Tallent-Halsell 1994). During the period of maximum exposure, August 7-23, 30 individuals of each sensitive species growing naturally in large openings are examined for symptoms of ozone injury. These include milkweed, black cherry, blackberry, white ash and dogbane. Symptoms are verified by a regional expert in ozone injury identification as part of the NFHM. For Mount Mansfield, plant evaluations are conducted at the Proctor Maple Research Center in an open field where the state ozone monitor is located. The availability of large (>3 acres) opening containing plants sensitive to ozone have not been possible at LBW. A location in Rupert (Bennington County) is used to represent exposure and injury for the southern Vermont site. Ozone exposure data are provided by the Vermont Air Pollution Control Division for the two Vermont sites: Bennington and Underhill.

Mount Mansfield
Results And Discussion

Insect populations of forest tent caterpillar remain below detection limits, as has been the case for the past 6 years, with no moths trapped. Spruce budworm populations at the 3800' elevation were the highest of all statewide monitoring sites, but was not associated with noticeable defoliation (Figure 1). The statewide average was 2.8 moths per trap. Pear thrips populations increased in 1997, but remain relatively low (Figure 2). A total of 621 thrips were caught on sticky traps, spanning a period from April 11through June 13 (Figure 3). At the time of budbreak, 60% of thrips adults were trapped. Only light defoliation was observed on scattered regeneration and trees this year.

Mount Mansfield and Lye Brook Wilderness Area
Results And Discussion

Ozone symptoms on sensitive bioindicator plants were confirmed at both northern and southern Vermont sites. Although southern Vermont received higher cumulative ozone levels, injury symptoms at the both sites showed moderate injury from ozone (Figure 4). Although symptoms are visible on susceptible plants, the extent and severity of ozone injury to forests is not well understood.

Results from aerial surveys to map areas of defoliation and decline at the Lye Brook Site detected an area of spruce decline on the west slope of the wilderness area (Figure 5). This is likely the result of freezing and thawing events occurring over the past winter. Also detected was an area of hardwood decline towards the southern end of the wilderness area.

The aerial survey at Mount Mansfield detected an area of persistent birch leaf miner damage on the north slope of the Browns River headwaters (Figure 6). No damage was detected in the Stevensville Brook or Ranch Brook headwaters.

Acknowledgments

Aerial survey and ground plot data collection was conducted by dedicated Forest Resource Protection staff. GIS maps of aerial survey information were provided by Tom Luther of the USDA Forest Service, Northeastern Area State & Private Forestry in Durham, NH. Ozone concentration data was provided by the Vermont Air Pollution Control Division.

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Figure 1. Spruce budworm population trends on Mount Mansfield at 3 elevations.

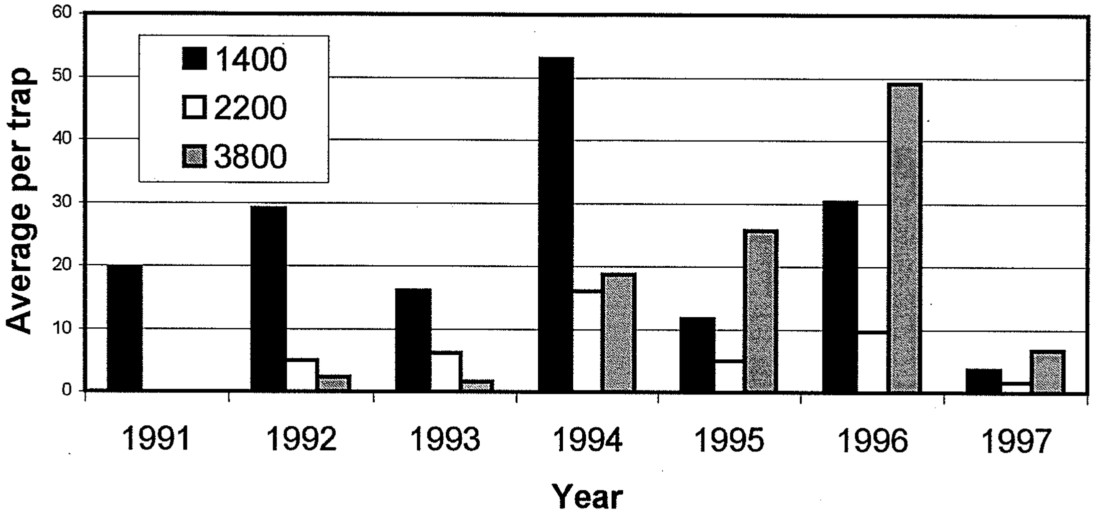

Figure 2. Trends in pear thrips populations at the Proctor Maple Research Center at 1400 feet on Mount Mansfield, as measured in the soil and emerging in the spring.

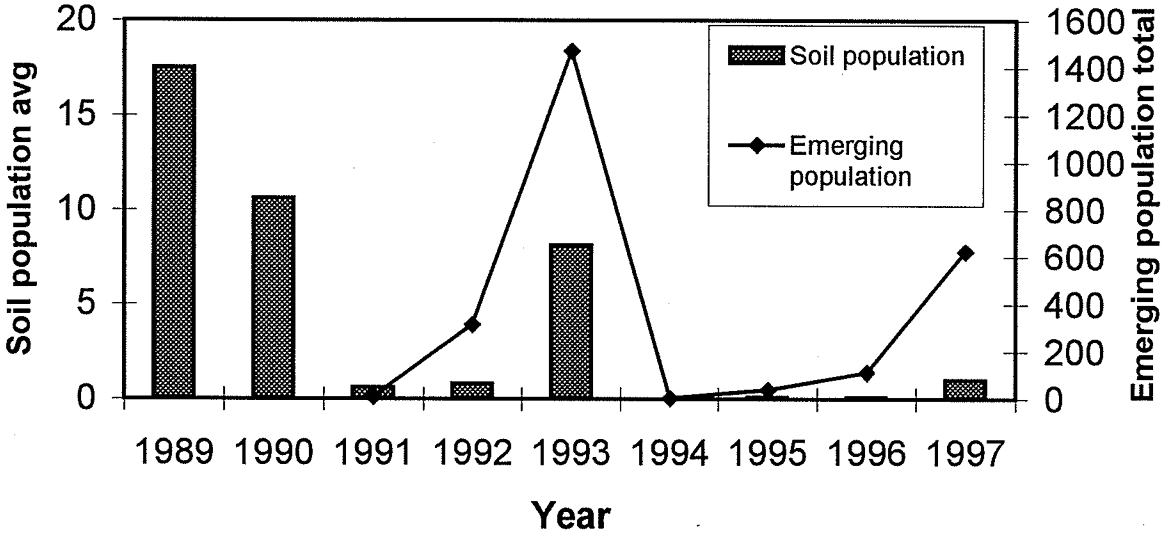

Figure 3. Timing of pear thrips adult emergence, sugar maple budbreak and temperature expressed as growing degree days, at the Proctor Maple Research Center, 1400 feet on Mount Mansfield.

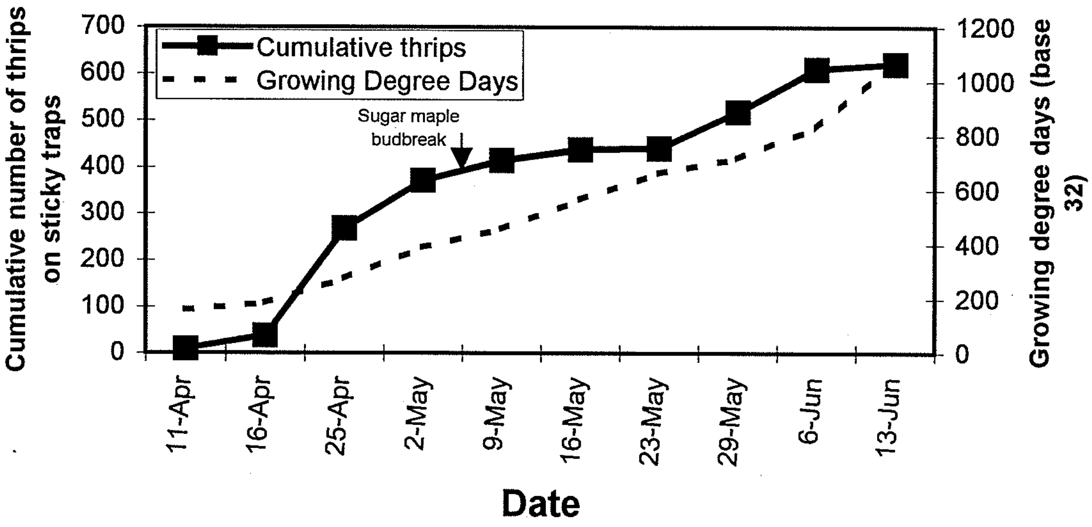

Figure 4. Weekly cumulative ozone exposures (expressed as cumulative sum60 ozone based on 24 hour period) representing the Mount Mansfield (Undershill) and Lye Brook (Bennington) study sites compared with injury to ozone sensitive bioindicator plants surveyed at Underhill and Rupert (Bennington County). Plant injury severity is based on a 0 - 5 rating system where 0=no injury, 1=1-6% of leaf area affected ,2=7-25%, 3=26-50%, 4=51-75%, and 5=>75%.

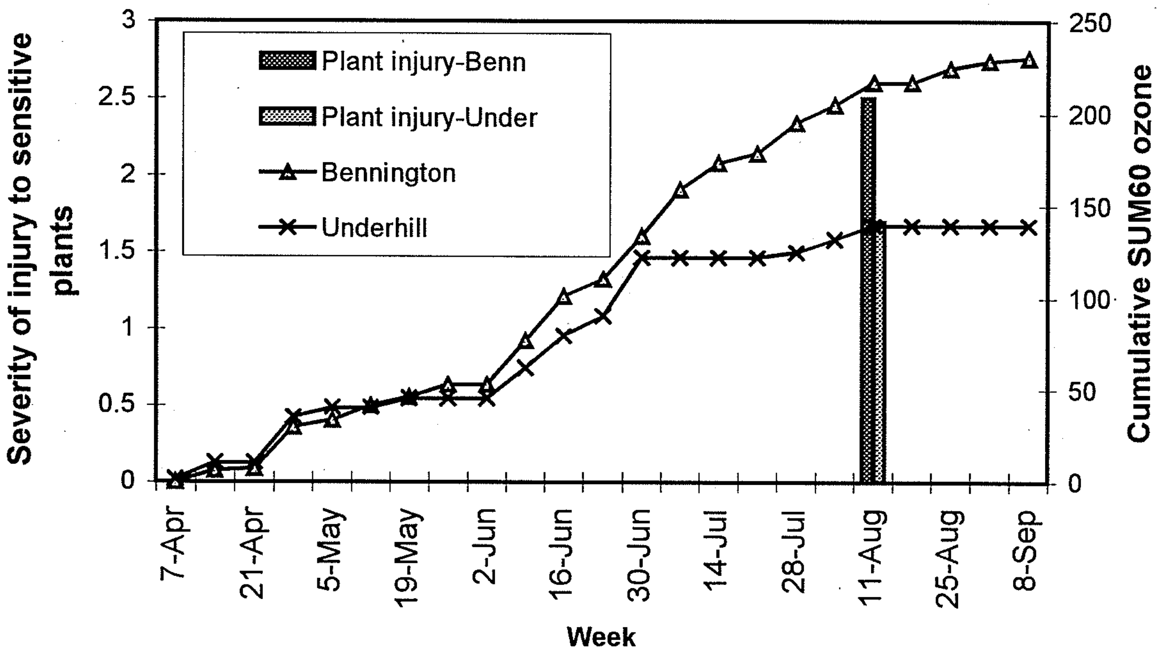

Figure 5. Forest damage mapped in Lye Brook Wilderness Area, 1997.

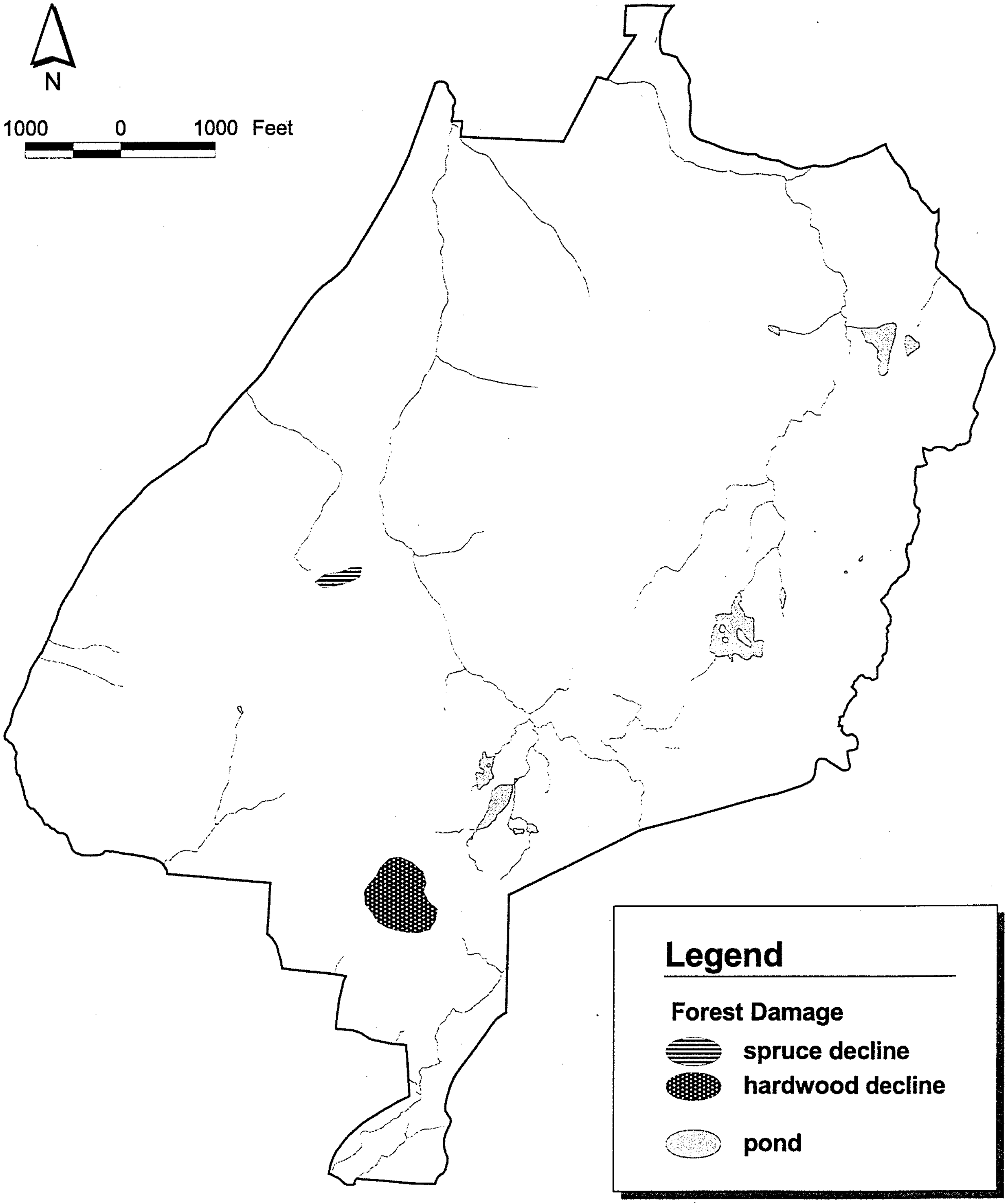

Figure 6. Forest damage mapped on Mount Mansfield, 1997.