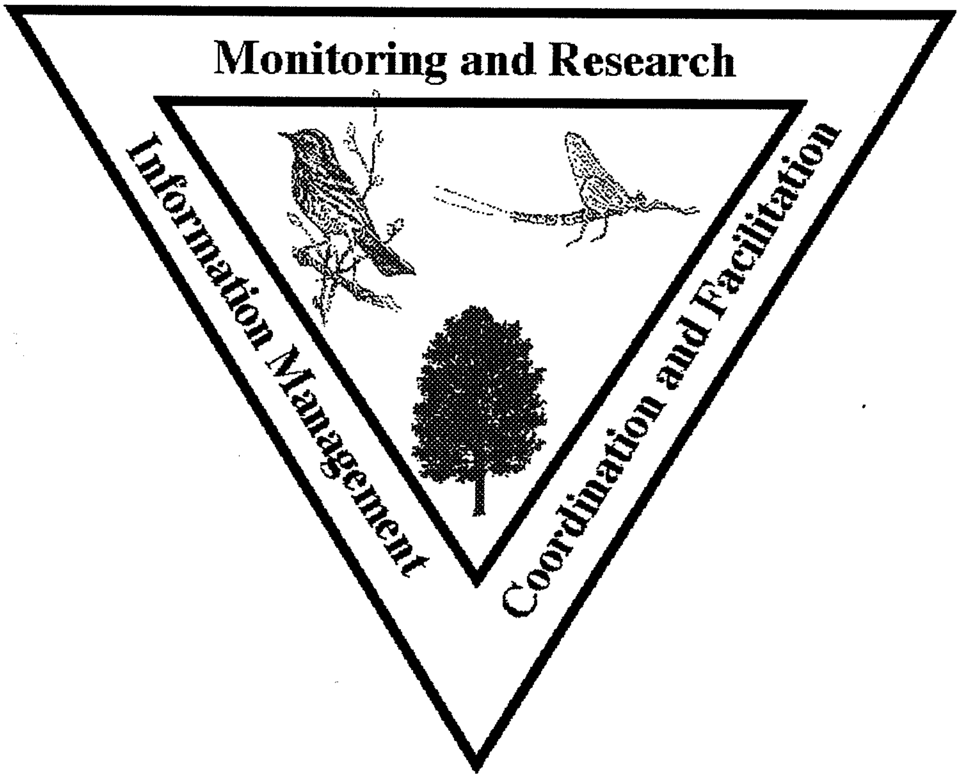
Vermont Monitoring Cooperative

Vermont's Intensive Forest Ecosystem Monitoring and Research Program

1998 Annual Report



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

Annual Report for 1998

Sandra Wilmot, Jennifer Supple,
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 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 Wilderness 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 1998, then proceeds to specific study results. Results are organized according to the type of information collected (atmospheric, flora, etc.), and includes studies conducted at Mount Mansfield and the Lye Brook Wilderness Area.

VMC Program Highlights for 1998

- In 1998, the VMC program continued to scale back activities as funding became scarce. The operating budget was minimal, and as a result there was a significant reduction in VMC staff, as well as time devoted to the VMC program by the Research and Monitoring Directors.

- Monitoring and research projects continued, supported by other sources of funding. Cumulatively, there were 98 research projects at Mount Mansfield and 24 research projects at Lye Brook by the end of 1998.

- The Annual Cooperators Meeting featured a panel discussion on improving the connection between scientists and educators.

- There were 45 requests for data and information through the VMC Office, with requests for weather data and general ecological information being the most common.

- Work to develop a data management infrastructure that would allow easy access to environmental data via the internet was initiated in a cooperative project between the City of Burlington and the University of Vermont, funded through an EPA EMPACT grant. VMC provided technical expertise to develop this dynamic web site. This project will allow the VMC to accomplish the development of a dynamic web site that allows access to the VMC Data Library and Card Catalog.

- A planning meeting was held to develop a long-term soil monitoring project at the two VMC study sites. Participants were from the Natural Resources Conservation Service, the University of Vermont, the Agency of Natural Resources, the US Forest Service Northeast Research Station and the Green Mountain National Forest. A summary of the goals and founding concepts was published in the VMC Newsletter.

- A "Site Characterization of the VMC Ecosystem Management Demonstration Project Area" was compiled by a UVM Graduate Student intern as a support document for future research efforts for this forest management study.

- The VMC was invited to participate in the New England Governors / Eastern Canadian Premiers Forest Sensitivity Mapping Project. This research effort will use intensive forest ecosystem research site data to develop maps to characterize the current status of acid deposition effects on forests.

- The VMC participated in a workshop sponsored by the National Forest to assess air quality issues on national forests. VMC members were valuable in providing input on research needs to address air quality issues for Class I Wilderness Areas.

- The GMNF supported new research on Ecosystem Susceptibility to Acid Deposition in the Lye Brook Wilderness area through air resources grant funds.

- Program outreach included:
  - Article published in the Vermont Center for Geographic Information Newsletter on VMC Data Library and sharing of Data. Audience is scientists, resource managers and interested public.
  - A VMC presentation titled "Monitoring Environmental Change in Vemront" at the Center for Research on Vermont.
  - A VMC display at the Annual Governor's Conference on Recreation, which featured displays on Green Space and Vermont's natural resources.
  - A VMC display was presented at the Statehouse to provide information to legislators on VMC findings. Of special interest was recent results on mercury cycling.
  - An article featuring VMC research on ice damage was highlighted in the Rutland Herald.
  - The Conde National Travel Magazine featured an article on the influence of El Nino on ice damaging storms, sighting VMC work on ice research.

Atmospheric

CLOUD WATER CHEMISTRY AND MERCURY DEPOSITION IN A HIGH ELEVATION SPRUCE FIR FOREST

In Partial Fulfillment of the Requirements
for the Degree of Master of Science
Specializing in Forestry

Excerpts from
A Thesis Presented by
Sean T. Lawson
To the Faculty of the Graduate College
The University of Vermont
School of Natural Resources
University of Vermont
October 1999

During 1997 and 1998, Sean Lawson carried out much of his research for his Masters degree in Forestry. Tim Scherbatskoy (UVM School of Natural Resources) served as his thesis advisor. This research was carried out in cooperation with the Vermont Monitoring Cooperative (VMC) within the VMC study area on the western slope of Mt. Mansfield, specifically in the summit area to the west of the radio and television transmitter facilities. What follows are the abstract of this thesis and relevant figures that show some of the key findings of this research. A copy of his entire thesis can be obtained from the UVM Libraries or from the VMC data library.

Cloud Water Deposition and Throughfall Chemistry in a High Elevation Spruce-Fir Forest at Mt. Mansfield, Vermont.

Sean T. Lawson, Timothy Scherbatskoy
the University of Vermont, Burlington, VT

Elizabeth G. Malcolm, Gerald I. Keeler
The University of Michigan, Ann Arbor, MI

As part of the Lake Champlain Basin watershed study of mercury (Hg) and pollutant deposition, cloud water and cloud throughfall collections were conducted at the south summit (1204m) of Mt. Mansfield, Vermont between August 10 and October 16, 1998, for multi-element chemical analysis. A passive strand-type Teflon collector was deployed during non-precipitating events to sample cloud/fog water at timberline, while three sets of paired funnels collected cloud throughfall under the red spruce-balsam fir canopy. Samples were analyzed for pH, conductivity, and concentrations of Hg, major ions (Ca^{2+}, K^{+}, Mg^{2+}, Na^{+}, Cl^{-}, $NO3^{-}$, $SO4^{-}$,NH_4^{+}), and 28 trace elements. Ultra-clean sampling and analysis techniques were utilized throughout the study.

Six events were sampled for cloud water alone and four events were sampled for both cloud water and cloud throughfall. Cloud water pH values were highly acidic, with a volume-weighted mean of 3.0 and a range of 2.1 to 4.4. Cloud throughfall chemistry showed substantial modification with a mean increase in pH

of 1.2 units. Much higher concentrations of Hg{2.3x), base cations (Ca^{2+}, K+, Mg^{2+}; 3-18x) and certain trace metals (Al, Ni, Cu, Mn, Rb, Sr; 2-34x) were observed in throughfall than in cloud water. These results suggest that despite recent reductions in S inputs to the atmosphere, cloud water remains highly acidic and can leach important nutrients from tree foliage. Cloud water dcposited an average of 0.42 ± 0.12 mm H_2O hr^{-1} and a total of 279 ng m^{-2} Hg to the forest floor during three non-precipitating cloud events. Estimated cloud water deposition of Hg was 7.4 mg m-2 for the period August 1 - October 31. Cloud events likely deposit significant annual amounts of water, mercury, and other pollutants to the high elevation ecosystem at Mt. Mansfield.

Table 1 - Estimated annual cloud water deposition at mountain locations in the northeastern United States.

Site	**Elevation (meters)**	**Year**	**Cloud H_2O (cm yr^{-1})**	**Cloud (%) frequency**	**Reference**
Mt. Mansfield, VT	1204	1998	92 ρ 26[a]	25[b]	Lawson et al. (1999)
Whiteface Mt., NY	1225	1986-90	81.1	23	Miller et al. (1993a)
Mt.Moosilauke, NH	1220	1990	40.5	--	Schaefer and Reiners (1990)
Mt. Moosilauke, NH	1220	1980-81	84.0	40	Lovett et al. (1982)
Madonna Mt.,VT	1110	1980-81	154.0	--	Scherbatskoy and Bliss (1984)
Camels Hump, VT	1110	1970	76.0	--	Leedy (1972)
Whiteface Mt., NY	1050	1986-89	28.4	10	Miller et al. (1993b)
Whiteface Mt., NY	1350	1986-89	153.5	36	Miner et al. (1993a)
Whiteface Mt., NY	1483	1987	127.0	42	Mohnen (1988)

a. Annual cloud water deposition estimated in this study from three non-precipitating cloud events, where mean cloud water input was measured at 0.42 ρ 0.12 mm hr^{-1} and extrapolated to annual basis using cloud frequency.

b. Cloud frequency estimate based on lower limit of visual and meteorological observations at Mt. Mansfield summit station (NCDC, 1999).

Table 2 - Mean concentrations (volume-weighted) of trace metals in four paired cloud water and throughfall collections at Mt. Mansfield, Vermont.

Element (µg L^{-1})	Al	Cr	Mn	Ni	Cu	Zn	As	Rb	Sr	Cd	Pb
Cloudwater (n=9)											
Mean	7.92	0.09	1.73	0.24	0.51	5.52	0.13	0.07	0.30	0.03	0.58
Std. dev.	31.60	0.19	5.33	0.58	1.11	12.08	6.82	0.34	1.42	0.16	2.56
Median	6.82	0.10	1.52	0.24	0.56	4.06	0.18	0.13	0.51	0.03	0.93
Maximum	101.31	0.63	17.30	1.90	3.64	30.27	2.12	1.08	4.61	0.52	8.17
Minimum	2.01	0.01	0.29	0.05	0.12	0.68	0.04	0.03	0.04	0.01	0.11
Throughfall (n=10)											
Mean	17.32	0.11	40.93	0.64	0.99	6.91	0.18	2.53	1.18	0.07	0.76
Std. dev.	13.79	0.08	52.30	0.57	0.36	6.76	0.12	3.14	1.73	0.09	0.49
Median	15.94	0.13	50.66	0.64	1.03	3.74	0.13	2.06	0.53	0.04	0.62
Maximum	55.58	0.23	172.14	2.11	1.61	23.94	0.39	10.26	4.62	0.27	1.54
Minimum	7.10	0.00	4.98	0.26	0.54	2.94	0.07	0.52	0.17	0.01	0.27
Net throughfall	9.40	0.02	39.20	0.40	0.48	1.39	0.05	2.46	0.88	0.05	0.18
Enrichment factor [a]	2.2	1.2	23.7	2.7	1.9	1.3	1.4	38.3	4.0	3.0	1.3

a. Enrichment factor calculated as mean throughfall divided by mean cloud water.

Table 3 - Mean (volume-weighted) mercury concentrations in three paired cloud water (CW) and throughfall (TF) collections at Mt. Mansfield, Vermont.

Hg (ng L^{-1})	Paired collections	
	Cloud water (n=7)	Throughfall (n=9)
Mean	7.51	17.49
Std. Dev	2.73	6.62
Median	6.18	16.47
Maximum	11.81	33.30
Minimum	3.74	9.95
Net Throughfall (TF-CW)		9.97
Enrichment factor (TF/CW)		2.3

Table 4 - Mean Hg concentrations and estimated deposition in four paired cloud water and cloud throughfall (TF) collections at Mt. Mansfield, Vermont.

	Date	8/18	8/26	9/10	10/1[a]	Total	Units
Hg Concentration	Throughfall	15.02	*	13.47	19.58		ng L^{-1}
	Cloud	7.52	33.9	*	4.83		
	Net Throughfall	7.50	*	1.66	14.75		
Hg Deposition	Cloud[b]	37.12	31.67	19.32	37.21	125.32	ng m^{-2}
	Net throughfall[C]	37.03	*	2.71	113.79	153.53	
	Total	74.15	31.67	22.03	151.00	278.85	
Cloud Deposition Rates	Hg	3.91	9.74	3.86	6.47		ng m^{-2} hr^{-1}
	Water	0.52	0.29	0.33	1.34[a]		mm h^{-1}

a. Cloud event on 10:1 contained some precipitation in briefsho\vers \\'hich could not be excluded from collection. All data for 10/1 reflects cloud + precipitation.

b. Hg deposition calculated as mean cloud Hg concentration x mean TF volume and does not account for evaporation or retention of water in the canopy, and thus underestimates total deposition.

c. Net throughfall deposition calculated as difference of cloud and total throughfall deposition,

* Volume obtained in 8/26 throughfall sample (17ml) too small for Hg analysis.

Table 5 - Cloud water and throughfall deposition of trace metals to the forest floor during four cloud events and estimated deposition by cloud water for the three month period (August 1 -October 31, 1998) at Mt. Mansfield, Vermont.

	Al	Cr	Mn	Ni	Cu	Zn	As	Rb	Sr	Cd	Pb
Cloud water	107.26	1.49	30.58	2.95	8.24	90.50	4.42	1.55	6.49	0.54	9.89
Net throughfall	181.12	0.35	662.93	7.49	7.12	4.18	-1.65	40.34	12.55	0.60	1.77
Total throughfall	288.38	1.84	693.51	10.44	15.36	94.68	2.77	41.89	19.04	1.14	11.66
Estimated cloudwater deposition (mg m^{-1}) (August 1 - October 31, 1998)	4.18	0.05	1.04	0.20	0.55	5.49	0.19	0.07	0.27	0.05	0.82

Meteorological Conditions at VMC Sites in 1998

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 1998 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) and tower (PMRC tower, 400m), established in 1988 and 1992, respectively; the VMC meteorological station on the west side of Mt. Mansfield (MMWest, 880 m (2900 ft)), established in 1997; the National Weather Service summit station, established in 1960; Colchester Reef (CR, 38 m), established in 1996 and the Clean Air Status and Trends Network (CASTNET), established in 1994 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 for 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 (CR; MMWest; PMRC tower) values for each parameter at each site. 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 the VMC sites are summarized in Table 1.

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 the appendix. Data for MMWest in May through August are not available.

This report contains a summary of annual averages; other time frames (daily, weekly, monthly) are in the Appendix. The Appendix contains summary statistics including means, maximum and minimum values, and number of observations. Fifteen minute average data (from MMWest, CR, CASTNET and PMRC tower) are arithmetically averaged to provide hourly means, which are then averaged into daily means. Monthly and yearly summaries are created from daily data.

Results and Discussion:

A comparison of several meteorological variables at individual sites can be found in the Appendix.

Daily total precipitation by month for all VMC sites is summarized (Appendix). Daily mean, minimum, and maximum temperatures for each site are shown by month (Appendix). Please note that the X-axis may cross the Y-axis at different locations, and that the Y-axis scale varies.

Growing degree days are based on start temperatures of 32 and 50 degrees Fahrenheit, temperature thresholds for plants and insects, respectively. Cummulative growing degree days are calculated by adding the degrees above the starting temperature (daily ave.) for a given day to the next day's above freezing value. Days when temperatures do not go above the base temperature are given a value of zero. Resutls are plotted in the Appendix.

The Northeast Regional Climate Center reported that in 1998 overall regional temperatures produced a warm winter and a wet summer. One consequence of the warm winter was the January 1998 ice storm, which resulted in the largest acreage of forestland damaged by ice in this century. Most of the northeast was dry during the second half of the year, but Vermont was not. The spring was cold and wet; May ended with severe thunderstorms and Bennington was struck by tornados. June and July were characterized by summer storms which caused statewide flooding. Ben and Jerry's had to cancel their annual summer concert in Warren, and the bridge on Route 116 in Bristol washed out. Burlington had the wettest summer on record, with 62.94 cm (24.78") of rain exceeding the previous record of 57.76 cm (22.74") from 1892.

Two excellent resources for meteorological information are the VT Climatology web site, at *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* or directly at *met-www.cit.cornell.edu/data_products.html* .

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Table 1: Annual summary of meteorological variables from VMC stations. N = the number of days with acceptable data.

Variable Name	CASTNet		Colchester Reef		Mount Mansfield (West 2900')		Mount Mansfield Summit		PMRC Air Quality Site		PMRC Tower	
	Data	N	Data	N	Data	N	Data	N	Data	N	Data	N
Average Air Temperature (C)	6.76	365	9.11	298	-0.13	219	3.26	361	10.35	283	8.17	362
Maximum Air Temperature (C)	25.63	365	30.42	298	22.32	219		361	28.50	283	28.70	362
Minimum Air Temperature (C)	-22.70	365	-19.50	298	-26.42	219		361	-24.90	283	-24.14	362
Maximum Air Temperature at Summit (C)		0		0		0	25.56	365		0		0
Minimum Air Temperature at Summit (C)		0		0		0	-33.89	361		0		0
Average Water Temperature (C)		0	8.95	64		0		0		0		0
Maximum Water Temperature (C)		0	13.87	64		0		0		0		0
Mimimum Water Temperature (C)		0	4.29	64		0		0		0		0
Average Snow Depth (mm)		0		0		0	658.09	363		0		0
Maximum Snow Depth (mm)		0		0		0	2870.20	363		0		0
Minimum Snow Depth (mm)		0		0		0	0.00	363		0		0
Average Barometric Pressure (mb)		0	1011.57	298		0		0	955.54	324		0
Maximum Barometric Pressure (mb)		0	1034.00	298		0		0	984.00	324		0
Minimum Barometric Pressure (mb)		0	986.00	298		0		0	930.00	324		0
Average Relative Humidity (%)	69.91	365	78.31	297	87.73	217		0	68.24	303		0
Minimum Relative Humidity (%)	100.00	365	104.60	297	104.40	217		0	100.00	303		0
Mimimum Relative Humidity (%)	-0.65	365	20.23	297	20.03	217		0	20.10	303		0
Average Precipitation (mm)	0.14	364		0	0.00	46	6.74	363	0.11	328		0
Maximum Precipitation (mm)	31.24	364		0	7.00	46	78.74	363	9.90	328		0
Minimum Precipitation (mm)	0.00	364		0	0.00	46	0.00	363	0.00	328		0
Total Precipitation (mm)	1208.02	364		0	14.00	46	2447.04	363	1161.49	328		0
Average Pyranometer (watts/m^2)	129.34	365	118.74	271	33.95	210		0		0		0
Maximum Pyranometer (watts/m^2)	1019.08	365	908.00	271	1016.00	210		0		0		0
Minimum Pyranometer (watts/m^2)	0.00	365	0.00	271	0.00	210		0		0		0
Average Relative Wind Speed (m/sec)	2.28	365	6.14	298	0.77	219		0	1.67	313	0.87	362

Variable Name	CASTNet		Colchester Reef		Mount Mansfield (West 2900')		Mount Mansfield Summit		PMRC Air Quality Site		PMRC Tower	
	Data	N	Data	N	Data	N	Data	N	Data	N	Data	N
Maximum Relative Wind Speed (m/sec)	12.35	365	20.78	298	8.30	219		0	7.60	313	7.26	362
Minimum Relative Wind Speed (m/sec)	0.00	365	0.00	298	0.00	219		0	0.00	313	0.00	362
Average Horizontal Wind Speed (m/sec)	2.47	365	6.23	298	1.02	219		0	1.92	128	1.04	362
Maximum Horizontal Wind Speed (m/sec)	12.73	365	21.14	298	9.08	219		0	8.21	128	7.86	362
Minimum Horizontal Wind Speed (m/sec)	0.05	365	0.00	298	0.00	219		0	0.13	128	0.00	362
Average Wind Direction (degrees)	201.23	365	193.02	298	190.45	219		0	186.88	328	191.76	362
Maximum Wind Direction	360.00	365	360.00	298	360.00	219		0	360.00	328	360.00	362
Minimum Wind Direction	0.00	365	0.00	298	0.00	219		0	0.00	328	0.00	362
Average Standard Deviation WD	25.33	365	7.88	298	36.83	219		0	31.01	328	22.93	362
Maximum Standard Deviation WD	85.84	365	75.30	298	80.80	219		0	85.00	328	80.80	362
Minimum Standard Deviation WD	0.00	365	0.00	298	0.00	219		0	0.00	328	0.00	362
Average Quantum (uE/m^2/sec)		0		0	97.72	204		0		0		0
Maximum Quantum (uE/m^2/sec)		0		0	2088.00	204		0		0		0
Minimum Quantum (uE/m^2/sec)		0		0	0.00	204		0		0		0

Ozone Monitoring Data Report

Phil Girton, Vermont Monitoring Cooperative
Rich Poirot, Air Pollution Control, Vermont Department of Environmental Conservation

Cooperators:
Vermont Department of Environmental Conservation (DEC) and the Green Mountain National Forest (GMNF)

Abstract:

Continuous ozone monitoring has been conducted at the VMC Mount Mansfield site and near the Lye Brook Wilderness Area. The work is a fundamental component of the monitoring and research activities there, providing basic information on the chemical environment.

The Vermont Department of Environmental Conservation has operated ozone monitoring stations in Bennington since April 1986 and in Underhill since 1988. CASTNet has been operating since 1994, just south of the Lye Brook Wilderness Area, providing hourly measurement of ozone concentrations.

Ozone concentration data and calculated metrics are summarized and compared between sites.

Objectives:

Continuous monitoring, at the VMC Mount Mansfield site and near the Lye Brook Wilderness Area, of the ozone concentration. Summary of data from the ozone monitoring program.

Methods:

The Vermont Department of Environmental Conservation's Air Pollution Control Division began monitoring hourly ozone concentration at the Proctor Maple Research Center (PMRC) and in Bennington to determine compliance with (1 hour) National Ambient Air Quality Standards. These stations operate from April 1st to October 31st.

The CASTNet station monitors hourly ozone level to provide air quality data specific to the Lye Brook Wilderness Area, a Class I Wilderness Area, to support research on the effects of air pollution on the Air Quality Related Values (AQRV) of the wilderness area. This station operates from May 1st to September 30th.

The following daily metrics were calculated from the hourly ozone concentration:

ξ Average Hourly Ozone (ppb)	Daily average ozone concentration
ξ Maximum Hourly Ozone (ppb)	Maximum daily ozone concentration
ξ Minimum Hourly Ozone (ppb)	Minimum daily ozone concentration
ξ Daytime Mean Hourly Ozone (ppb)	Mean hourly ozone concentration between 6:00 AM and 6:00 PM.
ξ Daytime Sum04 (ppm-hr)	Plants are suspectible to different levels of ozone concentration. Sum04 is the sum of concentrations greater than and equal to 0.04 ppm for that day. It provides an indication of the total ozone impact between 6:00 AM and 6:00 PM.
ξ Daytime Sum05 (ppm-hr)	Plants are suspectible to different levels of ozone concentration. Sum05 is the sum of concentrations greater than and equal to 0.05 ppm for that day. It provides an indication of the total ozone impact between 6:00 AM and 6:00 PM.
ξ Daytime Sum06 (ppm-hr)	Plants are suspectible to different levels of ozone concentration. Sum06 is the sum of concentrations greater than and equal to 0.06 ppm for that day. It provides an indication of the total ozone impact between 6:00 AM and 6:00 PM.
ξ Daytime Sum08 (ppm-hr)	Plants are suspectible to different levels of ozone concentration. Sum08 is the sum of concentrations greater than and equal to 0.08 ppm for that day. It provides an indication of the total ozone impact between 6:00 AM and 6:00 PM.
ξ Daytime Sum12 (ppm-hr)	Plants are suspectible to different levels of ozone concentration. Sum12 is the sum of concentrations greater than and equal to 0.12 ppm for that day. It provides an indication of the total ozone impact between 6:00 AM and 6:00 PM.
ξ Nighttime Mean Hourly Ozone (ppb)	Mean hourly ozone concentration from 6:00 PM on the date given until 6:00 AM on the following day.
ξ Nighttime Sum04 (ppm-hr)	Plants are suspectible to different levels of ozone concentration. Sum04 is the sum of concentrations greater than and equal to 0.04 ppm for that day. It provides an indication of the total ozone impact .from 6:00 PM on the date given until 6:00 AM on the following day.

ξ Nighttime Sum05 (ppm-hr)	Plants are suspectible to different levels of ozone concentration. Sum05 is the sum of concentrations greater than and equal to 0.05 ppm for that day. It provides an indication of the total ozone impact .from 6:00 PM on the date given until 6:00 AM on the following day.
ξ Nighttime Sum06 (ppm-hr)	Plants are suspectible to different levels of ozone concentration. Sum06 is the sum of concentrations greater than and equal to 0.06 ppm for that day. It provides an indication of the total ozone impact .from 6:00 PM on the date given until 6:00 AM on the following day.
ξ Nighttime Sum08 (ppm-hr)	Plants are suspectible to different levels of ozone concentration. Sum08 is the sum of concentrations greater than and equal to 0.08 ppm for that day. It provides an indication of the total ozone impact .from 6:00 PM on the date given until 6:00 AM on the following day.
ξ Nighttime Sum12 (ppm-hr)	Plants are suspectible to different levels of ozone concentration. Sum12 is the sum of concentrations greater than and equal to 0.12 ppm for that day. It provides an indication of the total ozone impact .from 6:00 PM on the date given until 6:00 AM on the following day.
ξ Cumulative Sum04 (ppm-hr)	Plants are effected by chronic ozone exposure Cumulative Sum04 is the sum of concentrations greater than and equal to 0.04 ppm for the year to date.
ξ Hours >40 ppb	Total number of hours with ozone concentration greater than 40 ppb.
ξ Sum04 (ppm-hr)	Plants are suspectible to different levels of ozone concentration. Sum04 is the sum of concentrations greater than and equal to 0.04 ppm for that day. It provides an indication of the total ozone impact.
ξ Cumulative Sum05 (ppm-hr)	Plants are effected by chronic ozone exposure Cumulative Sum05 is the sum of concentrations greater than and equal to 0.05 ppm for the year to date.
ξ Hours >50 ppb	Total number of hours with ozone concentration greater than 50 ppb.

ξ Sum05 (ppm-hr)	Plants are suspectible to different levels of ozone concentration. Sum05 is the sum of concentrations greater than and equal to 0.05 ppm for that day. It provides an indication of the total ozone impact.
ξ Cumulative Sum06 (ppm-hr)	Plants are effected by chronic ozone exposure Cumulative Sum06 is the sum of concentrations greater than and equal to 0.06 ppm for the year to date.
ξ Hours >60 ppb	Total number of hours with ozone concentration greater than 60 ppb.
ξ Sum06 (ppm-hr)	Plants are suspectible to different levels of ozone concentration. Sum06 is the sum of concentrations greater than and equal to 0.06 ppm for that day. It provides an indication of the total ozone impact.
ξ Cumulative Sum08 (ppm-hr)	Plants are effected by chronic ozone exposure Cumulative Sum08 is the sum of concentrations greater than and equal to 0.08 ppb for the year to date.
ξ Hours >80 ppb	Total number of hours with ozone concentration greater than 80 ppb.
ξ Sum08 (ppm-hr)	Plants are suspectible to different levels of ozone concentration. Sum08 is the sum of concentrations greater than and equal to 0.08 ppm for that day. It provides an indication of the total ozone impact.
ξ Sum12 (ppm-hr)	Plants are suspectible to different levels of ozone concentration. Sum12 is the sum of concentrations greater than and equal to 0.12 ppm for that day. It provides an indication of the total ozone impact.
ξ Hours >80 ppb	Total number of hours with ozone concentration greater than 120 ppb.

Results are presented in the following figures:

Figure 1: Four Highest Daily 1 Hour Maximum Ozone Values	Highest hourly ozone concentration and Date/Time of occurrence are presented.
Figure 1a: 3 Year Comparison of Four Highest Daily 1 Hour Maximum Ozone Values	A graphical comparison of ozone highest ozone levels.
Figure 2: Daily Values	The maximum daily measurement for the year with the exception of Minimum Hourly Ozone.

Figure 3: Cumulative Effects	Graphs comparing the cumulative ozone exposure for Sum04, Sum05, Sum06 and Sum08 between sites for the year.
Figure 4: Monthly Average and Maximum One Hour Ozone Values	Graph of monthly average and maximum ozone concentration for each site.
Figure 5: Weekly Values	Weekly average, maximum, minimum and toal values for metrics.
Figure 6: Annual Average Diurnal Pattern	Average ozone concentration for specific hour in the day. Averaged for the entire year for each site.
Figure 7: Monthly Average Diurnal Pattern	Average ozone concentration for specific hour in the day. Averaged for the the entire month for the year.

Figure 1: Four Highest Daily 1 Hour Maximum Ozone Values

Bennington

Rank: **1st** Value (ppb): **94**
7/27/1998 7:00:00 PM

Rank: **2nd** Value (ppb): **85**
5/29/1998 10:00:00 AM
5/29/1998 12:00:00 PM
5/29/1998 1:00:00 PM

Rank: **3rd** Value (ppb): **83**
5/29/1998 9:00:00 AM
5/29/1998 2:00:00 PM
7/15/1998 1:00:00 PM

Rank: **4th** Value (ppb): **82**
5/20/1998 3:00:00 PM
5/28/1998 1:00:00 PM
7/15/1998 2:00:00 PM
7/27/1998 5:00:00 PM
7/27/1998 9:00:00 PM

Lye Brook

Rank: **1st** Value (ppb): **99**
7/27/1998 8:00:00 PM

Rank: **2nd** Value (ppb): **94**
5/29/1998 2:00:00 PM

Rank: **3rd** Value (ppb): **94**
7/15/1998 11:00:00 PM

Rank: **4th** Value (ppb): **93**
7/14/1998 8:00:00 PM
7/14/1998 9:00:00 PM

Underhill

Rank: **1st** Value (ppb): **85**
7/15/1998 12:00:00 PM

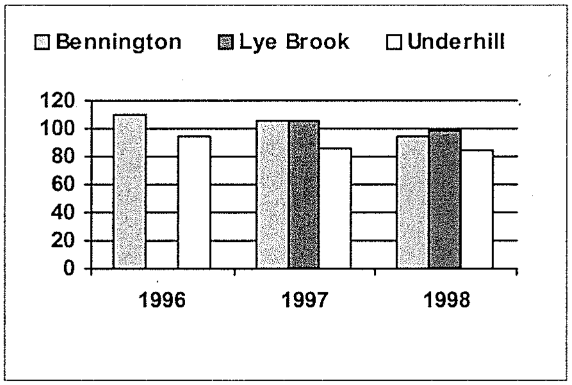
Rank: **2nd** Value (ppb): **82**
4/15/1998 2:00:00 PM

Rank: **3rd** Value (ppb): **80**
5/28/1998 12:00:00 PM
7/14/1998 5:00:00 PM
7/15/1998 4:00:00 PM

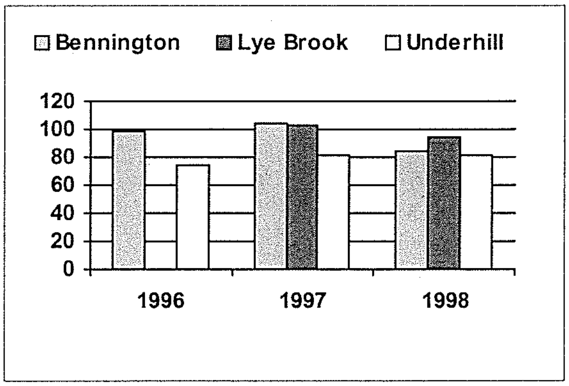
Rank: **4th** Value (ppb): **79**
4/15/1998 4:00:00 PM
5/15/1998 5:00:00 PM
5/28/1998 11:00:00 AM

Figure 1a: 3 Year Comparison of Four Highest Daily 1 Hour Maximum Ozone Values

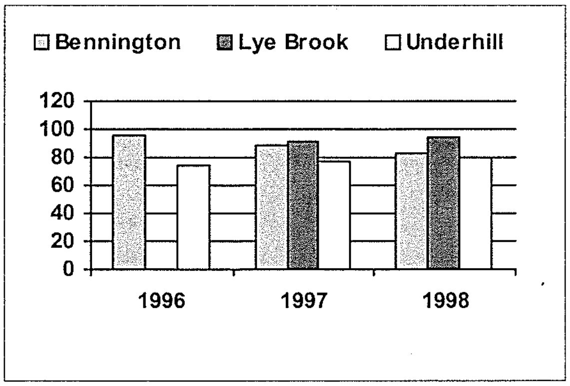
1st Highest Daily 1 Hour Maximum



2nd Highest Daily 1 Hour Maximum



3rd Highest Daily 1 Hour Maximum



4th Highest Daily 1 Hour Maximum

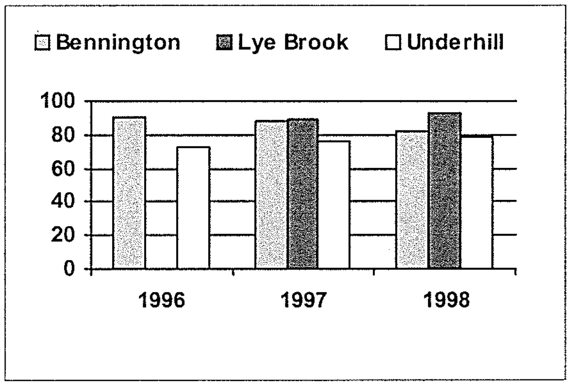


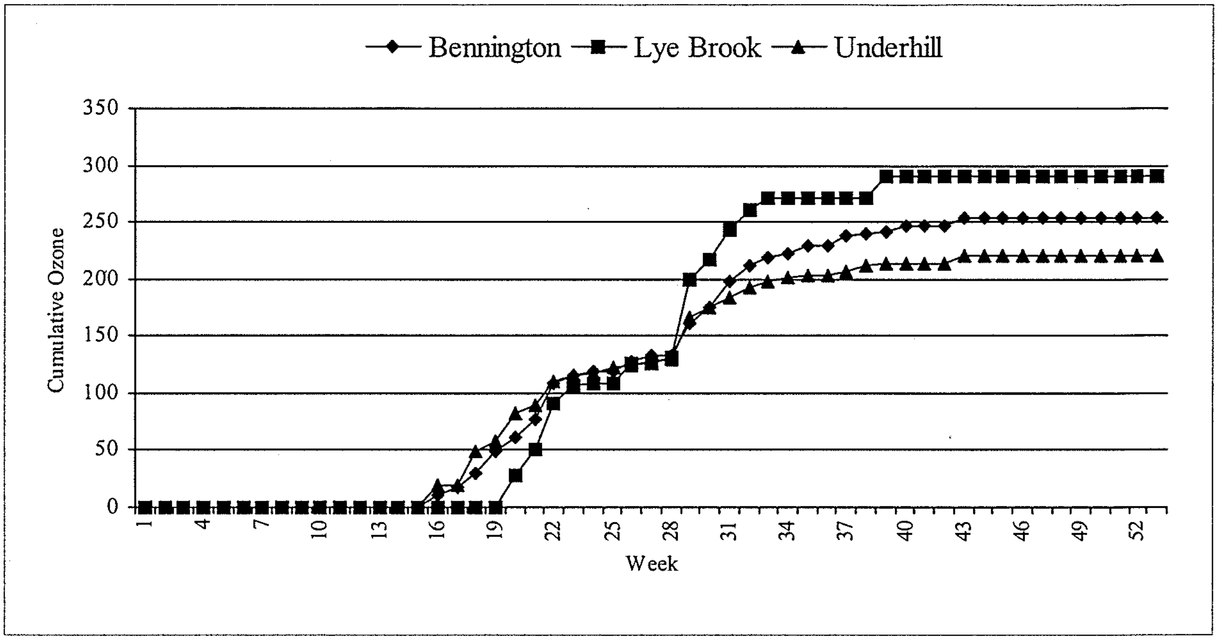
Figure 2: Daily Values for 1998

All values reflect the maximum daily measurement for the year with the exception of Minimum Hourly Ozone.

Metric	Bennington	Lye Brook	Underhill
Average Hourly Ozone (ppb)	63.65	80.46	72.74
Maximum Hourly Ozone (ppb)	94.00	99.00	85.00
Minimum Hourly Ozone (ppb)	3.00	1.00	3.00
Daytime Mean Hourly Ozone (ppb)	74.00	80.08	76.83
Daytime Sum04 (ppm-hr)	0.89	0.96	0.92
Daytime Sum05 (ppm-hr)	0.84	0.96	0.92
Daytime Sum06 (ppm-hr)	0.79	0.96	0.92
Daytime Sum08 (ppm-hr)	0.51	0.69	0.58
Daytime Sum12 (ppm-hr)	0.00	0.00	0.00
Nighttime Mean Hourly Ozone (ppb)	73.73	83.90	69.27
Nighttime Sum04 (ppm-hr)	0.81	1.01	0.76
Nighttime Sum05 (ppm-hr)	0.81	1.01	0.76
Nighttime Sum06 (ppm-hr)	0.78	1.01	0.76
Nighttime Sum08 (ppm-hr)	0.36	0.71	0.00
Nighttime Sum12 (ppm-hr)	0.00	0.00	0.00
Cumulative Sum04 (ppm-hr)	88.75	56.48	104.92
Hours >40 ppb	23.00	24.00	23.00
Sum04 (ppm-hr)	1.46	1.93	1.67
Cumulative Sum05 (ppm-hr)	55.25	43.99	58.44
Hours >50 ppb	23.00	24.00	23.00
Sum05 (ppm-hr)	1.46	1.93	1.63
Cumulative Sum06 (ppm-hr)	25.36	29.06	21.99
Hours >60 ppb	17.00	24.00	22.00
Sum06 (ppm-hr)	1.15	1.93	1.63
Cumulative Sum08 (ppm-hr)	1.68	4.60	0.90
Hours >80ppb	6.00	14.00	7.00
Sum08 (ppm-hr)	0.51	1.20	0.58
Hours >120 ppb	0.00	0.00	0.00
Sum12 (ppm-hr)	0.00	0.00	0.00

Figure 3: Cumulative Effect

Cumulative Sum04



Cumulative Sum05

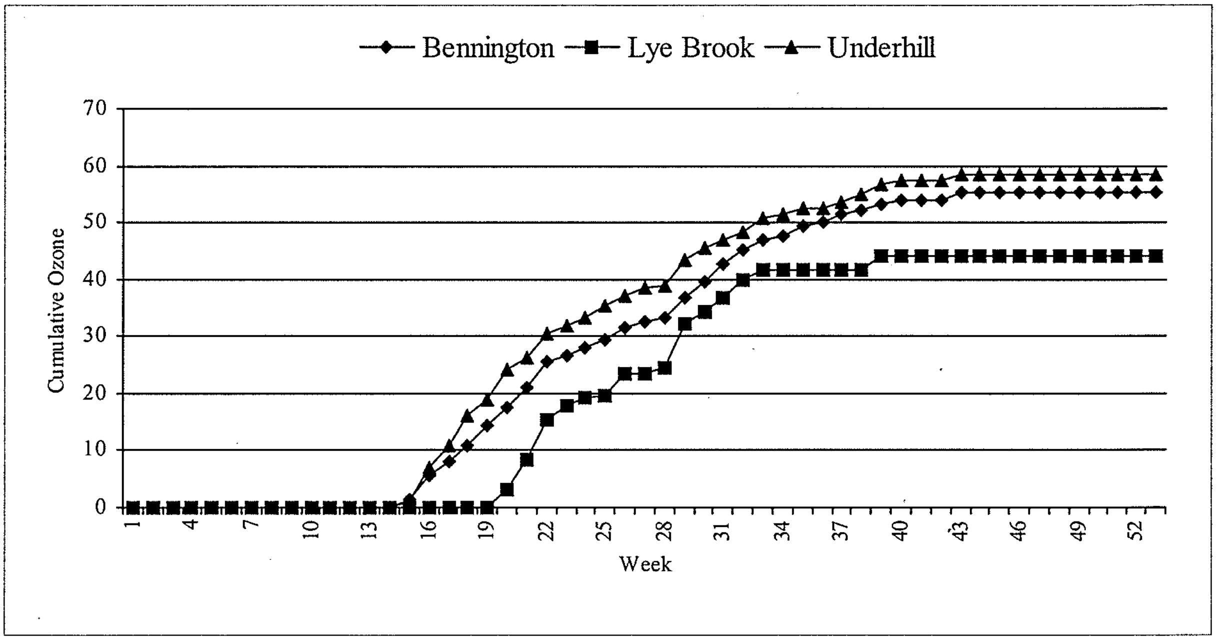
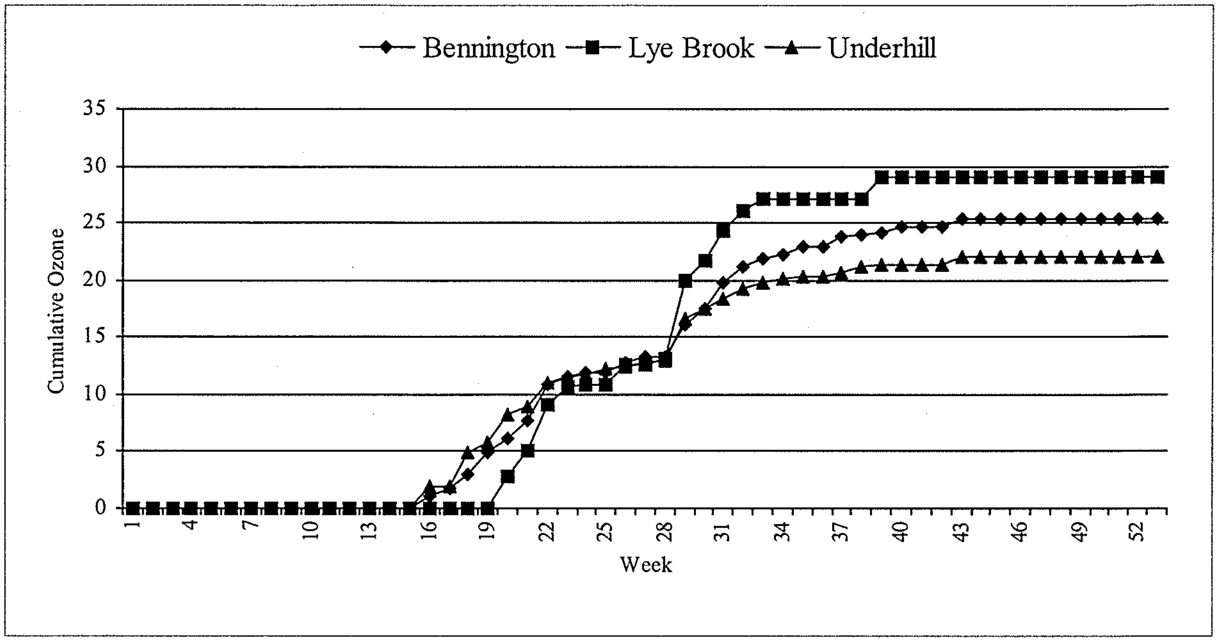


Figure 3: Cumulative Effect

Cumulative Sum06



Cumulative Sum08

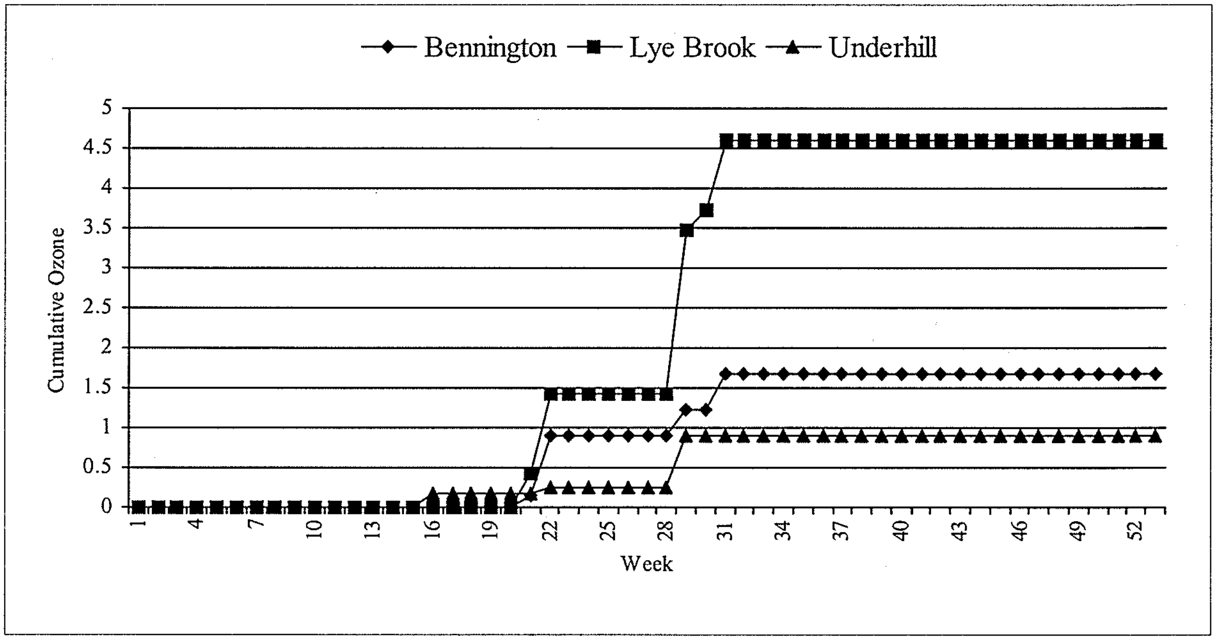
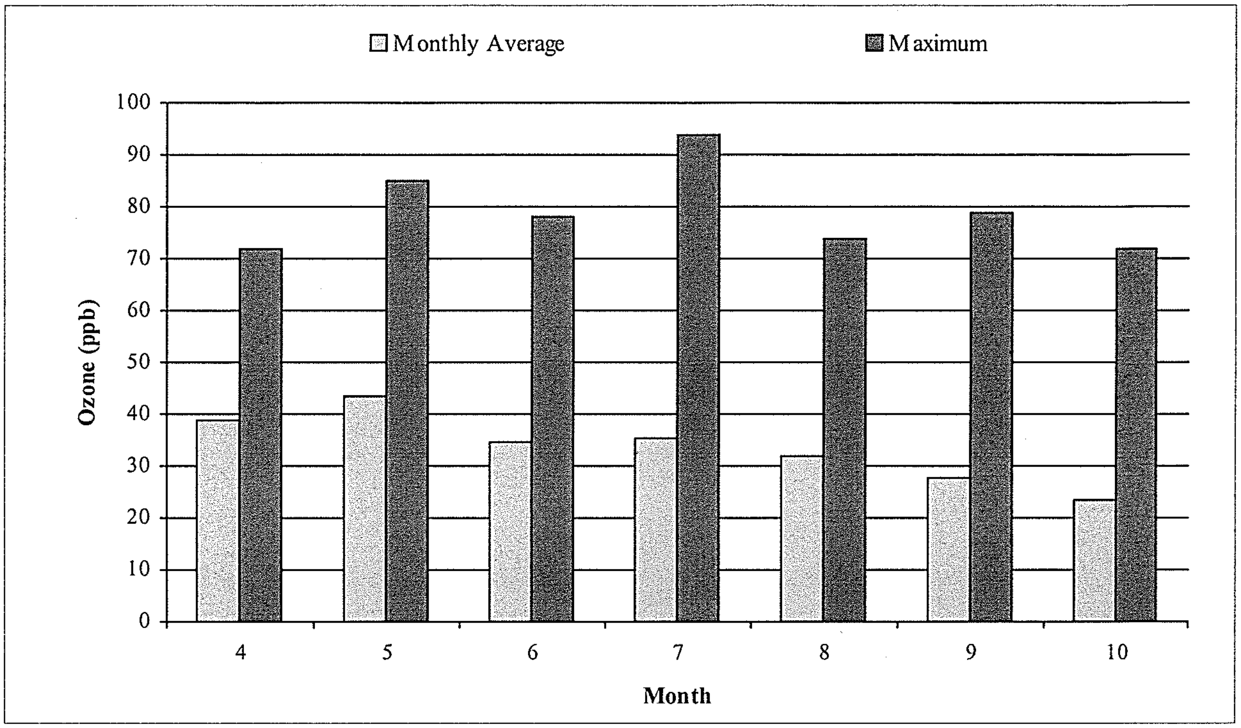


Figure 4: Monthly Average and Maximum One Hour Ozone Values

Bennington



Lye Brook

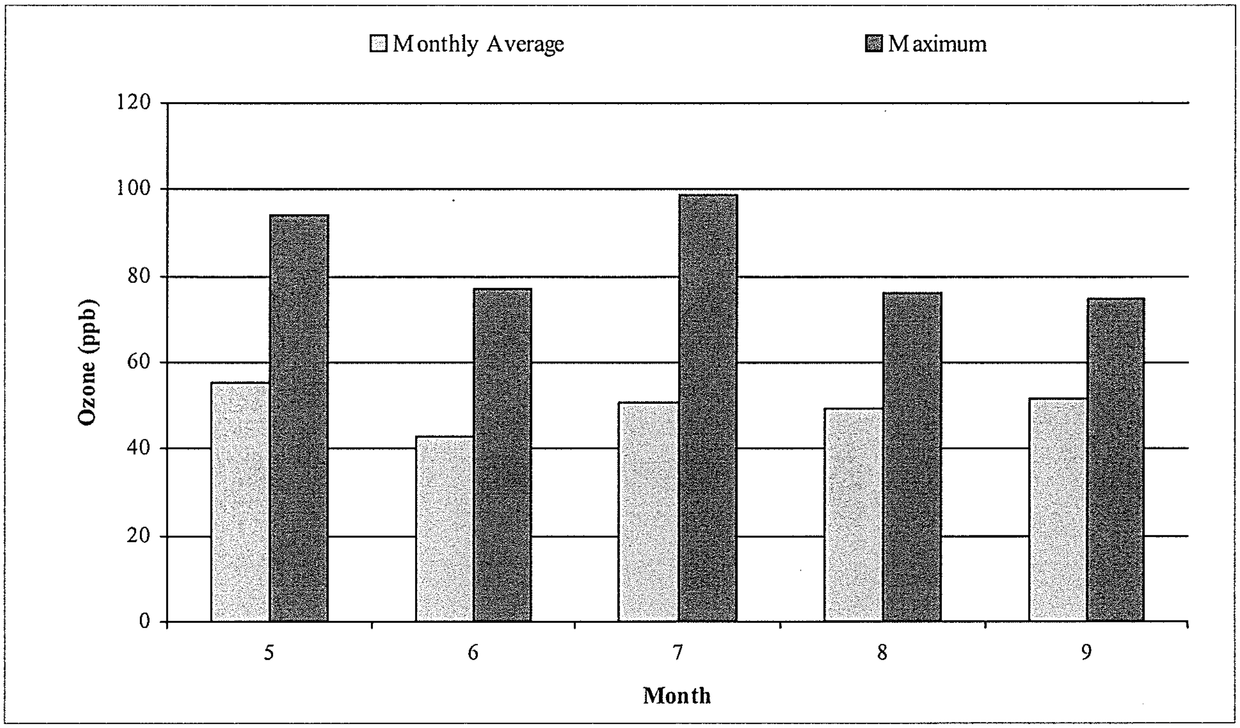


Figure 4: Monthly Average and Maximum One Hour Ozone Values

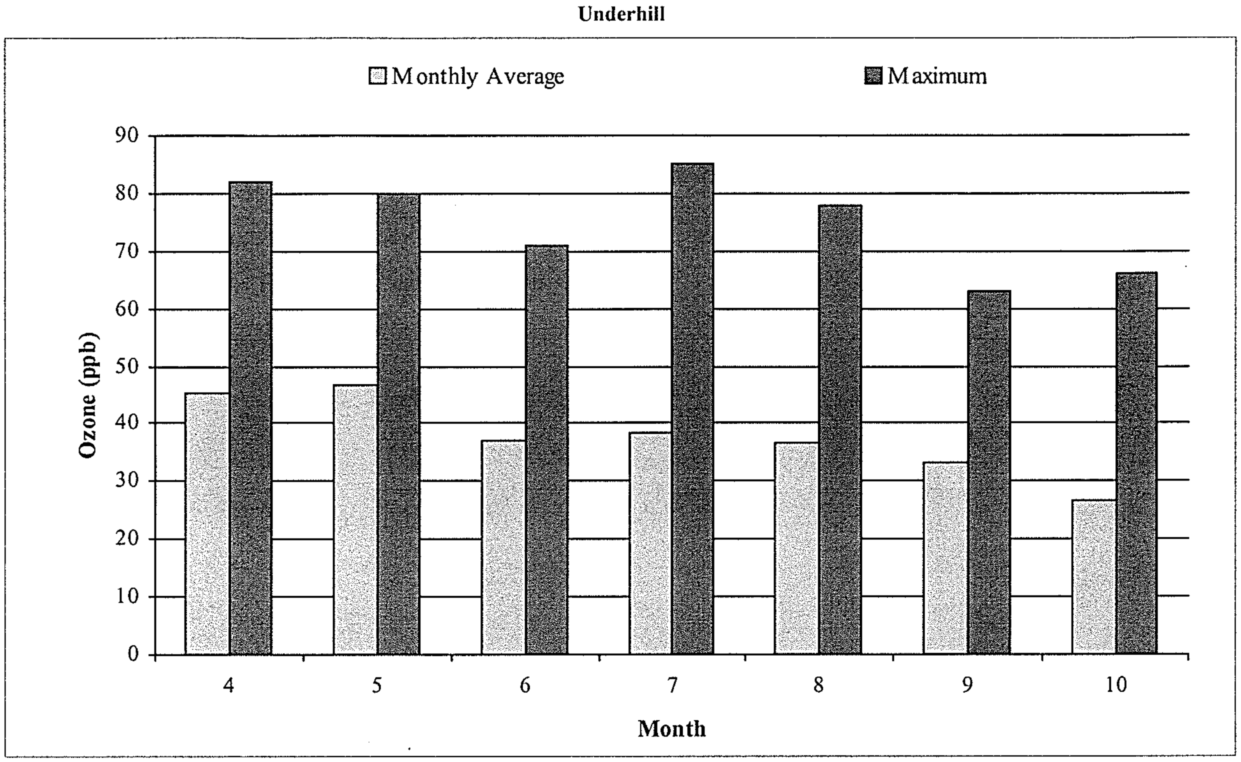


Figure 5: Weekly Values

Week	Metric	Bennington	Lye Brook	Underhill
14	Average Hourly Ozone (ppb)	28.65		31.96
	Maximum Hourly Ozone (ppb)	45.00		49.00
	Minimum Hourly Ozone (ppb)	7.00		15.00
	Daytime Mean Hourly Ozone (ppb)	30.75		32.65
	Daytime Sum04 (ppm-hr)	0.25		0.33
	Nighttime Mean Hourly Ozone (ppb)	28.57		32.70
	Nighttime Sum04 (ppm-hr)	0.08		0.08
	Cumulative Sum04 (ppm-hr)	0.29		0.41
	Hours >40 ppb	7.00		10.00
	Sum04 (ppm-hr)	0.29		0.41
	Cumulative Sum05 (ppm-hr)	0.00		0.00
	Cumulative Sum06 (ppm-hr)	0.00		0.00
	Cumulative Sum08 (ppm-hr)	0.00		0.00
15	Average Hourly Ozone (ppb)	39.52		43.03
	Maximum Hourly Ozone (ppb)	58.00		54.00
	Minimum Hourly Ozone (ppb)	7.00		29.00
	Daytime Mean Hourly Ozone (ppb)	44.38		44.82
	Daytime Sum04 (ppm-hr)	2.89		3.11
	Daytime Sum05 (ppm-hr)	1.44		1.03
	Nighttime Mean Hourly Ozone (ppb)	33.39		41.92
	Nighttime Sum04 (ppm-hr)	1.27		2.44
	Nighttime Sum05 (ppm-hr)	0.10		0.05
	Cumulative Sum04 (ppm-hr)	4.49		5.74
	Hours >40 ppb	89.00		116.00
	Sum04 (ppm-hr)	4.20		5.32
	Cumulative Sum05 (ppm-hr)	1.55		1.08
	Hours >50 ppb	29.00		21.00
	Sum05 (ppm-hr)	1.55		1.08
	Cumulative Sum06 (ppm-hr)	0.00		0.00
	Cumulative Sum08 (ppm-hr)	0.00		0.00
16	Average Hourly Ozone (ppb)	43.37		53.03
	Maximum Hourly Ozone (ppb)	71.00		82.00
	Minimum Hourly Ozone (ppb)	8.00		37.00
	Daytime Mean Hourly Ozone (ppb)	49.33		55.85
	Daytime Sum04 (ppm-hr)	3.80		4.64
	Daytime Sum05 (ppm-hr)	2.74		3.64
	Daytime Sum06 (ppm-hr)	0.77		1.58
	Nighttime Mean Hourly Ozone (ppb)	36.97		50.23
	Nighttime Sum04 (ppm-hr)	1.66		3.60
	Nighttime Sum05 (ppm-hr)	1.16		2.59
	Nighttime Sum06 (ppm-hr)	0.25		0.33
	Cumulative Sum04 (ppm-hr)	9.94		13.95

Figure 5: Weekly Values

Week	Metric	Bennington	Lye Brook	Underhill
16	Hours >40 ppb	104.00		153.00
	Sum04 (ppm-hr)	5.45		8.21
	Cumulative Sum05 (ppm-hr)	5.45		7.11
	Hours >50 ppb	69.00		105.00
	Sum05 (ppm-hr)	3.90		6.03
	Cumulative Sum06 (ppm-hr)	1.03		1.90
	Hours >60 ppb	16.00		28.00
	Sum06 (ppm-hr)	1.03		1.90
	Cumulative Sum08 (ppm-hr)	0.00		0.16
17	Average Hourly Ozone (ppb)	40.14		46.48
	Maximum Hourly Ozone (ppb)	63.00		60.00
	Minimum Hourly Ozone (ppb)	3.00		25.00
	Daytime Mean Hourly Ozone (ppb)	45.34		47.74
	Daytime Sum04 (ppm-hr)	2.98		3.52
	Daytime Sum05 (ppm-hr)	2.03		2.72
	Daytime Sum06 (ppm-hr)	0.67		0.06
	Nighttime Mean Hourly Ozone (ppb)	34.10		44.19
	Nighttime Sum04 (ppm-hr)	1.61		2.64
	Nighttime Sum05 (ppm-hr)	0.71		0.85
	Cumulative Sum04 (ppm-hr)	14.53		20.37
	Hours >40 ppb	91.00		130.00
	Sum04 (ppm-hr)	4.59		6.42
	Cumulative Sum05 (ppm-hr)	8.19		10.89
	Hours >50 ppb	49.00		71.00
	Sum05 (ppm-hr)	2.74		3.77
	Cumulative Sum06 (ppm-hr)	1.70		1.96
	Hours >60 ppb	11.00		1.00
	Sum06 (ppm-hr)	0.67		0.06
	Cumulative Sum08 (ppm-hr)	0.00		0.16
18	Average Hourly Ozone (ppb)	39.37		49.74
	Maximum Hourly Ozone (ppb)	72.00		75.00
	Minimum Hourly Ozone (ppb)	7.00		20.00
	Daytime Mean Hourly Ozone (ppb)	46.79		52.59
	Daytime Sum04 (ppm-hr)	3.15		3.87
	Daytime Sum05 (ppm-hr)	2.11		3.01
	Daytime Sum06 (ppm-hr)	1.11		1.89
	Nighttime Mean Hourly Ozone (ppb)	33.17		46.71
	Nighttime Sum04 (ppm-hr)	1.17		2.70
	Nighttime Sum05 (ppm-hr)	0.49		2.14
	Nighttime Sum06 (ppm-hr)	0.13		1.12
	Cumulative Sum04 (ppm-hr)	18.61	0.00	26.94
	Hours >40 ppb	78.00		116.00

Figure 5: Weekly Values

Week	Metric	Bennington	Lye Brook	Underhill
18	Sum04 (ppm-hr)	4.08		6.57
	Cumulative Sum05 (ppm-hr)	10.80	0.00	16.04
	Hours >50 ppb	45.00		84.00
	Sum05 (ppm-hr)	2.60		5.15
	Cumulative Sum06 (ppm-hr)	2.93	0.00	4.96
	Hours >60 ppb	19.00		44.00
	Sum06 (ppm-hr)	1.23		3.00
	Cumulative Sum08 (ppm-hr)	0.00	0.00	0.16
19	Average Hourly Ozone (ppb)	46.24		42.70
	Maximum Hourly Ozone (ppb)	67.00		62.00
	Minimum Hourly Ozone (ppb)	14.00		14.00
	Daytime Mean Hourly Ozone (ppb)	49.63		44.68
	Daytime Sum04 (ppm-hr)	3.56		3.06
	Daytime Sum05 (ppm-hr)	2.82		2.07
	Daytime Sum06 (ppm-hr)	1.26		0.67
	Nighttime Mean Hourly Ozone (ppb)	42.05		39.36
	Nighttime Sum04 (ppm-hr)	2.27		2.04
	Nighttime Sum05 (ppm-hr)	0.89		0.93
	Nighttime Sum06 (ppm-hr)	0.68		0.12
	Cumulative Sum04 (ppm-hr)	24.64	0.00	32.03
	Hours >40 ppb	116.00		101.00
	Sum04 (ppm-hr)	6.02		5.10
	Cumulative Sum05 (ppm-hr)	14.50	0.00	19.04
	Hours >50 ppb	64.00		54.00
	Sum05 (ppm-hr)	3.70		3.00
	Cumulative Sum06 (ppm-hr)	4.87	0.00	5.76
	Hours >60 ppb	31.00		13.00
	Sum06 (ppm-hr)	1.94		0.79
	Cumulative Sum08 (ppm-hr)	0.00	0.00	0.16
20	Average Hourly Ozone (ppb)	41.77	66.71	49.11
	Maximum Hourly Ozone (ppb)	75.00	78.25	79.00
	Minimum Hourly Ozone (ppb)	11.00	54.75	14.00
	Daytime Mean Hourly Ozone (ppb)	46.45	68.41	52.23
	Daytime Sum04 (ppm-hr)	3.02	1.84	3.81
	Daytime Sum05 (ppm-hr)	2.32	1.84	3.36
	Daytime Sum06 (ppm-hr)	1.00	1.78	1.94
	Nighttime Mean Hourly Ozone (ppb)	38.03	64.91	48.32
	Nighttime Sum04 (ppm-hr)	1.98	2.27	3.32
	Nighttime Sum05 (ppm-hr)	0.91	2.27	1.95
	Nighttime Sum06 (ppm-hr)	0.26	1.40	0.71
	Cumulative Sum04 (ppm-hr)	29.40	3.20	38.88
	Hours >40 ppb	91.00	48.00	126.00

Figure 5: Weekly Values

Week	Metric	Bennington	Lye Brook	Underhill
20	Sum04 (ppm-hr)	4.77	3.20	6.85
	Cumulative Sum05 (ppm-hr)	17.49	3.20	24.11
	Hours >50 ppb	51.00	48.00	86.00
	Sum05 (ppm-hr)	3.00	3.20	5.07
	Cumulative Sum06 (ppm-hr)	6.12	2.74	8.29
	Hours >60 ppb	19.00	40.00	39.00
	Sum06 (ppm-hr)	1.26	2.74	2.54
	Cumulative Sum08 (ppm-hr)	0.00	0.00	0.16
21	Average Hourly Ozone (ppb)	41.67	50.07	41.76
	Maximum Hourly Ozone (ppb)	82.00	90.50	68.00
	Minimum Hourly Ozone (ppb)	9.00	24.00	20.00
	Daytime Mean Hourly Ozone (ppb)	48.34	51.81	43.57
	Daytime Sum04 (ppm-hr)	3.15	3.51	2.61
	Daytime Sum05 (ppm-hr)	2.34	2.66	1.48
	Daytime Sum06 (ppm-hr)	1.12	1.23	0.52
	Nighttime Mean Hourly Ozone (ppb)	32.30	47.51	38.19
	Nighttime Sum04 (ppm-hr)	1.19	3.27	1.57
	Nighttime Sum05 (ppm-hr)	0.84	2.35	0.53
	Cumulative Sum04 (ppm-hr)	34.02	10.07	43.34
	Hours >40 ppb	84.00	122.00	89.00
	Sum04 (ppm-hr)	4.62	6.87	4.46
	Cumulative Sum05 (ppm-hr)	20.90	8.57	26.35
	Hours >50 ppb	57.00	89.00	40.00
	Sum05 (ppm-hr)	3.41	5.36	2.24
	Cumulative Sum06 (ppm-hr)	7.64	5.07	8.93
	Hours >60 ppb	22.00	34.00	10.00
	Sum06 (ppm-hr)	1.52	2.33	0.64
	Cumulative Sum08 (ppm-hr)	0.16	0.43	0.16
22	Average Hourly Ozone (ppb)	44.80	56.92	49.22
	Maximum Hourly Ozone (ppb)	85.00	94.00	80.00
	Minimum Hourly Ozone (ppb)	3.00	36.25	28.00
	Daytime Mean Hourly Ozone (ppb)	56.08	60.23	51.84
	Daytime Sum04 (ppm-hr)	4.37	4.81	3.71
	Daytime Sum05 (ppm-hr)	3.54	3.93	2.58
	Daytime Sum06 (ppm-hr)	2.45	2.46	1.43
	Daytime Sum08 (ppm-hr)	0.75	0.93	0.08
	Nighttime Mean Hourly Ozone (ppb)	32.58	54.38	46.84
	Nighttime Sum04 (ppm-hr)	1.44	4.42	2.96
	Nighttime Sum05 (ppm-hr)	1.02	3.03	1.44
	Nighttime Sum06 (ppm-hr)	0.73	1.64	0.71
	Cumulative Sum04 (ppm-hr)	39.84	19.25	49.91
	Hours >40 ppb	98.00	159.00	123.00

Figure 5: Weekly Values

Week	Metric	Bennington	Lye Brook	Underhill
22	Sum04 (ppm-hr)	5.82	9.18	6.58
	Cumulative Sum05 (ppm-hr)	25.46	15.35	30.37
	Hours >50 ppb	70.00	107.00	66.00
	Sum05 (ppm-hr)	4.56	6.79	4.01
	Cumulative Sum06 (ppm-hr)	10.83	9.11	11.07
	Hours >60 ppb	45.00	56.00	31.00
	Sum06 (ppm-hr)	3.19	4.04	2.13
	Cumulative Sum08 (ppm-hr)	0.91	1.44	0.24
	Hours >80ppb	9.00	12.00	1.00
	Sum08 (ppm-hr)	0.75	1.01	0.08
23	Average Hourly Ozone (ppb)	35.71	41.47	35.46
	Maximum Hourly Ozone (ppb)	72.00	72.75	71.00
	Minimum Hourly Ozone (ppb)	7.00	19.00	14.00
	Daytime Mean Hourly Ozone (ppb)	36.44	41.99	35.87
	Daytime Sum04 (ppm-hr)	1.29	1.23	1.14
	Daytime Sum05 (ppm-hr)	0.99	1.06	0.68
	Daytime Sum06 (ppm-hr)	0.66	0.72	0.18
	Nighttime Mean Hourly Ozone (ppb)	33.48	39.72	33.43
	Nighttime Sum04 (ppm-hr)	0.89	1.52	0.93
	Nighttime Sum05 (ppm-hr)	0.59	1.14	0.85
	Nighttime Sum06 (ppm-hr)	0.49	0.81	0.33
	Cumulative Sum04 (ppm-hr)	41.40	22.31	52.08
	Hours >40 ppb	29.00	54.00	40.00
	Sum04 (ppm-hr)	1.56	3.06	2.17
	Cumulative Sum05 (ppm-hr)	26.47	17.73	31.90
	Hours >50 ppb	16.00	38.00	26.00
	Sum05 (ppm-hr)	1.01	2.37	1.53
	Cumulative Sum06 (ppm-hr)	11.57	10.71	11.58
	Hours >60 ppb	11.00	24.00	8.00
	Sum06 (ppm-hr)	0.75	1.60	0.51
	Cumulative Sum08 (ppm-hr)	0.91	1.44	0.24
24	Average Hourly Ozone (ppb)	33.29	40.28	36.15
	Maximum Hourly Ozone (ppb)	69.00	62.50	62.00
	Minimum Hourly Ozone (ppb)	3.00	21.00	10.00
	Daytime Mean Hourly Ozone (ppb)	37.71	41.74	40.11
	Daytime Sum04 (ppm-hr)	1.96	2.21	1.82
	Daytime Sum05 (ppm-hr)	1.05	1.22	1.13
	Daytime Sum06 (ppm-hr)	0.27	0.06	0.18
	Nighttime Mean Hourly Ozone (ppb)	28.27	40.24	37.29
	Nighttime Sum04 (ppm-hr)	1.21	1.58	1.61
	Nighttime Sum05 (ppm-hr)	0.32	0.45	0.33
	Cumulative Sum04 (ppm-hr)	44.57	25.26	55.51

Figure 5: Weekly Values

Week	Metric	Bennington	Lye Brook	Underhill
24	Hours >40 ppb	65.00	58.00	73.00
	Sum04 (ppm-hr)	3.17	2.96	3.43
	Cumulative Sum05 (ppm-hr)	27.84	19.39	33.36
	Hours >50 ppb	24.00	30.00	27.00
	Sum05 (ppm-hr)	1.37	1.67	1.46
	Cumulative Sum06 (ppm-hr)	11.90	10.83	11.76
	Hours >60 ppb	5.00	2.00	3.00
	Sum06 (ppm-hr)	0.33	0.12	0.18
	Cumulative Sum08 (ppm-hr)	0.91	1.44	0.24
25	Average Hourly Ozone (ppb)	33.83	38.72	38.53
	Maximum Hourly Ozone (ppb)	59.00	53.50	61.00
	Minimum Hourly Ozone (ppb)	3.00	21.75	14.00
	Daytime Mean Hourly Ozone (ppb)	38.77	40.93	39.51
	Daytime Sum04 (ppm-hr)	1.81	2.38	2.13
	Daytime Sum05 (ppm-hr)	0.88	1.65	0.60
	Nighttime Mean Hourly Ozone (ppb)	27.52	28.16	36.58
	Nighttime Sum04 (ppm-hr)	0.72	0.31	1.60
	Nighttime Sum05 (ppm-hr)	0.54	0.17	1.25
	Cumulative Sum04 (ppm-hr)	47.09	25.82	59.24
	Hours >40 ppb	51.00	12.00	76.00
	Sum04 (ppm-hr)	2.52	0.56	3.73
	Cumulative Sum05 (ppm-hr)	29.25	19.55	35.20
	Hours >50 ppb	26.00	3.00	33.00
	Sum05 (ppm-hr)	1.42	0.16	1.85
	Cumulative Sum06 (ppm-hr)	11.90	10.83	12.19
	Cumulative Sum08 (ppm-hr)	0.91	1.44	0.24
26	Average Hourly Ozone (ppb)	37.43	51.66	40.22
	Maximum Hourly Ozone (ppb)	78.00	77.00	66.00
	Minimum Hourly Ozone (ppb)	3.00	20.75	16.00
	Daytime Mean Hourly Ozone (ppb)	43.34	49.66	43.59
	Daytime Sum04 (ppm-hr)	2.42	3.32	2.83
	Daytime Sum05 (ppm-hr)	1.92	2.69	1.38
	Daytime Sum06 (ppm-hr)	0.79	1.24	0.32
	Nighttime Mean Hourly Ozone (ppb)	31.39	49.70	36.59
	Nighttime Sum04 (ppm-hr)	1.01	2.62	1.66
	Nighttime Sum05 (ppm-hr)	0.17	2.22	0.54
	Cumulative Sum04 (ppm-hr)	50.51	30.60	63.73
	Hours >40 ppb	66.00	85.00	93.00
	Sum04 (ppm-hr)	3.42	4.78	4.49
	Cumulative Sum05 (ppm-hr)	31.34	23.43	37.12
	Hours >50 ppb	36.00	65.00	35.00
	Sum05 (ppm-hr)	2.09	3.88	1.92

Figure 5: Weekly Values

Week	Metric	Bennington	Lye Brook	Underhill
26	Cumulative Sum06 (ppm-hr)	12.75	12.61	12.51
	Hours >60 ppb	13.00	27.00	5.00
	Sum06 (ppm-hr)	0.85	1.77	0.32
	Cumulative Sum08 (ppm-hr)	0.91	1.44	0.24
27	Average Hourly Ozone (ppb)	31.13		34.85
	Maximum Hourly Ozone (ppb)	67.00		72.00
	Minimum Hourly Ozone (ppb)	3.00		13.00
	Daytime Mean Hourly Ozone (ppb)	39.23		37.43
	Daytime Sum04 (ppm-hr)	1.67	0.52	1.89
	Daytime Sum05 (ppm-hr)	1.10	0.38	0.96
	Daytime Sum06 (ppm-hr)	0.51	0.07	0.20
	Nighttime Mean Hourly Ozone (ppb)	24.84		32.88
	Nighttime Sum04 (ppm-hr)	0.73		1.12
	Nighttime Sum05 (ppm-hr)	0.27		0.40
	Cumulative Sum04 (ppm-hr)	52.67	30.60	66.70
	Hours >40 ppb	42.00		60.00
	Sum04 (ppm-hr)	2.16		2.97
	Cumulative Sum05 (ppm-hr)	32.72	23.43	38.48
	Hours >50 ppb	24.00		24.00
	Sum05 (ppm-hr)	1.37		1.36
	Cumulative Sum06 (ppm-hr)	13.26	12.61	12.84
	Hours >60 ppb	8.00		5.00
	Sum06 (ppm-hr)	0.51		0.33
	Cumulative Sum08 (ppm-hr)	0.91	1.44	0.24
28	Average Hourly Ozone (ppb)	30.96	40.43	34.69
	Maximum Hourly Ozone (ppb)	53.00	65.00	60.00
	Minimum Hourly Ozone (ppb)	3.00	23.50	19.00
	Daytime Mean Hourly Ozone (ppb)	36.69	41.29	35.60
	Daytime Sum04 (ppm-hr)	1.31	1.39	1.08
	Daytime Sum05 (ppm-hr)	0.42	0.83	0.32
	Nighttime Mean Hourly Ozone (ppb)	22.13	37.60	32.70
	Nighttime Sum04 (ppm-hr)	0.21	1.37	1.12
	Cumulative Sum04 (ppm-hr)	54.42	32.67	68.95
	Hours >40 ppb	39.00	41.00	49.00
	Sum04 (ppm-hr)	1.76	2.07	2.25
	Cumulative Sum05 (ppm-hr)	33.13	24.61	38.97
	Hours >50 ppb	8.00	21.00	9.00
	Sum05 (ppm-hr)	0.42	1.18	0.48
	Cumulative Sum06 (ppm-hr)	13.26	13.11	12.90
	Cumulative Sum08 (ppm-hr)	0.91	1.44	0.24
29	Average Hourly Ozone (ppb)	38.97	58.49	46.06
	Maximum Hourly Ozone (ppb)	83.00	93.75	85.00

Figure 5: Weekly Values

Week	Metric	Bennington	Lye Brook	Underhill
29	Minimum Hourly Ozone (ppb)	3.00	10.75	12.00
	Daytime Mean Hourly Ozone (ppb)	49.89	60.27	48.69
	Daytime Sum04 (ppm-hr)	3.10	4.35	3.07
	Daytime Sum05 (ppm-hr)	2.88	3.95	2.62
	Daytime Sum06 (ppm-hr)	2.38	3.53	2.30
	Daytime Sum08 (ppm-hr)	0.25	1.01	0.66
	Nighttime Mean Hourly Ozone (ppb)	27.26	57.02	44.19
	Nighttime Sum04 (ppm-hr)	1.03	3.88	2.36
	Nighttime Sum05 (ppm-hr)	0.68	3.71	1.69
	Nighttime Sum06 (ppm-hr)	0.42	3.32	1.38
	Cumulative Sum04 (ppm-hr)	58.56	40.95	74.38
	Hours >40 ppb	67.00	121.00	89.00
	Sum04 (ppm-hr)	4.13	8.28	5.43
	Cumulative Sum05 (ppm-hr)	36.70	32.27	43.27
	Hours >50 ppb	54.00	107.00	64.00
	Sum05 (ppm-hr)	3.56	7.66	4.31
	Cumulative Sum06 (ppm-hr)	16.06	19.96	16.57
	Hours >60 ppb	40.00	92.00	52.00
	Sum06 (ppm-hr)	2.80	6.85	3.68
	Cumulative Sum08 (ppm-hr)	1.24	3.48	0.90
	Hours >80ppb	4.00	24.00	8.00
	Sum08 (ppm-hr)	0.33	2.04	0.66
30	Average Hourly Ozone (ppb)	36.20	44.68	38.16
	Maximum Hourly Ozone (ppb)	72.00	84.00	73.00
	Minimum Hourly Ozone (ppb)	3.00	1.00	14.00
	Daytime Mean Hourly Ozone (ppb)	42.80	40.16	38.48
	Daytime Sum04 (ppm-hr)	2.42	2.60	1.79
	Daytime Sum05 (ppm-hr)	1.83	2.18	1.12
	Daytime Sum06 (ppm-hr)	0.81	1.56	0.32
	Nighttime Mean Hourly Ozone (ppb)	29.08	51.48	37.29
	Nighttime Sum04 (ppm-hr)	1.15	2.03	1.66
	Nighttime Sum05 (ppm-hr)	0.97	1.91	1.00
	Nighttime Sum06 (ppm-hr)	0.59	1.57	0.67
	Cumulative Sum04 (ppm-hr)	62.12	43.26	77.82
	Hours >40 ppb	65.00	37.00	66.00
	Sum04 (ppm-hr)	3.57	2.31	3.45
	Cumulative Sum05 (ppm-hr)	39.50	34.14	45.39
	Hours >50 ppb	48.00	27.00	36.00
	Sum05 (ppm-hr)	2.80	1.86	2.12
	Cumulative Sum06 (ppm-hr)	17.46	21.66	17.56
	Hours >60 ppb	22.00	24.00	15.00
	Sum06 (ppm-hr)	1.40	1.70	0.99

Figure 5: Weekly Values

Week	Metric	Bennington	Lye Brook	Underhill
30	Cumulative Sum08 (ppm-hr)	1.24	3.73	0.90
31	Average Hourly Ozone (ppb)	35.05	51.04	36.11
	Maximum Hourly Ozone (ppb)	94.00	99.00	75.00
	Minimum Hourly Ozone (ppb)	3.00	23.50	17.00
	Daytime Mean Hourly Ozone (ppb)	40.30	41.80	36.80
	Daytime Sum04 (ppm-hr)	1.81	2.21	1.70
	Daytime Sum05 (ppm-hr)	1.55	1.49	0.55
	Daytime Sum06 (ppm-hr)	0.80	1.10	0.13
	Nighttime Mean Hourly Ozone (ppb)	29.39	49.00	35.95
	Nighttime Sum04 (ppm-hr)	1.63	2.32	1.12
	Nighttime Sum05 (ppm-hr)	1.59	1.70	1.07
	Nighttime Sum06 (ppm-hr)	1.53	1.70	0.68
	Cumulative Sum04 (ppm-hr)	65.56	46.32	80.64
	Hours >40 ppb	55.00	44.00	54.00
	Sum04 (ppm-hr)	3.44	3.06	2.81
	Cumulative Sum05 (ppm-hr)	42.63	36.84	47.01
	Hours >50 ppb	48.00	36.00	27.00
	Sum05 (ppm-hr)	3.13	2.71	1.62
	Cumulative Sum06 (ppm-hr)	19.80	24.31	18.37
	Hours >60 ppb	33.00	35.00	12.00
	Sum06 (ppm-hr)	2.34	2.65	0.80
	Cumulative Sum08 (ppm-hr)	1.68	4.60	0.90
32	Average Hourly Ozone (ppb)	35.02	50.16	39.07
	Maximum Hourly Ozone (ppb)	73.00	75.25	75.00
	Minimum Hourly Ozone (ppb)	3.00	27.00	19.00
	Daytime Mean Hourly Ozone (ppb)	45.45	50.47	42.05
	Daytime Sum04 (ppm-hr)	3.09	3.01	2.16
	Daytime Sum05 (ppm-hr)	2.07	2.29	1.05
	Daytime Sum06 (ppm-hr)	1.13	1.40	0.62
	Nighttime Mean Hourly Ozone (ppb)	24.82	50.38	37.26
	Nighttime Sum04 (ppm-hr)	0.58	2.61	1.32
	Nighttime Sum05 (ppm-hr)	0.36	1.31	0.52
	Nighttime Sum06 (ppm-hr)	0.31	0.71	0.20
	Cumulative Sum04 (ppm-hr)	69.23	51.34	83.85
	Hours >40 ppb	68.00	95.00	66.00
	Sum04 (ppm-hr)	3.67	5.02	3.21
	Cumulative Sum05 (ppm-hr)	45.07	39.94	48.31
	Hours >50 ppb	41.00	52.00	21.00
	Sum05 (ppm-hr)	2.43	3.09	1.30
	Cumulative Sum06 (ppm-hr)	21.24	26.03	19.18
	Hours >60 ppb	22.00	26.00	12.00
	Sum06 (ppm-hr)	1.44	1.72	0.82

Figure 5: Weekly Values

Week	Metric	Bennington	Lye Brook	Underhill
32	Cumulative Sum08 (ppm-hr)	1.68	4.60	0.90
33	Average Hourly Ozone (ppb)	35.07	54.62	42.15
	Maximum Hourly Ozone (ppb)	65.00	76.00	78.00
	Minimum Hourly Ozone (ppb)	3.00	35.25	16.00
	Daytime Mean Hourly Ozone (ppb)	39.12	49.62	44.45
	Daytime Sum04 (ppm-hr)	2.19	3.00	2.72
	Daytime Sum05 (ppm-hr)	1.20	1.92	1.60
	Daytime Sum06 (ppm-hr)	0.44	0.78	0.42
	Nighttime Mean Hourly Ozone (ppb)	30.25	50.24	39.14
	Nighttime Sum04 (ppm-hr)	1.32	1.50	1.91
	Nighttime Sum05 (ppm-hr)	0.56	1.16	0.61
	Nighttime Sum06 (ppm-hr)	0.18	0.73	0.12
	Cumulative Sum04 (ppm-hr)	72.74	53.57	88.52
	Hours >40 ppb	71.00	39.00	93.00
	Sum04 (ppm-hr)	3.51	2.23	4.67
	Cumulative Sum05 (ppm-hr)	46.82	41.67	50.79
	Hours >50 ppb	31.00	28.00	43.00
	Sum05 (ppm-hr)	1.76	1.74	2.48
	Cumulative Sum06 (ppm-hr)	21.85	27.15	19.72
	Hours >60 ppb	10.00	17.00	8.00
	Sum06 (ppm-hr)	0.62	1.12	0.54
	Cumulative Sum08 (ppm-hr)	1.68	4.60	0.90
34	Average Hourly Ozone (ppb)	26.14		32.04
	Maximum Hourly Ozone (ppb)	68.00		72.00
	Minimum Hourly Ozone (ppb)	3.00		14.00
	Daytime Mean Hourly Ozone (ppb)	36.85		34.45
	Daytime Sum04 (ppm-hr)	1.82		1.29
	Daytime Sum05 (ppm-hr)	0.93		0.47
	Daytime Sum06 (ppm-hr)	0.33		0.47
	Nighttime Mean Hourly Ozone (ppb)	13.84		27.74
	Nighttime Sum04 (ppm-hr)	0.04		0.43
	Cumulative Sum04 (ppm-hr)	74.60	53.57	90.47
	Hours >40 ppb	37.00		41.00
	Sum04 (ppm-hr)	1.86		1.95
	Cumulative Sum05 (ppm-hr)	47.75	41.67	51.31
	Hours >50 ppb	16.00		8.00
	Sum05 (ppm-hr)	0.93		0.52
	Cumulative Sum06 (ppm-hr)	22.18	27.15	20.19
	Hours >60 ppb	5.00		7.00
	Sum06 (ppm-hr)	0.33		0.47
	Cumulative Sum08 (ppm-hr)	1.68	4.60	0.90
35	Average Hourly Ozone (ppb)	33.59		35.90

Figure 5: Weekly Values

Week	Metric	Bennington	Lye Brook	Underhill
35	Maximum Hourly Ozone (ppb)	74.00		61.00
	Minimum Hourly Ozone (ppb)	3.00		15.00
	Daytime Mean Hourly Ozone (ppb)	40.45		36.43
	Daytime Sum04 (ppm-hr)	2.01		1.56
	Daytime Sum05 (ppm-hr)	1.27		0.61
	Daytime Sum06 (ppm-hr)	0.44		0.06
	Nighttime Mean Hourly Ozone (ppb)	26.25		36.22
	Nighttime Sum04 (ppm-hr)	1.01		1.27
	Nighttime Sum05 (ppm-hr)	0.48		0.52
	Cumulative Sum04 (ppm-hr)	77.62	53.57	93.29
	Hours >40 ppb	59.00		60.00
	Sum04 (ppm-hr)	3.02		2.83
	Cumulative Sum05 (ppm-hr)	49.50	41.67	52.43
	Hours >50 ppb	30.00		21.00
	Sum05 (ppm-hr)	1.75		1.13
	Cumulative Sum06 (ppm-hr)	22.89	27.15	20.25
	Hours >60 ppb	11.00		1.00
	Sum06 (ppm-hr)	0.70		0.06
	Cumulative Sum08 (ppm-hr)	1.68	4.60	0.90
36	Average Hourly Ozone (ppb)	27.76		31.87
	Maximum Hourly Ozone (ppb)	60.00		53.00
	Minimum Hourly Ozone (ppb)	3.00		12.00
	Daytime Mean Hourly Ozone (ppb)	36.45		33.36
	Daytime Sum04 (ppm-hr)	1.99		0.62
	Daytime Sum05 (ppm-hr)	0.65		0.10
	Nighttime Mean Hourly Ozone (ppb)	18.99		30.91
	Nighttime Sum04 (ppm-hr)	0.10		0.56
	Nighttime Sum05 (ppm-hr)	0.06		0.05
	Cumulative Sum04 (ppm-hr)	79.70	53.57	94.26
	Hours >40 ppb	44.00		22.00
	Sum04 (ppm-hr)	2.08		0.97
	Cumulative Sum05 (ppm-hr)	50.20	41.67	52.59
	Hours >50 ppb	13.00		3.00
	Sum05 (ppm-hr)	0.70		0.15
	Cumulative Sum06 (ppm-hr)	22.95	27.15	20.25
	Cumulative Sum08 (ppm-hr)	1.68	4.60	0.90
37	Average Hourly Ozone (ppb)	27.91		30.54
	Maximum Hourly Ozone (ppb)	79.00		63.00
	Minimum Hourly Ozone (ppb)	3.00		15.00
	Daytime Mean Hourly Ozone (ppb)	34.79		32.36
	Daytime Sum04 (ppm-hr)	1.47		0.91
	Daytime Sum05 (ppm-hr)	0.98		0.69

Figure 5: Weekly Values

Week	Metric	Bennington	Lye Brook	Underhill
37	Daytime Sum06 (ppm-hr)	0.76		0.37
	Nighttime Mean Hourly Ozone (ppb)	20.10		26.43
	Nighttime Sum04 (ppm-hr)	0.35		0.57
	Nighttime Sum05 (ppm-hr)	0.17		0.42
	Cumulative Sum04 (ppm-hr)	81.52	53.57	95.96
	Hours >40 ppb	33.00		33.00
	Sum04 (ppm-hr)	1.82		1.70
	Cumulative Sum05 (ppm-hr)	51.35	41.67	53.69
	Hours >50 ppb	18.00		20.00
	Sum05 (ppm-hr)	1.15		1.11
	Cumulative Sum06 (ppm-hr)	23.77	27.15	20.62
	Hours >60 ppb	12.00		6.00
	Sum06 (ppm-hr)	0.82		0.37
	Cumulative Sum08 (ppm-hr)	1.68	4.60	0.90
38	Average Hourly Ozone (ppb)	27.04		32.77
	Maximum Hourly Ozone (ppb)	66.00		62.00
	Minimum Hourly Ozone (ppb)	3.00		10.00
	Daytime Mean Hourly Ozone (ppb)	34.62		33.85
	Daytime Sum04 (ppm-hr)	1.49		0.95
	Daytime Sum05 (ppm-hr)	0.68		0.68
	Daytime Sum06 (ppm-hr)	0.26		0.18
	Nighttime Mean Hourly Ozone (ppb)	18.99		33.73
	Nighttime Sum04 (ppm-hr)	0.47		1.09
	Nighttime Sum05 (ppm-hr)	0.17		0.75
	Cumulative Sum04 (ppm-hr)	83.48	53.57	97.80
	Hours >40 ppb	40.00		35.00
	Sum04 (ppm-hr)	1.96		1.85
	Cumulative Sum05 (ppm-hr)	52.20	41.67	55.02
	Hours >50 ppb	15.00		23.00
	Sum05 (ppm-hr)	0.85		1.32
	Cumulative Sum06 (ppm-hr)	24.02	27.15	21.11
	Hours >60 ppb	4.00		8.00
	Sum06 (ppm-hr)	0.26		0.49
	Cumulative Sum08 (ppm-hr)	1.68	4.60	0.90
39	Average Hourly Ozone (ppb)	25.80	51.61	35.68
	Maximum Hourly Ozone (ppb)	61.00	74.75	60.00
	Minimum Hourly Ozone (ppb)	3.00	10.25	13.00
	Daytime Mean Hourly Ozone (ppb)	33.85	44.97	37.44
	Daytime Sum04 (ppm-hr)	1.65	1.84	2.00
	Daytime Sum05 (ppm-hr)	1.15	1.68	1.23
	Daytime Sum06 (ppm-hr)	0.18	1.28	0.18
	Nighttime Mean Hourly Ozone (ppb)	18.86	44.22	33.66

Figure 5: Weekly Values

Week	Metric	Bennington	Lye Brook	Underhill
39	Nighttime Sum04 (ppm-hr)	0.28	1.94	1.33
	Cumulative Sum04 (ppm-hr)	85.31	56.48	101.15
	Hours >40 ppb	36.00	51.00	69.00
	Sum04 (ppm-hr)	1.83	2.91	3.35
	Cumulative Sum05 (ppm-hr)	53.35	43.99	56.72
	Hours >50 ppb	21.00	37.00	31.00
	Sum05 (ppm-hr)	1.15	2.32	1.70
	Cumulative Sum06 (ppm-hr)	24.20	29.06	21.29
	Hours >60 ppb	3.00	30.00	3.00
	Sum06 (ppm-hr)	0.18	1.91	0.18
	Cumulative Sum08 (ppm-hr)	1.68	4.60	0.90
40	Average Hourly Ozone (ppb)	28.55		31.32
	Maximum Hourly Ozone (ppb)	71.00		56.00
	Minimum Hourly Ozone (ppb)	3.00		13.00
	Daytime Mean Hourly Ozone (ppb)	32.10	37.43	32.15
	Daytime Sum04 (ppm-hr)	0.77	1.13	0.83
	Daytime Sum05 (ppm-hr)	0.73	0.69	0.38
	Nighttime Mean Hourly Ozone (ppb)	22.56	46.67	28.69
	Nighttime Sum04 (ppm-hr)	0.70	0.48	0.48
	Cumulative Sum04 (ppm-hr)	86.79	56.48	102.59
	Hours >40 ppb	31.00		31.00
	Sum04 (ppm-hr)	1.56		1.48
	Cumulative Sum05 (ppm-hr)	54.07	43.99	57.26
	Hours >50 ppb	12.00		10.00
	Sum05 (ppm-hr)	0.73		0.54
	Cumulative Sum06 (ppm-hr)	24.61	29.06	21.29
	Cumulative Sum08 (ppm-hr)	1.68	4.60	0.90
41	Average Hourly Ozone (ppb)	18.67		22.97
	Minimum Hourly Ozone (ppb)	3.00		3.00
	Daytime Mean Hourly Ozone (ppb)	22.32		24.14
	Nighttime Mean Hourly Ozone (ppb)	14.71		20.86
42	Average Hourly Ozone (ppb)	16.59		21.67
	Minimum Hourly Ozone (ppb)	3.00		3.00
	Daytime Mean Hourly Ozone (ppb)	20.36		22.64
	Nighttime Mean Hourly Ozone (ppb)	12.86		22.74
43	Average Hourly Ozone (ppb)	31.07		34.43
	Minimum Hourly Ozone (ppb)	3.00		19.00
	Daytime Mean Hourly Ozone (ppb)	33.76		34.98
	Daytime Sum04 (ppm-hr)	0.90		0.88
	Daytime Sum05 (ppm-hr)	0.73		0.65
	Daytime Sum06 (ppm-hr)	0.41		0.39
	Nighttime Mean Hourly Ozone (ppb)	29.69		33.99

Figure 5: Weekly Values

Week	Metric	Bennington	Lye Brook	Underhill
43	Nighttime Sum04 (ppm-hr)	0.58		0.83
	Nighttime Sum05 (ppm-hr)	0.45		0.53
	Nighttime Sum06 (ppm-hr)	0.35		0.32
	Hours >40 ppb	26.00		30.00
	Sum04 (ppm-hr)	1.49		1.63
	Hours >50 ppb	19.00		20.00
	Sum05 (ppm-hr)	1.18		1.18
	Hours >60 ppb	11.00		11.00
	Sum06 (ppm-hr)	0.75		0.70
44	Average Hourly Ozone (ppb)	26.73		26.75
	Minimum Hourly Ozone (ppb)	3.00		17.00
	Daytime Mean Hourly Ozone (ppb)	29.79		27.15
	Nighttime Mean Hourly Ozone (ppb)	23.56		26.56
	Hours >40 ppb	7.00		6.00
	Sum04 (ppm-hr)	0.31		0.25

Figure 6: Annual Average Diurnal Pattern

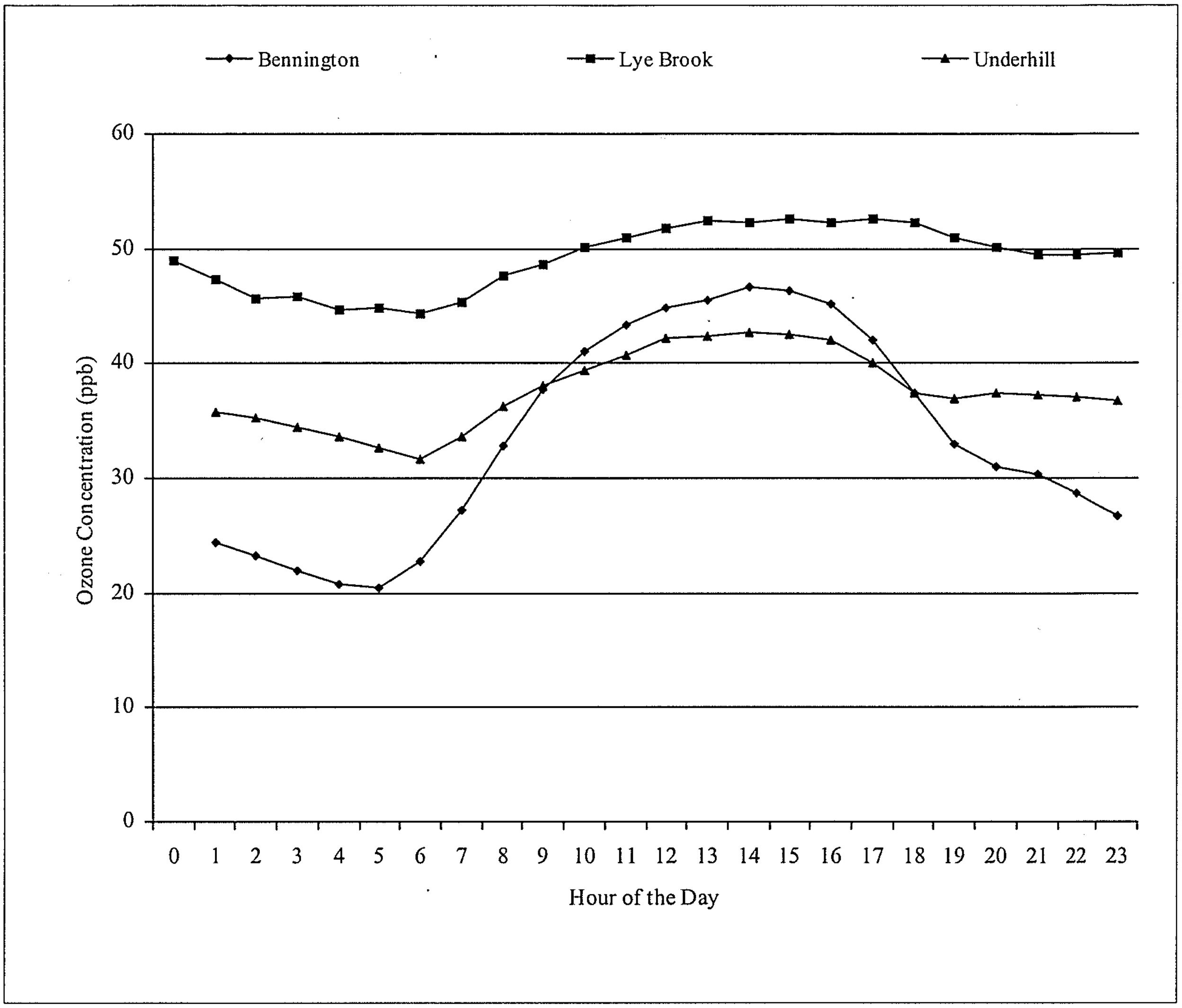
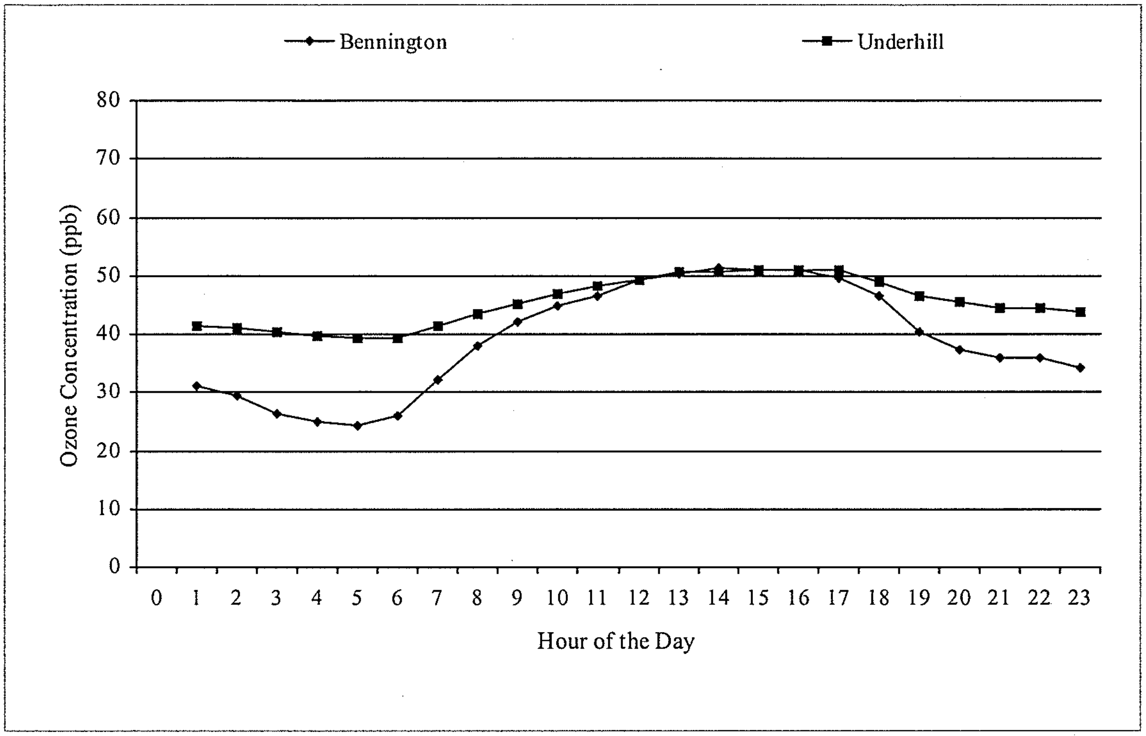


Figure 7: Monthly Average Diurnal Pattern

April



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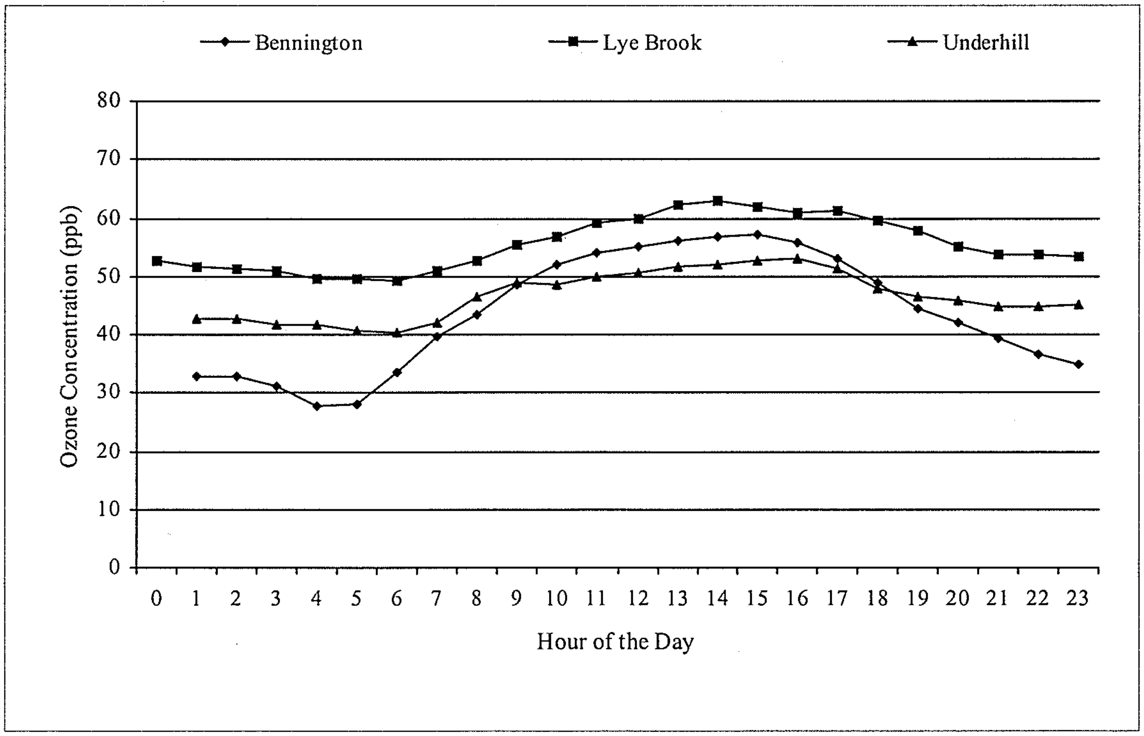
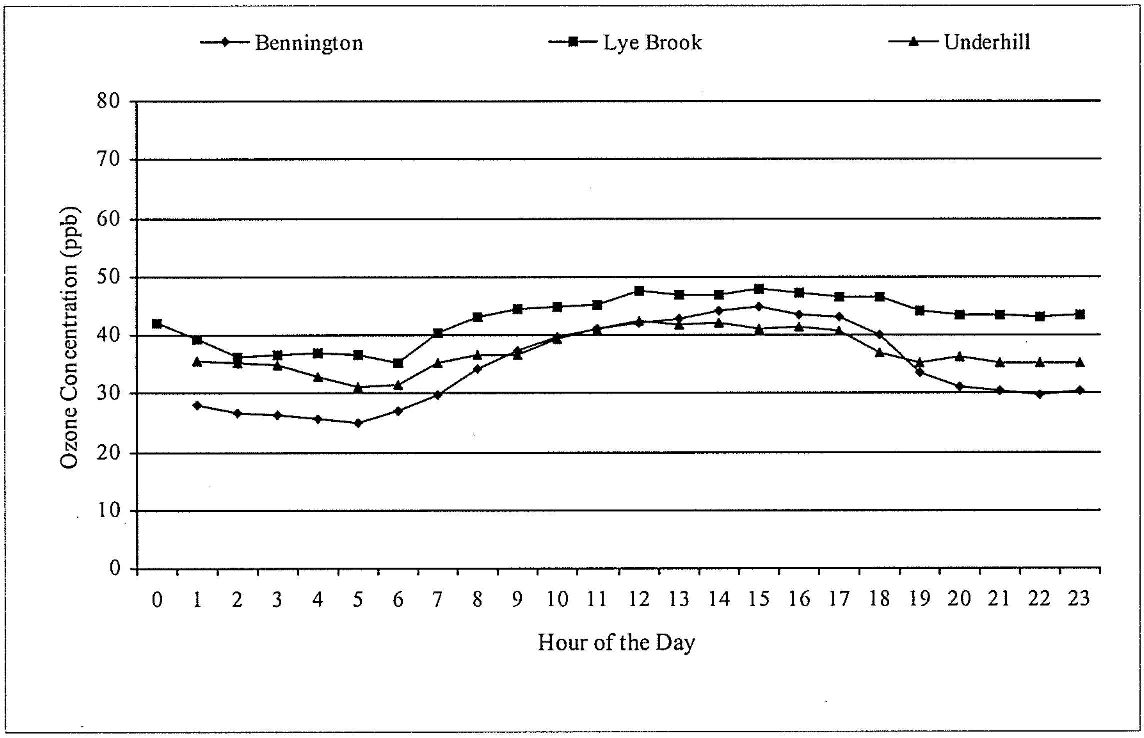


Figure 7: Monthly Average Diurnal Pattern

June



July

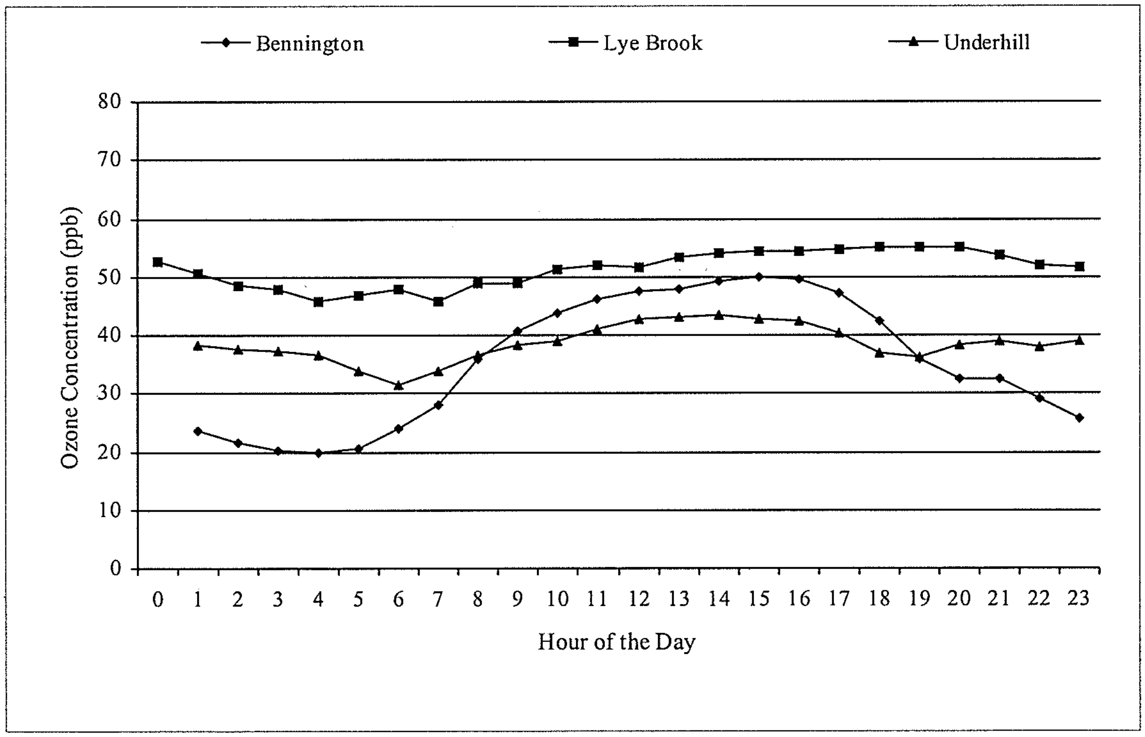
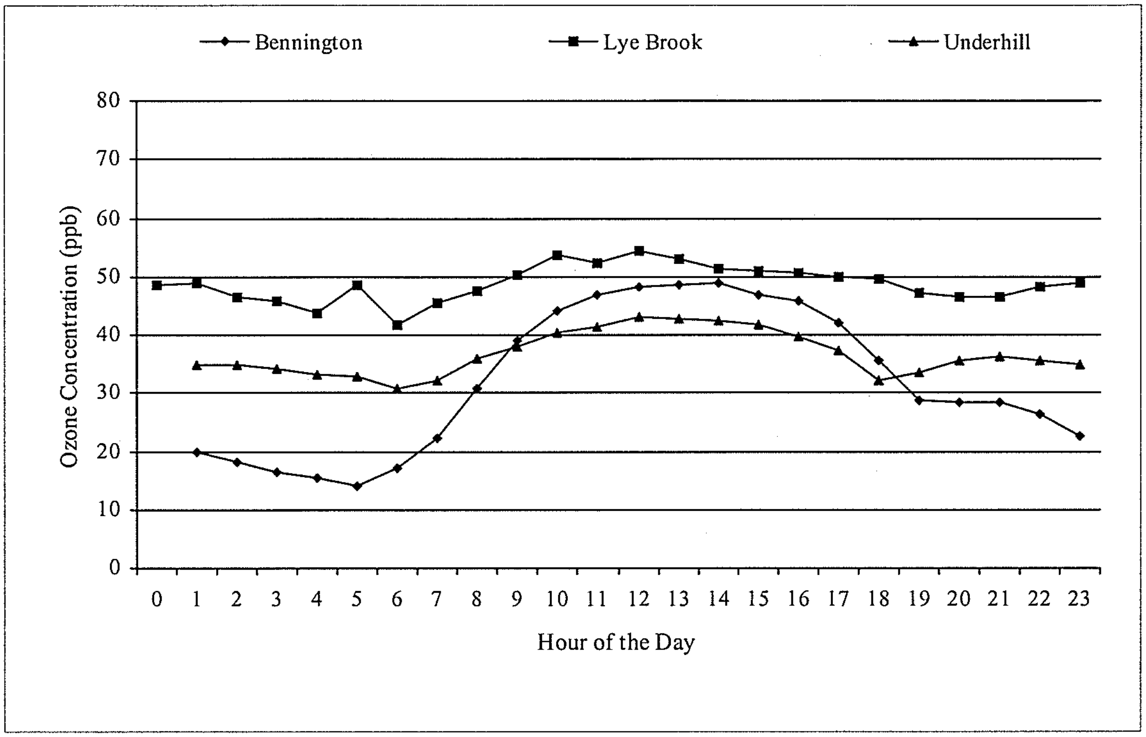


Figure 7: Monthly Average Diurnal Pattern

August



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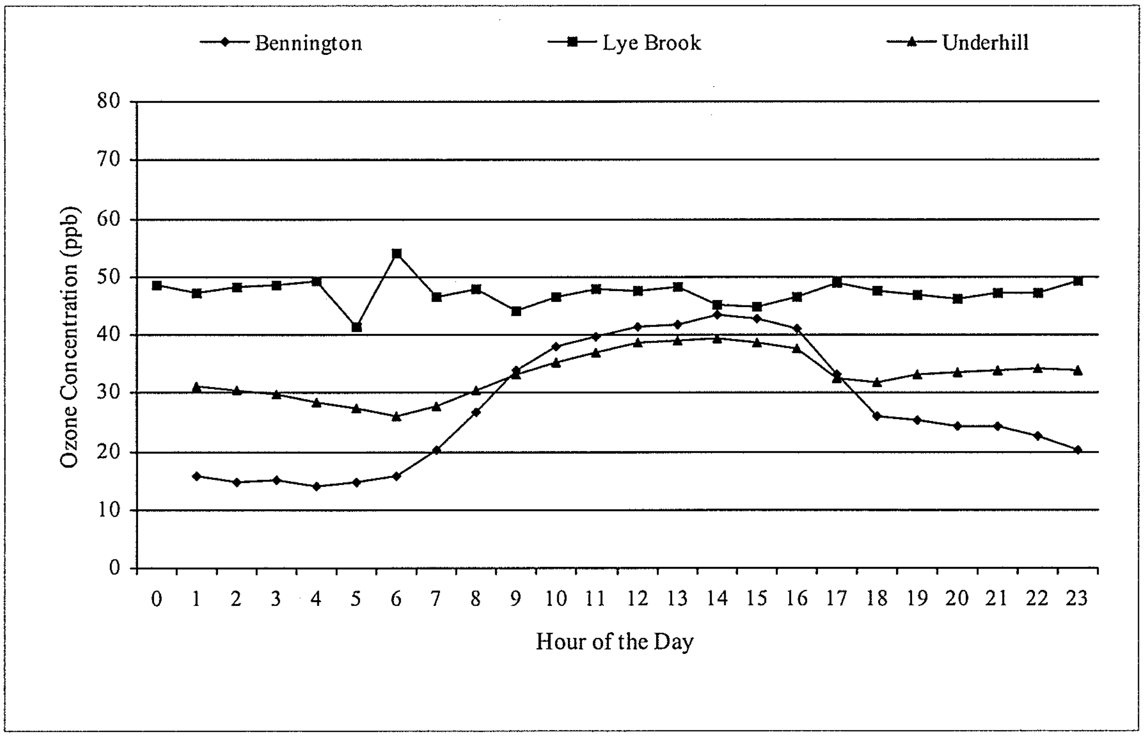
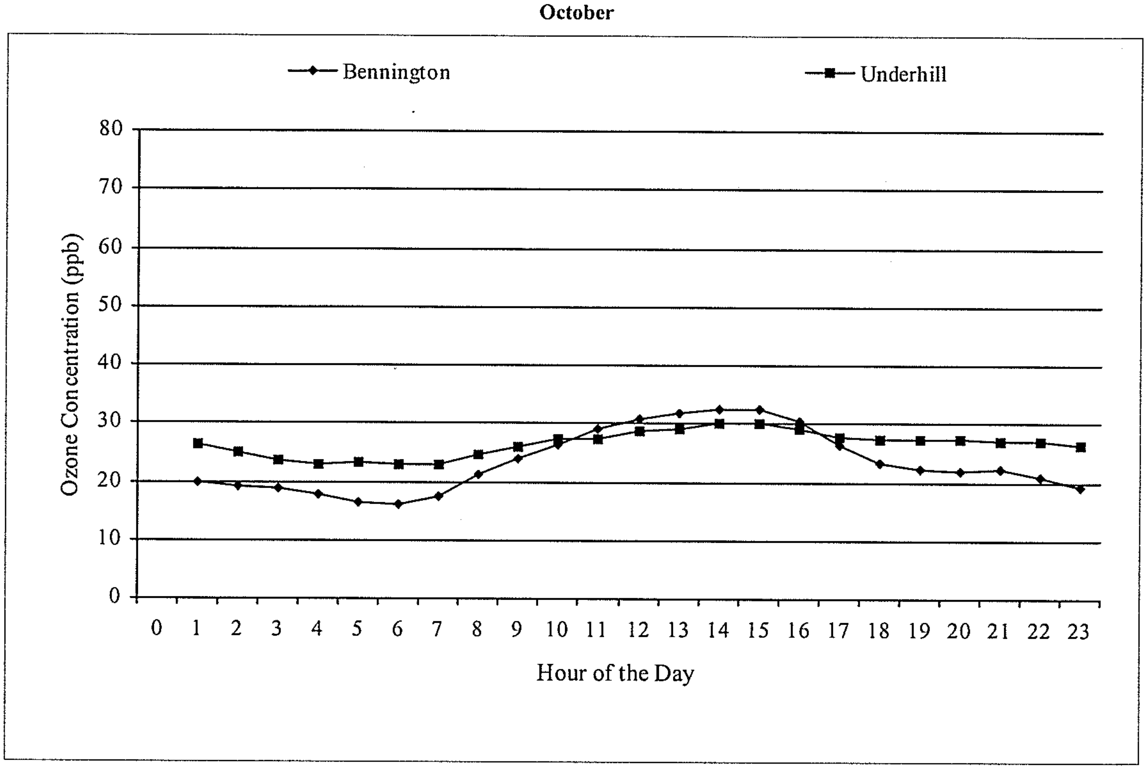


Figure 7: Monthly Average Diurnal Pattern



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 are provided in Appendix B.

Objectives:

The objective of this report is to provide a summary comparing precipitation chemistry data collected by various networks at the VMC Mount Mansfield and Lye Brook Wilderness Area sites.

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. CASTNet Winter 1998-1999 data was not available. (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.

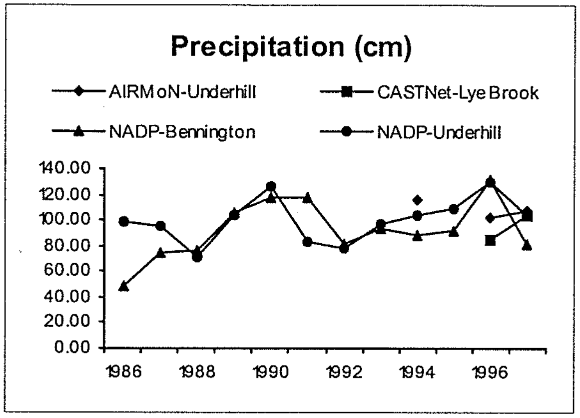
Citations:

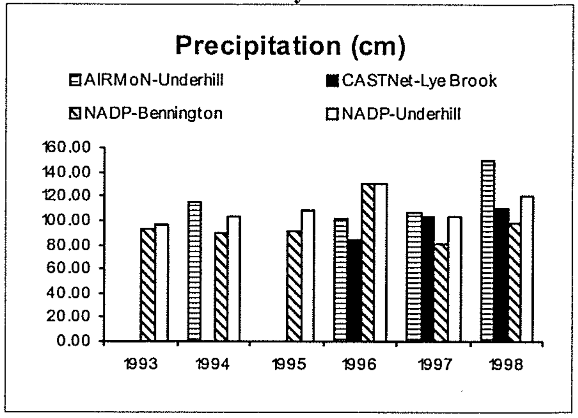
National Atmospheric Deposition Program (NRSP-3)/National Trend Network. (2000). NADP Program Office, Illinois State Water Survey, 2204 Griffith Drive, Champaign, IL 61820

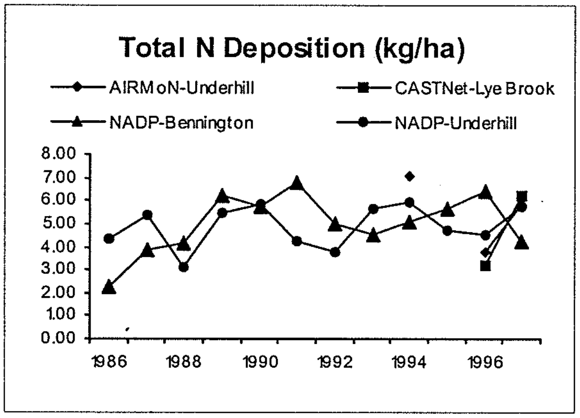
National Atmospheric Deposition Program (NRSP-3)/Atmospheric Integrated Research Monitoring Network. (2000) NADP Program Office, Illinois State Water Survey, 2204 Griffith Drive, Champaign, IL 61820

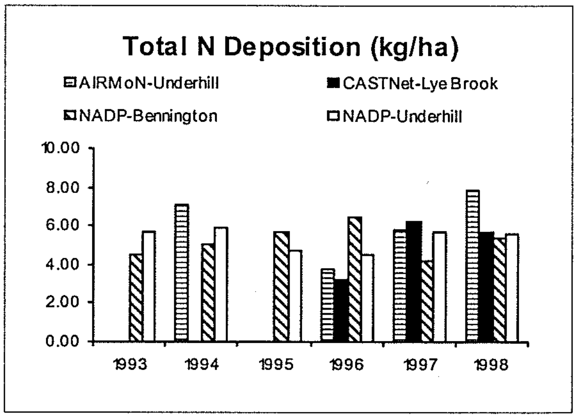
Annual Wet Deposition: Precipitation, Total Nitrogen and Sulfur Deposition 1998

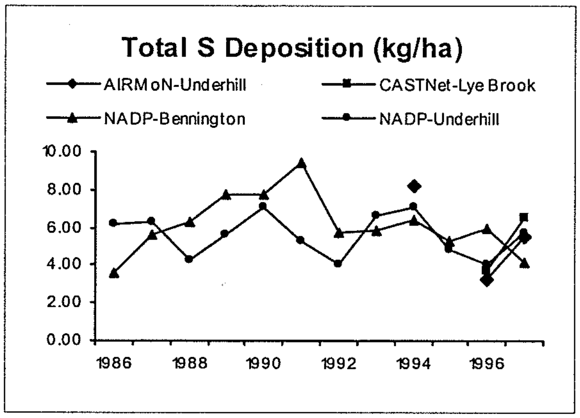
Period of Record | **Last 5 years**

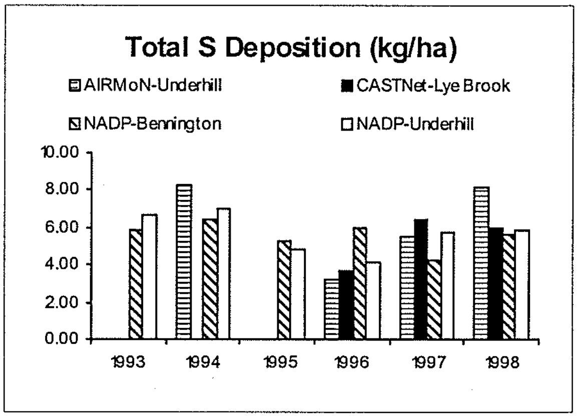












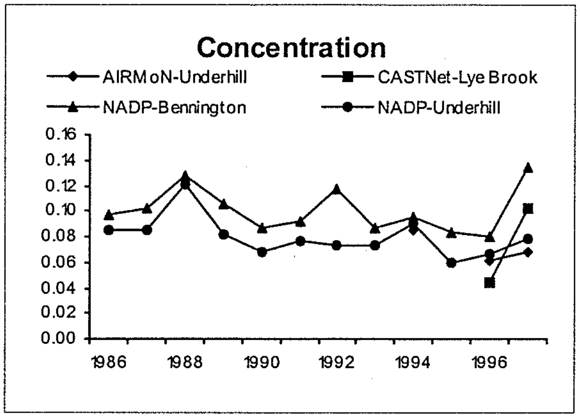
	Precipitation (cm)		Total N Deposition (kg/ha)		Total S Deposition (kg/ha)		
Location	Current Year	Period of Record Average	Current Year	Period of Record Average	Current Year	Period of Record Average)	Years of Data
AIRMoN-Underhill	150.22	118.48	7.85	6.12	8.21	6.30	4
CASTNet-Lye Brook	110.01	99.08	5.68	5.03	5.94	5.37	3
NADP-Bennington	98.30	92.57	5.40	5.01	5.64	6.13	13
NADP-Underhill	121.08	101.47	5.61	4.96	5.89	5.63	13

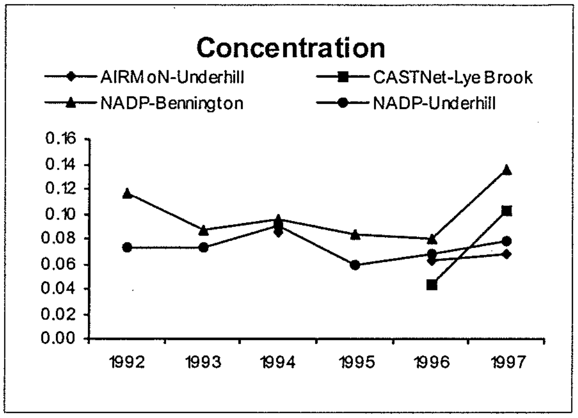
Annual Wet Deposition by Chemical 1998

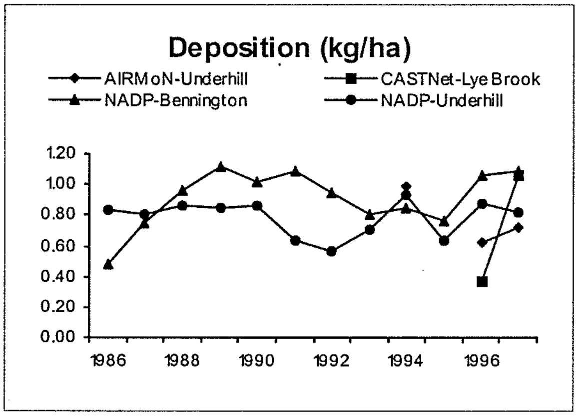
Chemical: Ca **Concentration Units:** mg/l

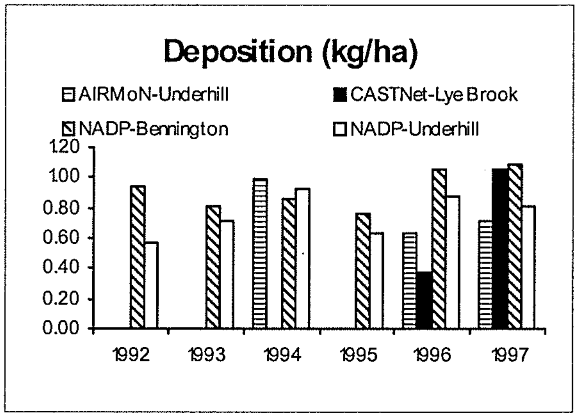
Period of Record

Last 5 years







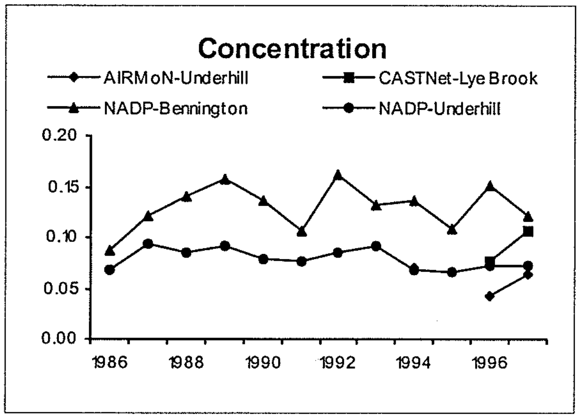


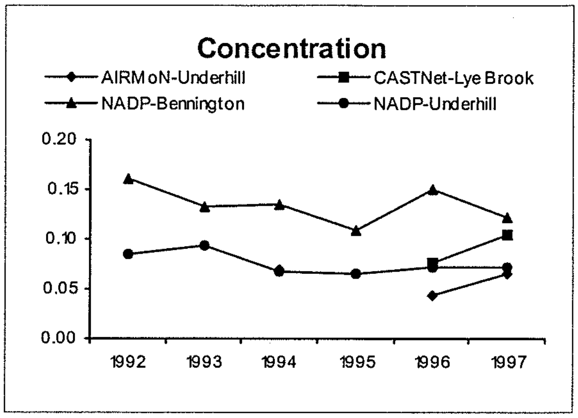
Location	Concentration		Deposition (kg/ha)		Years of Data
	Current Year	Period of Record Average	Current Year	Period of Record Average	
AIRMoN-Underhill	0.06	0.07	0.88	0.80	4
CASTNet-Lye Brook	0.08	0.07	0.83	0.75	3
NADP-Bennington	0.10	0.10	1.00	0.92	13
NADP-Underhill	0.07	0.08	0.85	0.79	13

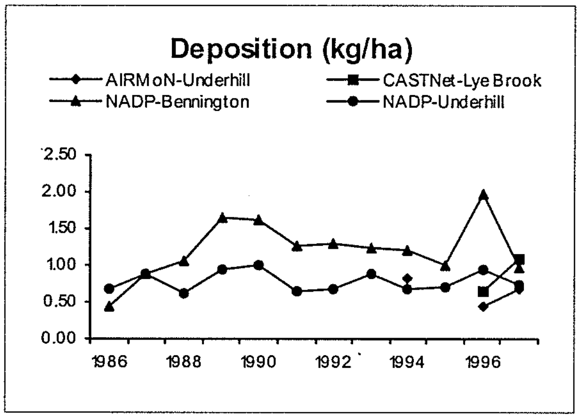
Annual Wet Deposition by Chemical 1998

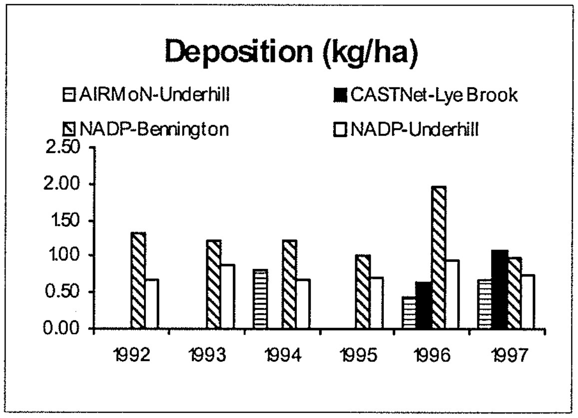
Chemical: Cl **Concentration Units:** mg/l

Period of Record **Last 5 years**







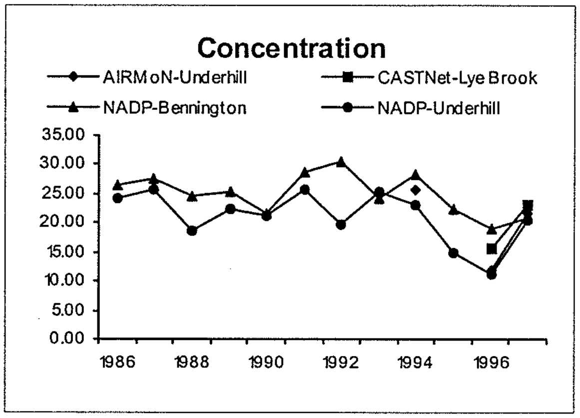


Location	Concentration		Deposition (kg/ha)		Years of Data
	Current Year	Period of Record Average	Current Year	Period of Record Average	
AIRMoN-Underhill	0.06	0.06	0.95	0.72	4
CASTNet-Lye Brook	0.12	0.10	1.33	1.02	3
NADP-Bennington	0.09	0.13	0.90	1.19	13
NADP-Underhill	0.06	0.08	0.72	0.78	13

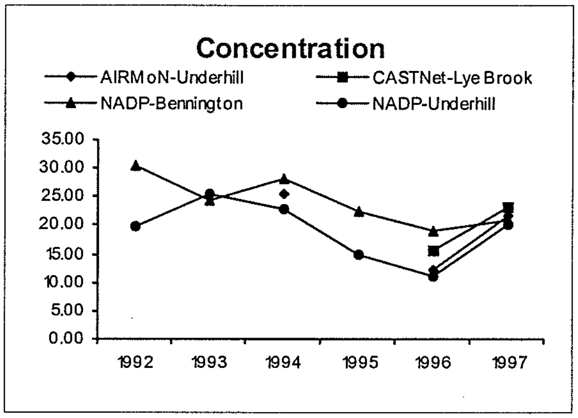
Annual Wet Deposition by Chemical 1998

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

Period of Record



Last 5 years

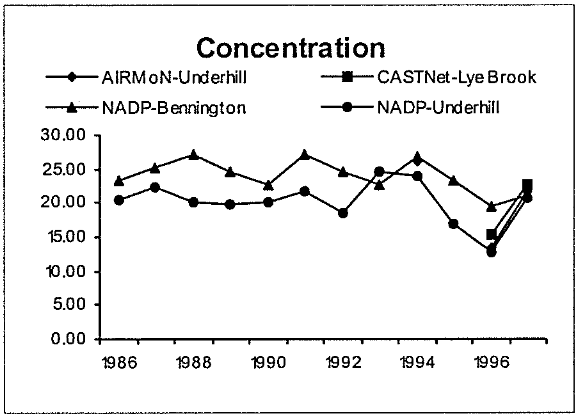


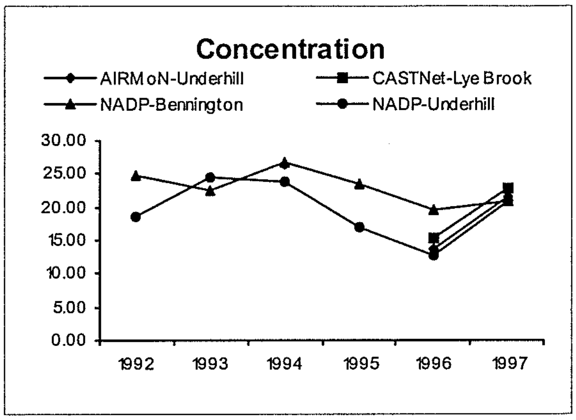
Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
AIRMoN-Underhill	21.43	20.15			4
CASTNet-Lye Brook	19.52	19.38			3
NADP-Bennington	22.72	24.77			13
NADP-Underhill	19.78	20.93			13

Annual Wet Deposition by Chemical 1998

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

Period of Record **Last 5 years**



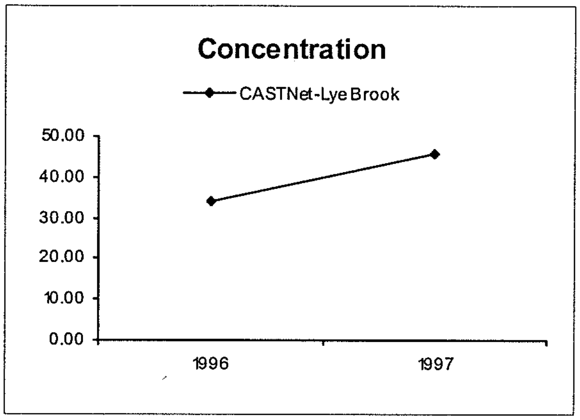


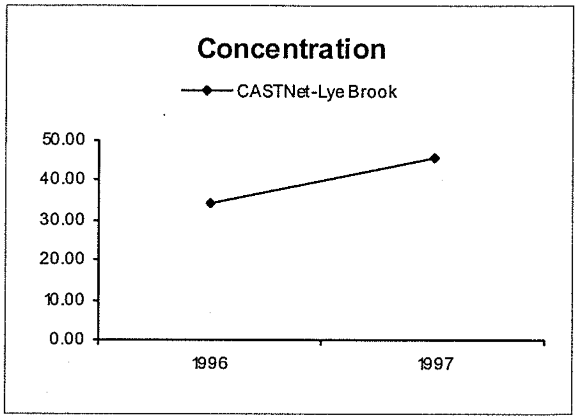
Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
AIRMoN-Underhill	21.85	20.83			4
CASTNet-Lye Brook	19.54	19.25			3
NADP-Bennington	22.26	23.86			13
NADP-Underhill	18.74	20.05			13

Annual Wet Deposition by Chemical 1998

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

Period of Record **Last 5 years**



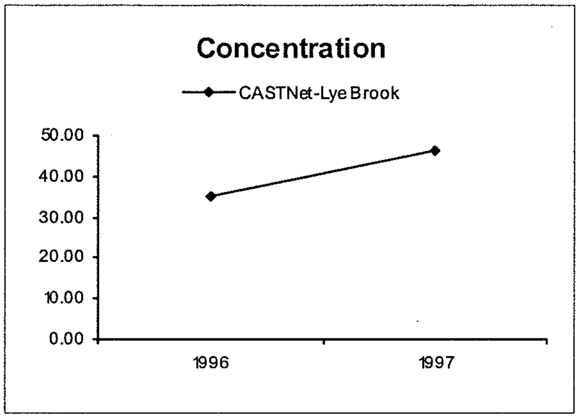


	Concentration		Deposition (kg/ha)		
Location	Current Year	Period of Record Average	Current Year	Period of Record Average	Years of Data
CASTNet-Lye Brook	38.69	39.50			3

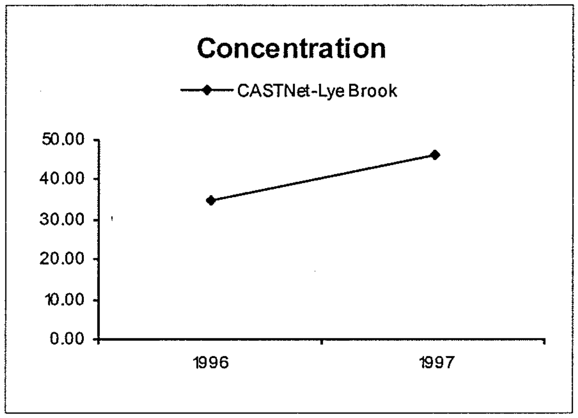
Annual Wet Deposition by Chemical 1998

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

Period of Record



Last 5 years

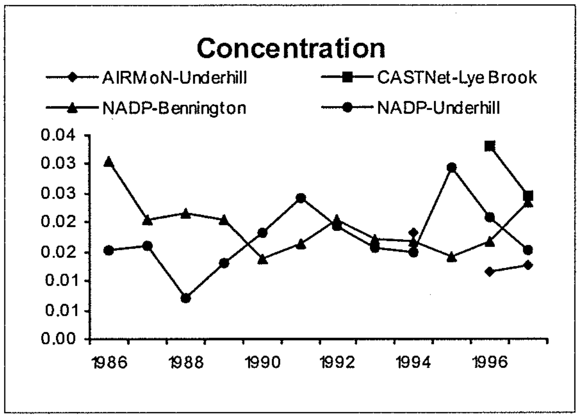


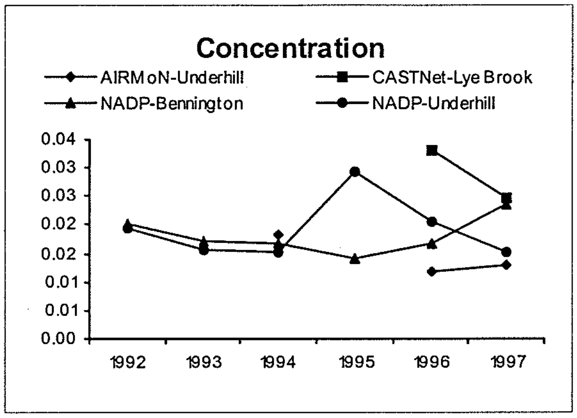
	Concentration		Deposition (kg/ha)		
Location	Current Year	Period of Record Average	Current Year	Period of Record Average	Years of Data
CASTNet-Lye Brook	38.57	39.90			3

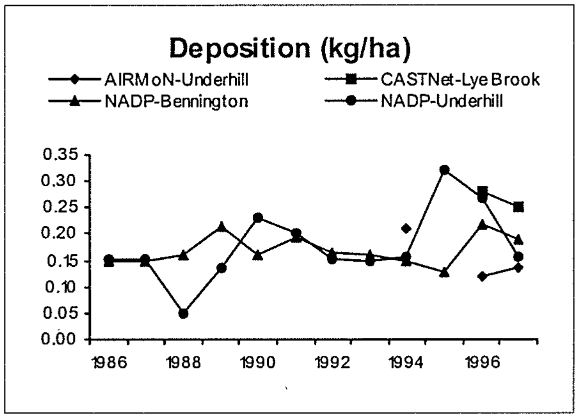
Annual Wet Deposition by Chemical 1998

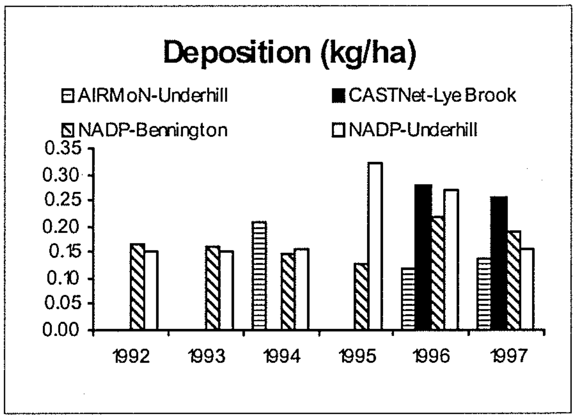
Chemical: K **Concentration Units:** mg/l

Period of Record **Last 5 years**







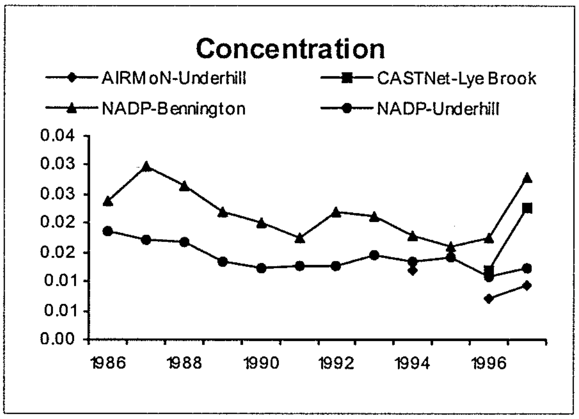


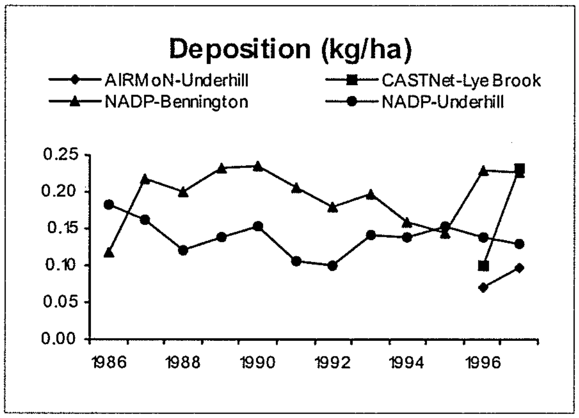
Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
AIRMoN-Underhill	0.01	0.01	0.19	0.16	4
CASTNet-Lye Brook	0.04	0.03	0.46	0.33	3
NADP-Bennington	0.02	0.02	0.17	0.17	13
NADP-Underhill	0.02	0.02	0.21	0.18	13

Annual Wet Deposition by Chemical 1998

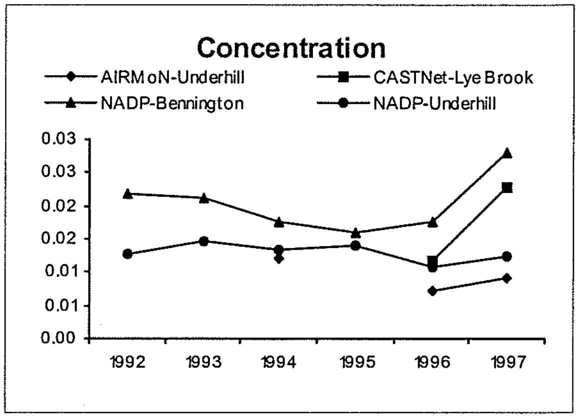
Chemical: Mg **Concentration Units:** mg/l

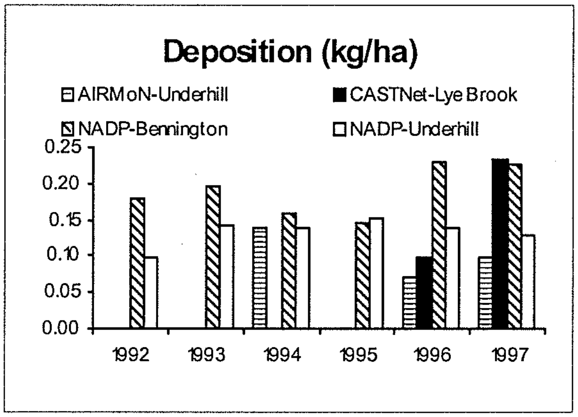
Period of Record





Last 5 years



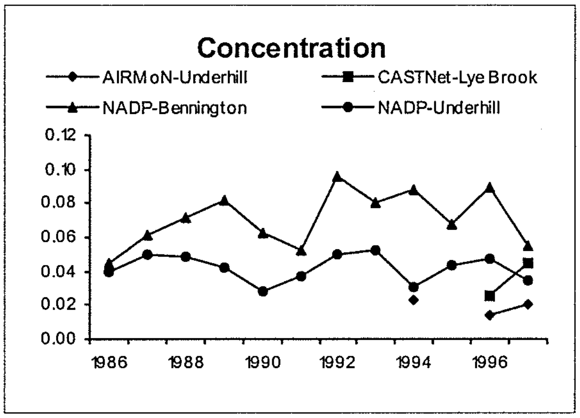


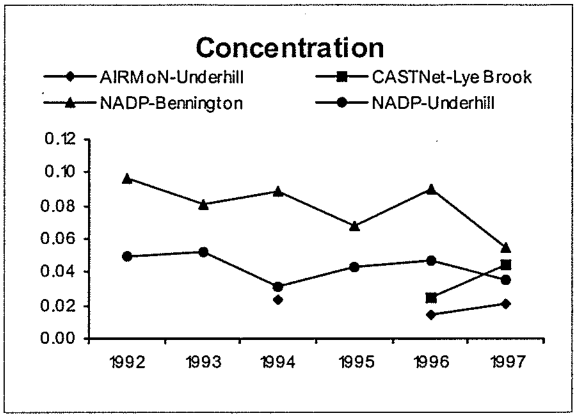
Location	Concentration		Deposition (kg/ha)		Years of Data
	Current Year	Period of Record Average	Current Year	Period of Record Average	
AIRMoN-Underhill	0.01	0.01	0.13	0.11	4
CASTNet-Lye Brook	0.01	0.02	0.16	0.16	3
NADP-Bennington	0.02	0.02	0.17	0.19	13
NADP-Underhill	0.01	0.01	0.14	0.14	13

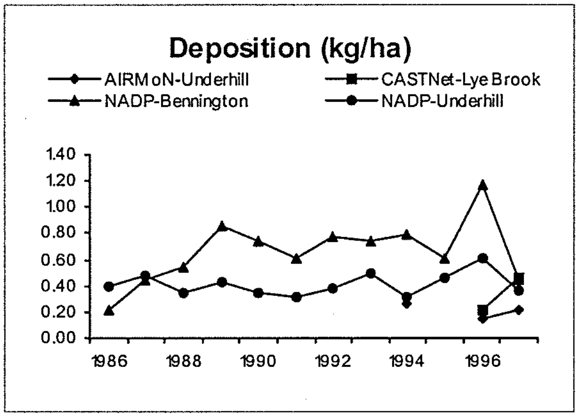
Annual Wet Deposition by Chemical 1998

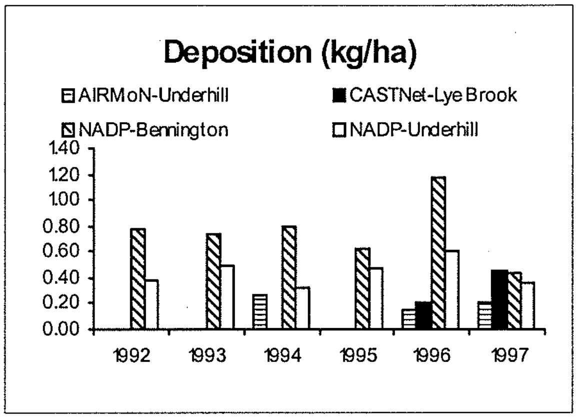
Chemical: Na **Concentration Units:** mg/l

Period of Record **Last 5 years**







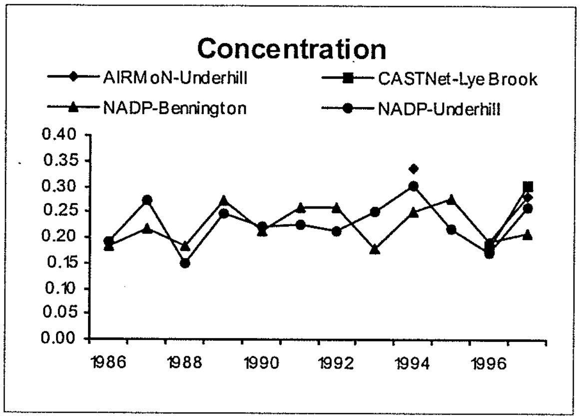


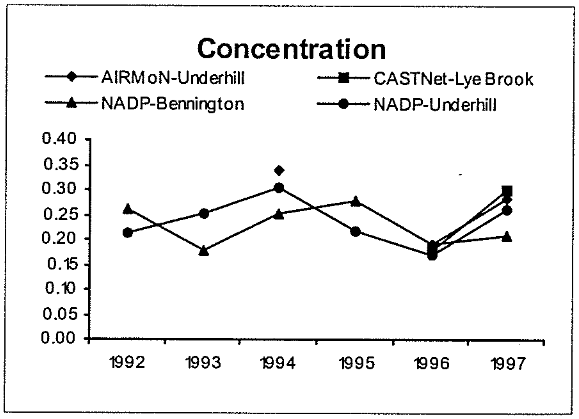
Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
AIRMoN-Underhill	0.02	0.02	0.30	0.23	4
CASTNet-Lye Brook	0.06	0.04	0.62	0.43	3
NADP-Bennington	0.03	0.07	0.34	0.64	13
NADP-Underhill	0.02	0.04	0.26	0.40	13

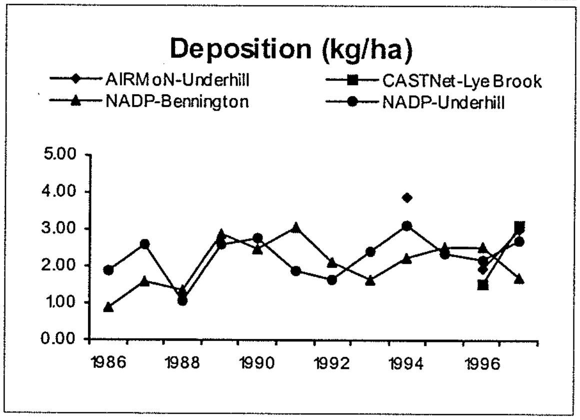
Annual Wet Deposition by Chemical 1998

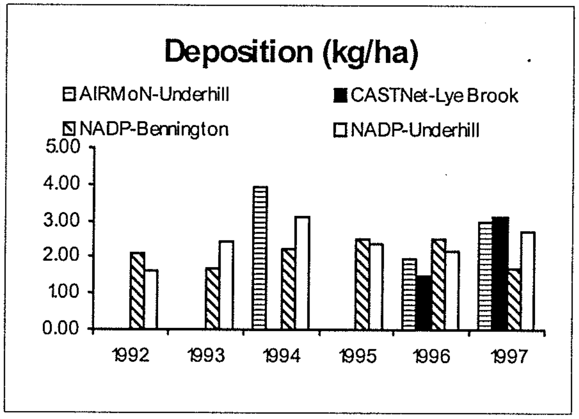
Chemical: NH4 **Concentration Units:** mg/l

Period of Record **Last 5 years**







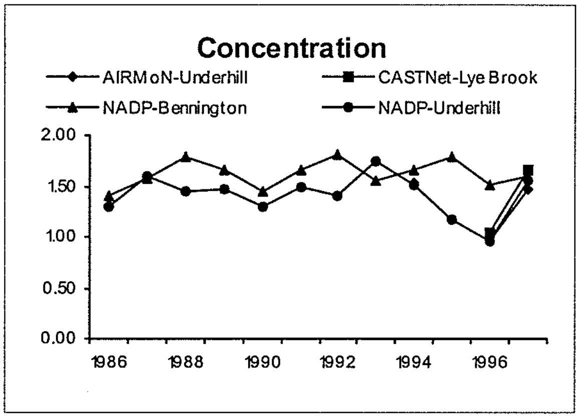


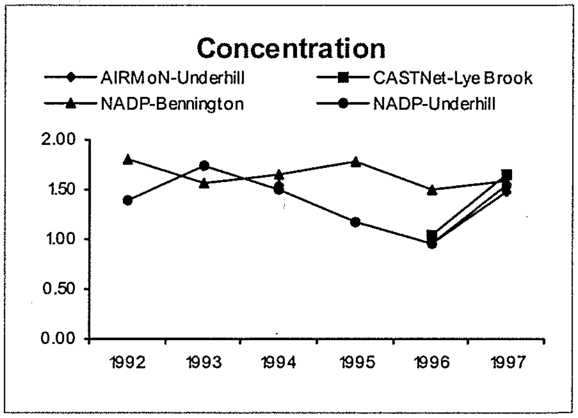
Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
AIRMoN-Underhill	0.33	0.29	4.98	3.46	4
CASTNet-Lye Brook	0.28	0.26	3.13	2.58	3
NADP-Bennington	0.23	0.23	2.28	2.10	13
NADP-Underhill	0.24	0.23	2.91	2.32	13

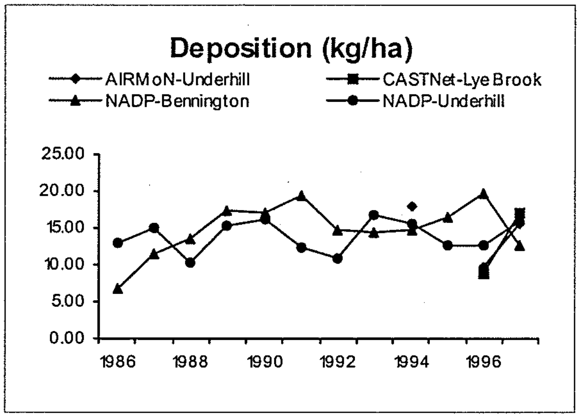
Annual Wet Deposition by Chemical 1998

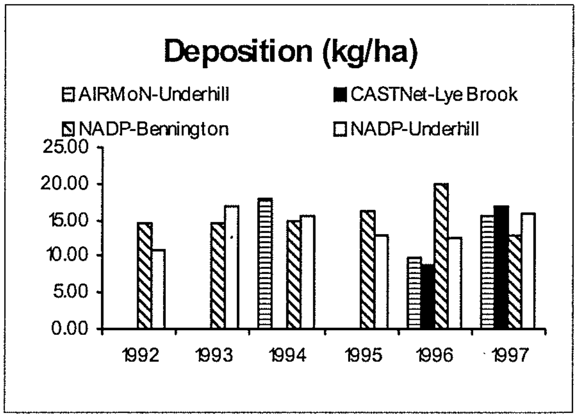
Chemical: NO3 **Concentration Units:** mg/l

Period of Record **Last 5 years**







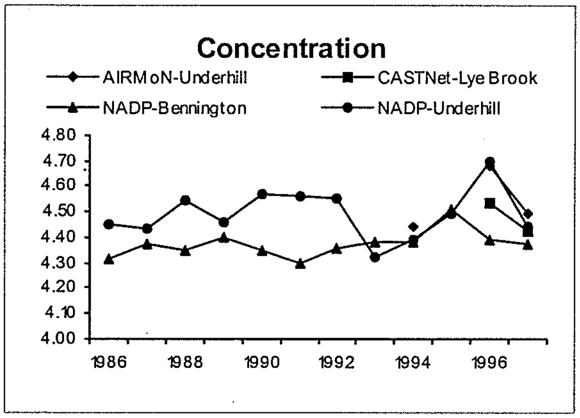


	Concentration		Deposition (kg/ha)		
Location	Current Year	Period of Record Average	Current Year	Period of Record Average	Years of Data
AIRMoN-Underhill	1.17	1.28	17.59	15.20	4
CASTNet-Lye Brook	1.30	1.34	14.35	13.40	3
NADP-Bennington	1.63	1.62	16.05	14.96	13
NADP-Underhill	1.22	1.40	14.83	13.97	13

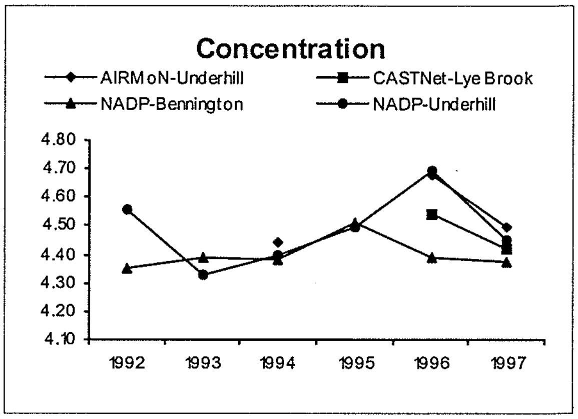
Annual Wet Deposition by Chemical 1998

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

Period of Record



Last 5 years

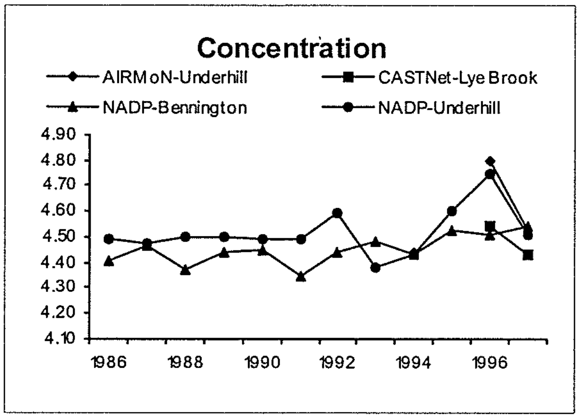


Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
AIRMoN-Underhill	4.52	4.54			4
CASTNet-Lye Brook	4.50	4.49			3
NADP-Bennington	4.37	4.37			13
NADP-Underhill	4.50	4.49			13

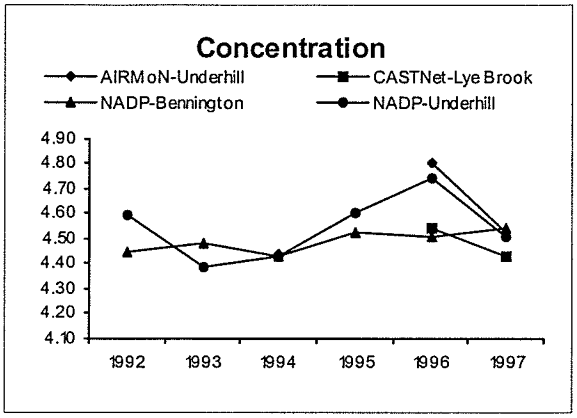
Annual Wet Deposition by Chemical 1998

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

Period of Record



Last 5 years

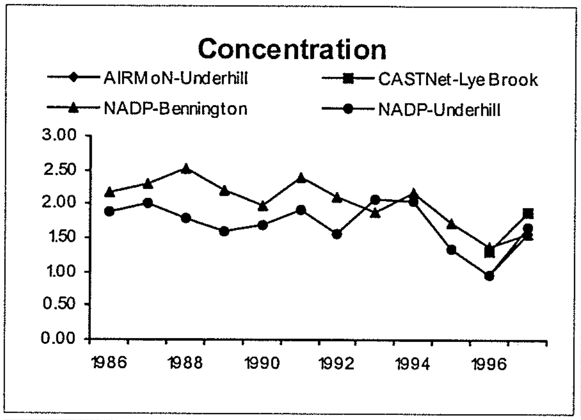


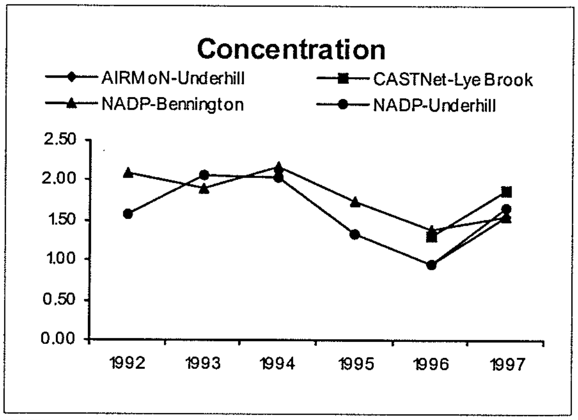
Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
AIRMoN-Underhill	4.51	4.57			4
CASTNet-Lye Brook	4.50	4.49			3
NADP-Bennington	4.46	4.45			13
NADP-Underhill	4.51	4.52			13

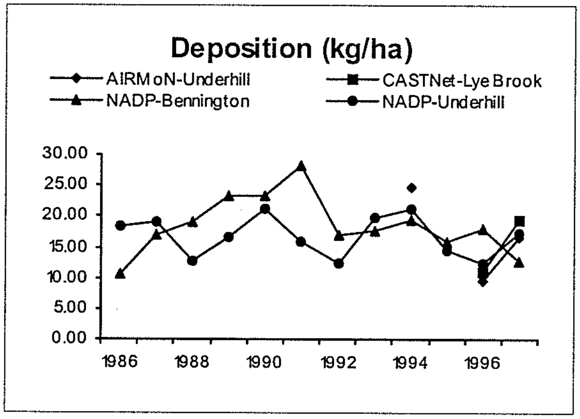
Annual Wet Deposition by Chemical 1998

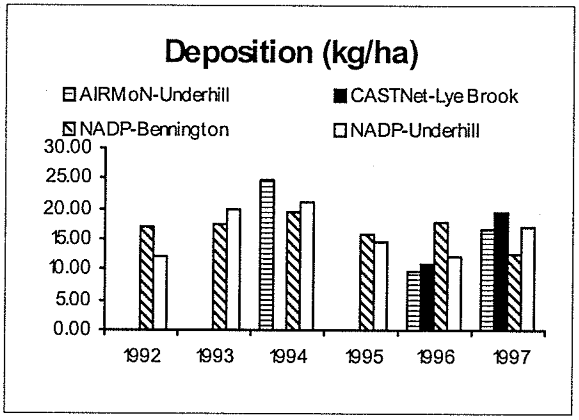
Chemical: SO4 **Concentration Units:** mg/l

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	1.64	1.57	24.58	18.87	4
CASTNet-Lye Brook	1.62	1.60	17.77	16.08	3
NADP-Bennington	1.72	2.01	16.89	18.35	13
NADP-Underhill	1.46	1.69	17.63	16.84	13

Vermont Acid Precipitation Monitoring Program
Data Summary Report 1980-1998 for Underhill and Mt. Mansfield

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

Cooperators:

UVM Proctor Maple Research Center: Mim Pendleton
WCAX-TV Mt. Mansfield Transmitter Station: Mike Rainey
Stowe Mountain Resort and Simon Operating Systems (S.O.S): Tyler Utton and S.O.S. Staff

Abstract:

The VMC monitoring stations located at Underhill and Mt. Mansfield are included in the Vermont Acid Precipitation Monitoring Program (VAPMP). For the past 3 years, Mt. Mansfield has provided incomplete data. This was due to two factors: (1) radio frequency interference at the summit and (2) a lack of coordination between collection and analysis of the sample. Initially, problems developed from intense radio frequency emitted from the summit's transmitters. The interference resulted in erratic pH readings. As a result, pH analysis was moved to the base of the mountain and conducted by personnel from Simon Operating Systems. A high turn over of personnel at Simon Operating Systems and problems with coordinating transport resulted in intermittent collection and timely processing. As of June 1999, both collection and analysis will be conducted at the summit with a portable pH meter.

The VAPMP has demonstrated that the majority of bulk precipitation in Vermont is unquestionably acidic. State-wide, forty-three percent of all events occur between the pH of 4.1-4.6, while fifty-three percent of events at the VMC sites are within that range. Ninety-four percent of state-wide precipitation events have a pH of less than 5.60, the theoretical pH of unpolluted rain. At the Mt Mansfield and Underhill sites, ninety-eight percent of all events have a pH of less than 5.6. Overall, Mt Mansfield and Underhill have more acidic precipitation than other VAPMP sites.

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 Vermont Department of Environmental Conservation (VTDEC) began monitoring precipitation events through the Vermont Acid Precipitation Monitoring 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. The Mt. Mansfield station has an Orion SA 250 portable pH meter with a Cole Parmer combination electrode with a calomel reference. This pH meter was necessary to eliminate electrical interference.

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 melt completely 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 25EC. 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:

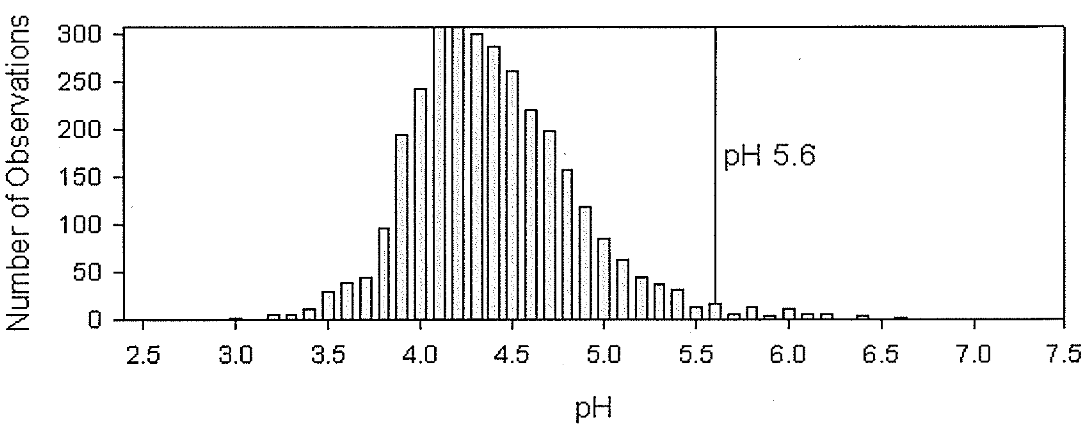
<u>Frequency of Distribution</u>

Fifty-three percent of all precipitation events at Mt. Mansfield and Underhill occurred between pH 4.1 - 4.6. Ninety-eight percent of all precipitation events from July 1980 through December 1998 are less than pH 5.60, the theoretical pH for unpolluted precipitation. 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).

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 typically have the lowest annual volume weighted pH.

<u>Seasonal Variation</u>

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.



Graph 1. VAPMP Frequency Distribution for VMC stations, 1980-1998. 3,180 Observations

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

SITE	1980	1981	1982	1983	1984	1985	1986	1987	1988
Mt.	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	1998
Mt. Mansfield	4.26	4.28	4.14	4.03	4.25	4.13	ND	ND	3.73*	ND
Underhill	4.34	4.46	4.41	4.46	4.28	4.31	4.38	4.52	4.38	4.42
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 **=site closed

Table 2. Seasonal Volume-Weighted pH 1981-1998.

	1981		1982		1983		1984		1985		1986	
SITE	W	S	W	S	W	S	W	S	W	S	W	S
Mt. Mansfield	4.32	4	4.37	4.25	4.45	4.4	4.21	4.21	4.2	4.24	4.52	4.39
Underhill	ND	ND	ND	ND	ND	4.25	4.44	4.14	4.3	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	4.6
Underhill	4.4	4.36	4.12	4.23	4.12	4.5	4.35	4.53	4.44	4.5	4.33	4.62

SITE	1993		1994		1995		1996		1997		1998	
	W	S	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*	3.63*	ND
Underhill	4.25	4.25	4.41	4.19	4.36	4.36	4.37	4.46	4.39	4.35	4.38	4.51

*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.)

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 from Mt. Mansfield 1997 was remarkably 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 and pass over the mountains (VAEC 1984; Scherbatskoy and Bliss 1983). The VAPMP data support these suggested relationships.

Future plans:

As of June 1999, the Mount Mansfield Station is conducting all collection and analysis of precipitation at the summit. Due to the importance of this station, the Program has made considerable effort to continue its operation. Bob Rickner, a WCAX transmitter operator, will be conducting all analyses.

The Morrisville station closed at the end of 1997, and a nearby station was opened in Hyde Park. This station closed in early 1998. We are currently seeking a volunteer in the Morrisville area to continue precipitation monitoring.

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Surface Waters

Aquatic Macroinvertebrate Monitoring at the Vermont Monitoring Cooperative Research Site Underhill, Vermont

by the
Vermont Department of Environmental Conservation

1998 marks the 8th year that the Vermont Department of Environmental Conservation (VTDEC) has sampled the aquatic macroinvertebrate communities at two stream sites in the upper Brown's River drainage basin on the western slope of Mount Mansfield. Both sites are located at an elevation of 1400 feet on small first-order mountain streams: Browns River and Stevensville Brook. These streams are steep and rocky and are subject to extreme variations in flow. Drainage areas are small and predominantly forested. These sites represent conditions that are minimally affected by human activities other than atmospheric deposition. Long-term sampling is undertaken at these sites in order to gather data describing the natural variability of aquatic macroinvertebrate communities between years.

Macroinvertebrates are sampled once per year using standard semi-quantitative methods during the months September-October. Samples are collected from riffle areas of the streams to standardize for physical habitat type. Organisms collected are identified to the lowest practical level, generally genus or species. Methodologies are consistent with those used by VTDEC in statewide monitoring programs making data comparable across a wide range of monitoring sites in Vermont.

Macroinvertebrate taxonomic data are used to calculate "metrics" descriptive of community structure and function. These metrics include: relative abundance; number of mayfly, stonefly, and caddisfly taxa per sample and per site (M-EPT and T-EPT); biotic index (after Hilsenhoff-indicator of organic enrichment); percent composition of the functional groups Detrivore-Shredders and Collector-Gatherers; and percent composition of stoneflies and mayflies. The following table summarizes the eight year statistics for these metrics.

Vermont DEC will continue to monitor these two sites in order to further refine descriptions of natural variability within the structure and function of macroinvertebrate communities inhabiting steep rocky mountain streams in the Green Mountains of Vermont.

Mercury in soil, soil water, and stream water in two forested catchments on Mt. Mansfield, Vermont

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ABSTRACT

Soil solution and stream water from locations in two small forested catchments in Underhill Center, VT were collected April–November 1997 and analyzed for mercury (Hg), dissolved organic carbon (DOC), color, trace elements, and major ions. Mercury concentrations in Oa and B horizon soil water ranged from 1.1 to 34.9 ng L^{-1} and 0.1 to 10.2 ng L^{-1}, respectively. In streams, dissolved Hg was 0.9 to 4.1 ng L^{-1} and total (dissolved + particulate) Hg was 0.9 to 9.2 ng L^{-1}. Mercury and other trace metals were typically present in higher concentrations in soil water than streams, indicating additional removal of these elements below the sampling depths before reaching streams. In soil water and stream water, Hg was positively correlated with DOC and color. Mercury concentrations followed a pattern similar to other trace metals that form complexes with organic compounds, such as Al, Cr, Cu, and Pb. Most of the Hg in the streams is associated with particulate matter, but the small and continual contribution of dissolved Hg from soil water and groundwater also exports significant amounts of Hg from these forested systems.

This report includes the main findings of my master's thesis. Copies of the thesis (with the complete data set included in appendices) are on file at the University of Vermont library and at the VMC headquarters.

INTRODUCTION

Mercury (Hg) contamination in freshwater fish is a widespread environmental problem throughout the northern hemisphere. Atmospheric sources of Hg are thought to be responsible for increasing Hg burdens in Lake Champlain (Watzin, 1992; Scherbatskoy *et al.*, 1997) but the sources and mechanisms of transport and accumulation are not well understood. Because of the large land-to-lake area ratio of the Lake Champlain basin (19:1), with 64% of the land area forested (unpublished data, Vermont Center for Geographic Information, October 1998), the presence of Hg in forest soils likely influences the loading of Hg to the surface waters that drain into Lake Champlain.

Mercury in forest soils is strongly bound to soil constituents or revolatilized into the atmosphere. In a small forested catchment in Underhill Center, VT, dissolved Hg concentrations in stream water are consistently low (< 4 ng L^{-1}), but accounted for 26 and 38% of the total Hg exported in the stream during two years of study (Scherbatskoy *et al.*, 1998). Although Hg has also been shown to be primarily associated with suspended sediment in rivers and streams (Kolka, 1996; Balogh *et al.*, 1997; Scherbatskoy *et al.*, 1998), the small percentage of Hg mobilized from soils to streams may contribute 25–75% of Hg reaching lakes (Lee *et al.*, 1994).

The objectives of this work were to: (i) determine the concentrations of Hg, dissolved organic carbon (DOC), and several trace metals in soil and stream solutions in two small catchments in the Lake Champlain basin, (ii) compare the behavior of Hg with DOC and trace metals in these media, and (iii) use the results to identify factors that might affect the transport of dissolved Hg in an upland catchment.

Materials and Methods

SITE CHARACTERISTICS

This study focuses on two small catchments on the western slope of Mt. Mansfield in Underhill Center, VT (Figure 1). The sites are centrally located in the Lake Champlain basin, approximately 31 km northeast of Burlington, VT and 120 km south-southeast of Montréal, PQ. Both sites lie within the Lamoille River watershed. Nettle Brook is a small stream draining an 11-ha mixed hardwoods catchment between 445 and 664 m elevation. Since October 1993, water samples have been collected for Hg and major ions at a continuously gauged v-notch weir at 445 m elevation. Stream 10 is a small stream draining a 7.4-ha mixed conifer and hardwoods catchment between 775 and 1180 m elevation. Water samples have been collected here since March 1995.

FIELD SAMPLING TECHNIQUES

Passive capillary wick soil water samplers were custom made based on designs described in Holder *et al.* (1991); Knutson *et al.* (1993); and Knutson and Selker (1996), and shown in Donlon (1999). Two shallow collectors (just below the Oa horizon, 4–7 cm below ground surface) and two deep collectors (below the Bhs or within the B horizon, 22–28 cm below ground surface) were installed at each of two sampling locations along Nettle Brook (Middle and Upper sites shown on Figure 1). At the Stream 10 site, it was only possible to install one lysimeter at each depth because of rock obstructions and seasonal time constraints. A total of 10 lysimeters were installed between 26 September and 18 December 1996.

Soil solution and stream samples were collected during spring snowmelt and major rain events between 20 April and 3 November 1997. Bottles for collecting soil solution were set out just prior to each storm event and were collected when the bottle was full or after precipitation ended. Grab samples of stream water were collected during storms near the three soil water sites and at the Nettle Brook weir (Figure 1), with an attempt to collect successive samples during the storm as stream flow increased, crested, and descended. Typically it was only possible to sample once before and once after stream flow peaked.

Soil samples were also collected in December 1997 at each soil water sampling site within a 10 m vicinity of the lysimeters. Soil samples were collected at two depths (4–7 cm and 22–28 cm, or the same horizons where the lysimeters were placed) using a soil corer. Soil that did not come in contact with the corer was collected into acid-cleaned polypropylene vials.

Clean technique was used in handling all samples: all equipment and supplies used in sampling were rigorously acid-cleaned in a 4 or 11 day cycle (Burke *et al.*, 1995); sample bottles were Teflon-taped and triple-bagged; and particle-free gloves were worn when handling the samples.

SAMPLE PROCESSING

Upon collection, samples were brought to Proctor Maple Research Center (PMRC) in Underhill Center, VT. Subsamples were poured off inside a portable counter-top HEPA-filtered clean chamber for analysis of pH, conductivity, DOC, color, and major ions. Samples for Hg and trace metals analyses were shipped by overnight courier to the University of Michigan Air Quality Laboratory (UMAQL) in Ann Arbor, MI where they were oxidized with BrCl to a 1% solution and refrigerated until analysis. Subsamples of those samples with sufficient volume were filtered before oxidation through 0.22-µm nitrocellulose filters (Millipore MF) to separate operationally-defined dissolved and particulate fractions. This size filter was chosen to maximize discrimination between dissolved Hg and Hg associated with particles.

Subsamples retained at PMRC were analyzed for pH (Orion EA920) and conductivity (VWR Scientific EC 2052), and then filtered using a 0.7-µm glass fiber syringe filter (Whatman 13-mm ZC GF/F). This size filter was chosen because it is the smallest glass fiber syringe filter available. Filtered water samples were refrigerated until analysis for DOC, color, and major ions.

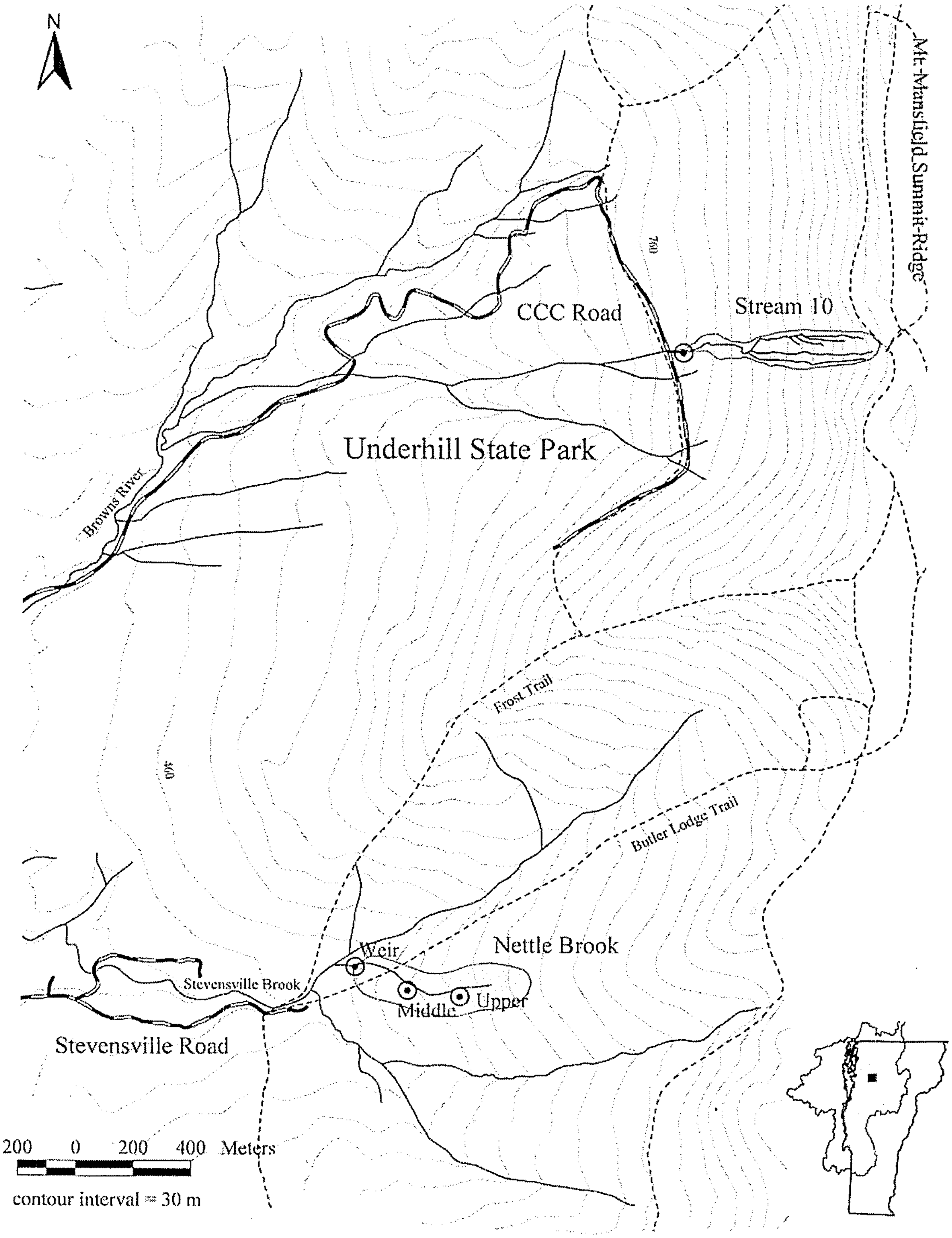

Figure I. Site map. Circles indicate soil water and stream sampling locations. Inset shows the location of the study sites within the boundaries ofVermont and the Lake Champlain basin.

Soil samples were shipped to UMAQL where they were dried, ground with acid-cleaned glass mortars and pestles, and microwave digested with 10% HNO_3 as described in Rea and Keeler (1998).

LABORATORY ANALYSIS

All Hg analysis was performed at the UMAQL in a Class 100 clean room using cold vapor atomic fluorescence spectrometry (CVAFS). Trace metal analysis at UMAQL was conducted on a Perkin-Elmer Elan 5000A inductively coupled plasma-mass spectrometer (ICP-MS) equipped with a thin film electron multiplier. The elements that were analyzed on this machine include Li, Be, Mg, Al, Ti, V, Cr, Mn, Co, Ni, Cu, Zn, As, Rb, Sr, Cd, Ba, La, Ce, Nd, Sm, Tl, and Pb. The full set of analytical results is presented in Donlon (1999).

DOC was determined by ultraviolet persulfate oxidation with infrared detection at the USGS laboratory in Albany, New York using a Dohrman C analyzer. Color was analyzed on a UV-visible recording spectrophotometer (Shimadzu UV160U) at the University of Vermont School of Natural Resources. Absorbence at 420 nm was compared against a standard curve using platinum cobalt (Pt Co) solutions (Fischer SP120-500) (Black and Christman, 1963).

Major elements and ions (Ca, K, Mg, Na, S, Si, P, NH_4^+, Cl^-, NO_3^-, PO_4^{3-}, and SO_4^{2-}) were analyzed following standard methods at the University of Vermont Agricultural and Environmental Testing Laboratory. A Perkin-Elmer Optima DV inductively coupled plasma atomic emission spectrophotometer (ICP-AES) was used to measure concentrations of elements. Nitrate and ammonium were determined by colorimetric analysis on a Lachat QuikChem AE flow injection analyzer. Chloride, phosphate, and sulfate were measured by chemically suppressed ion chromatography using a Dionex 2000 series instrument. In addition to the water samples, soil samples collected from the study sites were analyzed for C, H, and N. These samples were analyzed using an Exeter Analytical CE440 CHN elemental analyzer.

RESULTS

SOILS

Two soil samples were collected at two depths at each of the three study sites. Results from two samples (Oa depth at the Upper Nettle and Stream 10 sites) are not available because of possible contamination in one of the samples and laboratory error in the other. Because of the small number of samples collected, the data give only a general idea of the level of Hg in soils at the sites. The average Hg concentrations at the Oa horizon (4–7 cm below ground surface) were 151.0, 309.4, and 169.0 ng g^{-1} (dry weight) at mid Nettle, upper Nettle, and Stream 10, respectively. Oa soils at these sites contained 11–18% carbon. The average Hg concentrations at the B horizon (22–28 cm below ground surface) were 68.9, 46.6, and 74.7 ng g^{-1} (dry weight) at the three sites, respectively. B horizon soils at these sites contained 1.4–3.7% carbon. Figure 2 presents Hg and DOC concentrations in soil, soil water, and stream water by site.

At all sites, Hg concentrations in soil were higher in the Oa horizon than in the B horizon. Other trace metals that followed this trend include As, Ba, Cd, and Pb. Several other trace metals followed the opposite trend, with higher concentrations in the B horizon, including Al, Ce, Cr, La, Mg, Mn, Ni, and Zn.

SOIL WATER

Soil water was collected during one spring snowmelt event and eight summer and fall rainstorms between 20 April and 3 November 1997 at the Nettle Brook sites, and during six summer and fall rainstorms at the Stream 10 site. Concentrations of Hg were significantly higher in Oa horizon soil water than in B horizon water at all three sites. DOC and color were also higher in the Oa horizon soil water, but significance varied by site.

Mercury, DOC, and color was significantly lower at the upper Nettle site than the other sites at both depths. The upper Nettle site is located on a wet hillslope.

Soil water pH at all sites was lower in the Oa horizon, but the difference was only statistically significant at the mid Nettle site. Soil water pH at the Stream 10 site was significantly lower than the Nettle sites at both depths. Stream 10 is the site at highest elevation.

Mercury in Oa horizon soil water was positively correlated with DOC and color at all three sites ($r^2 = .81–.98$, $p = .03–.0002$ at individual sites). In B horizon water, the positive correlation between Hg and DOC or color was not as strong but sample sizes were smaller. Hg in soil water was most consistently correlated with DOC and color but also tended to be positively correlated with As, Cu, Pb, Ti, and rare earth metals (Ce, La, Sm), and negatively correlated with K, Na, Rb, and NO_3.

Most trace metals followed the pattern of higher concentrations in Oa horizon soil water than in B horizon water. However, no trace metals were analyzed in B horizon water at the mid Nettle site because of insufficient sample volumes collected at this depth. At the Stream 10 site, several trace metals and ions followed the opposite trend and were present in higher concentrations in B horizon soil waters, including Ca, Cr, Mg, Mn, Na, Si, SO_4, and Zn.

STREAM WATER

Stream samples were collected near the three soil water sampling sites and at the Nettle Brook weir during rain events when soil water was collected. There were no statistically significant differences in the total Hg, dissolved Hg, and DOC concentrations between sites. Color at the upper Nettle location was significantly higher than at Stream 10 ($F = 4.25, p = .0096$). The upper Nettle site is directly downstream from a boggy area. Stream pH was significantly higher at the lowest elevation site (Nettle weir) and significantly lower at the highest elevation site (Stream 10) ($F = 335.47, p = .0001$).

Total and dissolved Hg were positively correlated with DOC and color at all sites ($r^2 = .51–.96$, $p = .09–.001$ for each site). Total and dissolved Hg were also positively correlated with Al, As, Cu, Cr, Ni, Pb, Ti, V, rare earth metals (Ce, La, Nd, Sm), and stream temperature. Mercury tended to be negatively correlated with Cl, Na, and SO_4.

Concentrations of most analytes were higher in soil water than in stream water. Exceptions to this trend occurred at Stream 10 (for Cu, La, Mn, Ce) and at the upper Nettle Brook site (for As, Ba, Mn), where stream concentrations of these elements exceeded soil water concentrations by 6 to 60%. Mercury and V in stream water were roughly equal to that of soil water at the upper Nettle site. The upper Nettle site is on a wet hillslope with many seeps.

At the Nettle Brook weir, where flow rate was continually measured, total Hg (particulate + dissolved) and most other trace metal concentrations increased as flow increased. Dissolved Hg concentrations, on the other hand, only slightly increased as flow increased. This was also true for Cu, but dissolved Al, Nd, and Pb increased as flow increased. Concentrations of dissolved Ca, Mg, Si, and SO_4 became diluted as flow increased, which is a typical pattern for groundwater-derived chemicals. At lower flow conditions, Hg had a higher dissolved proportion than most trace metals but as flow increased, more and more Hg was associated with particles. Although other trace metals such as Al, Cu, Ce, and Pb also followed this pattern, it is notable that Hg and Ti (a crustal element) show the strongest decrease with flow.

DISCUSSION

In soils, Hg had higher concentrations in the Oa horizon than in the B horizon, as did As, Ba, Cd, and Pb. These elements have atmospheric sources, and their prevalence in the Oa horizon probably reflects accumulation resulting from atmospheric deposition, as byproducts from fuel combustion, metal smelting, and other uses (Nriagu and Pacyna, 1988). Barium has recently been proposed to be a good indicator of unleaded gasoline and diesel oil

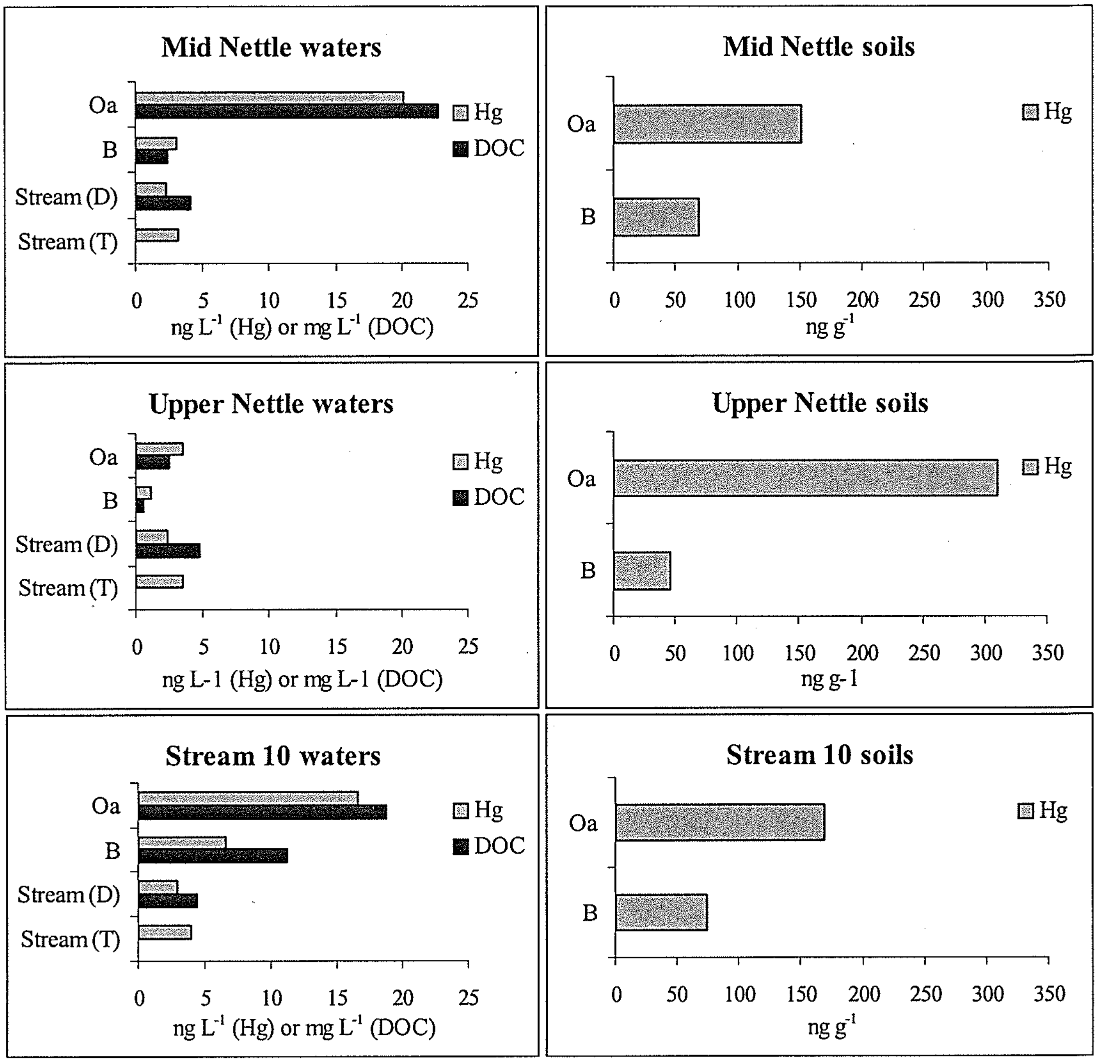

Figure 2. Mercury and DOC concentrations in soil water, stream water, and soils collected between April and November, 1997 in Underhill Center, VT.

emissions (Monaci and Bargagli, 1997). The elements Al, Ce, Cr, La, Mg, Mn, Ni, and Zn, had higher concentrations in the B horizon. These elements have a crustal origin, and are likely present as products of bedrock weathering, although Cr, Mn, Ni, and Zn can also have atmospheric sources (Driscoll *et al.*, 1988; Nriagu and Pacyna, 1988).

Soils are a net sink for atmospherically deposited Hg. Using the Hg input–output balance at Nettle Brook presented by Scherbatskoy *et al.* (1998) and a re-volatilization rate of 90 mg ha^{-1} yr^{-1} (in Sweden; Bishop *et al.*, 1998), it is likely that Hg is accumulating in catchment soils.

The observed pattern of higher Hg (or other trace metals) and DOC in Oa horizon soil water than B horizon soil water has been noted in part by others (McDowell and Wood, 1984; Bergkvist, 1987; Driscoll *et al.*, 1988; Lazerte *et al.*, 1989; David *et al.*, 1992; Bishop *et al.*, 1995). These analytes also tended to have higher soil water concentrations than stream water concentrations, indicating that additional adsorption of these ions and metals occurs as water percolates downward and discharges into the streams as groundwater. Removal of DOC and trace metals in the upper part of the B horizon is a part of natural soil formation (Bergkvist, 1987; Cantrell, 1989). The relatively high Hg concentrations that were found in Oa horizon soil water represents Hg that will largely be retained in the catchment, attached to soil or re-volatilized to the atmosphere.

At the Nettle Brook weir, flow-related increases in total stream water concentrations of Hg and also Li, Al, Ti, Mn, Co, Cu, Zn, Cd, La, Ce, Nd, Sm, and Pb were observed during the study. The majority of Hg transport occurs during the highest flow events, particularly during years of significant and rapid snowmelt (Scherbatskoy *et al.*, 1998). Release of Hg in rivers and stream water during increased flow events has been shown to be related to sediment transport (Balogh *et al.*, 1997; Scherbatskoy *et al.*, 1998). Dissolved stream water concentrations at the Nettle Brook weir were not as sensitive to stream flow rate as the total (dissolved + particulate) concentrations were. As observed in previous years of study (Scherbatskoy *et al.*, 1998), dissolved Hg concentrations only slightly increased with increased flow. The pattern of Hg as a function of stream flow points towards stream flow rates and the amount of suspended sediment as being critical to the behavior of Hg.

Based on the concentrations of Hg we observed in Oa soils and soil water, an event that causes a rise in the water table high enough to direct flow from the upper soil horizons to streams should cause more Hg and DOC to be exported to streams. However, we have never observed a dramatic increase in dissolved Hg at Nettle Brook. Instead, dissolved Hg represents a small but steady input to Nettle Brook. Why doesn't dissolved Hg seem to behave like DOC or dissolved Al, Zn, Cd, or Pb at Nettle Brook, which do increase with increased flow? It is possible that dissolved Hg coming from soil water or other sources during storms is quickly adsorbed by suspended organic particulate matter upon entry into the stream. Adsorption could occur immediately or in the sample bottle before analysis. The order of affinity to organic compounds ($Hg^{2+} > Cu^{2+} > Pb^{2+} > Zn^{2+} > Ni^{2+} > Co^{2+} = Cd^{2+} > Mn^{2+}$ (Cheam and Gamble, 1974; Förstner and Wittman, 1981; Takamatsu *et al.*, 1983) might support these hypotheses, especially because dissolved Cu also did not increase much with flow. Mercury's relationship with reduced S functional groups on organic compounds (Xia *et al.*, 1999) might make adsorption onto suspended sediment more favorable for Hg-organic complexes than for complexes with other metals in uncontaminated waters.

Given that Hg is primarily exported in association with particulate matter in forest streams, land use practices that minimize soil erosion into streams (such as during logging) will also serve to limit transport of Hg to surface waters and ultimately to Lake Champlain. The fate of this Hg as it travels downstream towards Lake Champlain through agricultural and developed lands has not yet been explored. Much of the particulate phase Hg in upland watersheds may be re-deposited further downstream. Ultimately the Hg present in dissolved form may be enough to account for the Hg entering the food web in Lake Champlain, but no research has yet been done to look at the cycling of Hg in this lake and its watershed.

ACKNOWLEDGMENTS

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Streamflow and water quality monitoring West slope of Mt. Mansfield

1998 Annual Report

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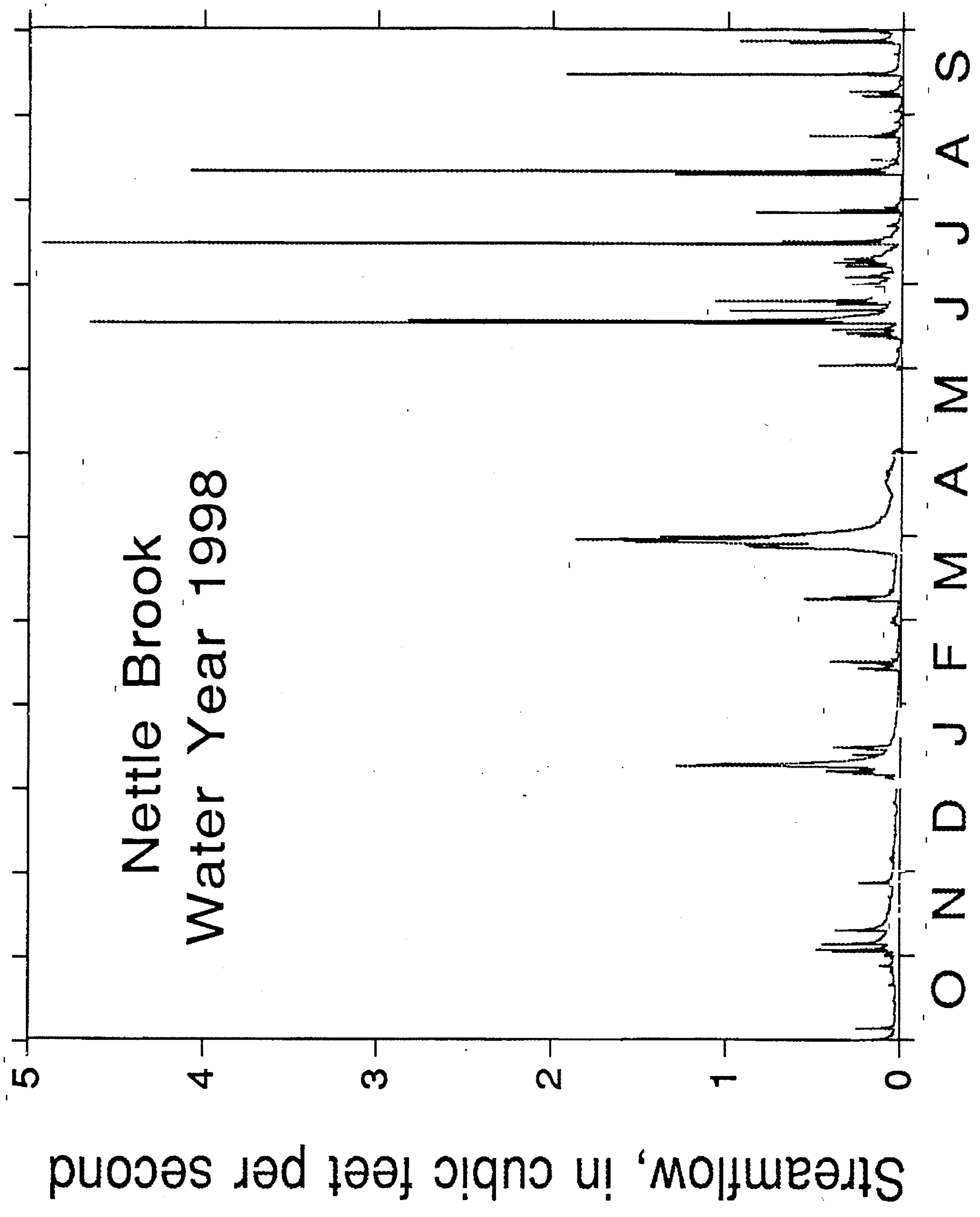
The USGS, in collaboration with the VMC, established a stream gage at Nettle Brook on the west slope of Mt. Mansfield in September 1993. A 90-degree V-notch weir was installed in the stream channel. Water levels are tracked by a float in a stilling well in hydraulic contact with the pool behind the weir. 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 1998 water year (October 1997 through September 1998) was wetter than average in northern Vermont, particularly in the summer of 1998. In the fall (of 1997), a dry October and December were balanced by a wet November. A significant thaw came (uncharactersistically) early in January, followed by minor thaws in mid-February and early March. Record heat in late March melted a large portion of the snowpack, leading to near record levels on Lake Champlain and a somewhat damped but respectable peak flow at the elevation of Nettle Brook. The low snowpack and light precipitation led to well below average flow in April and May. This situation reversed markedly in June. The summer of 1998 was very wet, with many storms and several very high flow events. This pattern continued through the end of September.

There was little demand for editing of the streamflow data in water year 1998 as there were no active water quality monitoring projects. However, the data appear to be largely free of major artifacts from ice and debris.


Nettle Brook
Water Year 1998
Streamflow, in cubic feet per second
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1
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3
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Terrestrial Fuana

Amphibian Monitoring on Mt. Mansfield, Vermont
1993-1998

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Update, February 1999

Background

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 and 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. Six 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 five times per month during rain events throughout the field season (April through October excluding August). The abundance indices are generated using the three most successful trap-nights per month. For more detailed information on methods, locations of fences, and survey results, see the 1995 VForEM annual report.

Changes in species composition

Table 1 summarizes 1998 captures for all species. Two species were caught at the fences this year that were not caught last year: Dusky salamander and Gray treefrog. Dusky salamanders have been caught at the fences in previous years but never as many as were caught this year (10). Dusky salamanders usually confine their movements to the thoroughly saturated soils of seeps, springs, and edges of brooks. The fences at this site were located to intercept the movements of species that travel through better-drained upland forests. I suspect that the increase in the number of this species caught is the result of very wet soil conditions which facilitated their movement from seeps near the fences, rather than an increase in the size of the population at this site. The Gray treefrog is a species that we have located in previous surveys of this site, but it rarely gets caught due to its excellent climbing ability.

The Redback salamander increased from 49% of the salamander population in 1997 to 63% of the population in 1998. This is a result of its apparent population increase. Similarly the American toad increased from 22% of the frog population last year to 35% of the population this year. This is not only the result of an increase in the number of toads, but also a concurrent decrease in the number of Wood frogs.

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 1998. Traps were opened whenever conditions were appropriate for amphibian movement from April through October excluding August. Data used are from the three most successful trappings per month (ρ 7 days): March 31, April 17, and May 2; May 3, 7, and 21; May 30, June 13, and June 17; July 17, 24, 31; September 13, 15, and 29; and October 8, 11, and 29. Data from 18 of 31 trap-efforts are used. Trapping on March 31 was possible at the lower two drift-fences only. Malformity, maximum size, and first metamorph data are taken from all 31 trappings.

Common name	**Scientific 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**	**# malformed/ total[4]**
Salamanders										
Redback salamander	*Plethodon cinereus*	97	1	1%	Oct. 29	90	5.4	63%	29%	0/103
Eastern newt	*Notophthalmus viridescens*	24	0	0%	NA	90	1.3	15%	7%	0/27
Spotted salamander	*Ambystoma maculatum*	21	4	19%	Sept. 8	184	1.2	14%	6%	1/26
Dusky salamander	*Desmognathus fuscus*	10	0	0%	NA	99	0.6	6%	3%	0/11
Northern two-lined	*Eurycea bislineata*	3	0	0%	NA	90	0.2	2%	1%	0/6
Group totals		155	5	3%	---	---	8.6	100%	46%	1/173
Frogs and Toads										
Wood frog	*Rana sylvatica*	84	27	32%	July 17	58	4.7	46%	25%	1/107
American toad	*Bufo americanus*	64	12	19%	July 31	79	3.6	35%	19%	2/70
Spring peeper	*Pseudacris crucifer*	19	0	0%	NA	37	1.1	10%	6%	0/25
Green frog	*Rana clamitans*	14	9	64%	June 26	59	0.8	8%	4%	1/17
Gray treefrog	*Hyla versicolor*	1	0	0%	NA	NA	0.1	1%	<1%	0/1
Group totals		182	48	26%	---	---	10.1	100%	54%	4/220
Amphibian totals		337	53	16%	---	---	18.7	---	100%	5/393

[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), *D. fuscus* (30 mm), *E. bislineata* (60 mm), *N. viridescens* (45 mm), *P. cinereus* (32 mm), *B. americanus* (32 mm), *H. versicolor* (26 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] These may contain old deformities (traumatic) as well as malformities (developmental). Salamanders missing all or portions of their tails are not included. The total number checked may contain specimens that were caught more than once.

Young of the year and malformities

Table 1 also summarizes young of the year and malformity data. Although the number of young of the year was not radically different from the previous year, the number of malformities reported is quite different. Not a single malformed amphibian had been caught in any of the fences at this site since 1993, although a deformed Wood frog was caught by hand near one of the fences in 1994. This year, five of a total of 393 amphibians caught (~1.3%) had an external malformity of some sort. Four species were represented: American toad (2), Wood frog (1), Spotted salamander (1), and Green frog (1). Three of the five malformed individuals were young of the year. It should be noted that the sample size of young of the year amphibians is quite small for each species. Three of a combined total of 53 young of the year amphibians were malformed (3/53= 5.7%). This is not an alarming percentage, but the apparent increase is of interest. It is possible that this year's technicians did a more thorough job of checking than was done in previous years. At this point the apparent increase in malformities at this site is only a curiosity, but it should be monitored carefully in future years.

Trends

Table 2 shows abundance indices for all the species caught from 1993 to 1998. Linear regressions most closely fit most of the data plots, so they were used to show potential trends. Last year the data gathered suggested that seven of the eight species abundant enough to monitor had shown an average increase over the previous five years: American toad, Green frog, Pickerel frog, Wood frog, Eastern newt, Redback salamander, and Spotted salamander. This year's data show that two of these species were caught in greater numbers this year than last: American toad and Redback salamander. Fewer Green frogs, Red efts, and Wood frogs, were caught this year than last, but a linear regression run on the six-years of data continues to suggest positive increases for all of them. Although Pickerel frog was never caught frequently, it had appeared to be on the increase. It disappeared entirely from the fences this year. The Spotted salamander that had appeared to be on the increase through 1997 was caught in low enough numbers in 1998 to reverse its apparent trend. Spring peeper was the only species whose numbers had dropped over the five-year period ending last year. This year we caught more of them but not enough to reverse the trend of the last five years.

Table 3 shows selected statistics generated from the last six years of data, including statistics on the reliability of the apparent trends. The likelihood that an apparent trend reflects a true trend in population numbers is referred to as power. Statistically it is defined as the likelihood of correctly rejecting the null hypothesis (no trend). My goal is to achieve a power of 90% or greater. The powers of these data sets are dependent upon a number of variables: the length of the series of data gathering units (at this point six years), the number of times per year data are gathered (12-18), the number of locations from which data are gathered (in this case one, because although three fences are used, the data are combined), the variability of the data collected (differs for each species), the starting value of the abundance indices (differs for each species), the direction of the trend to be evaluated, how small a trend I hope to be able to detect (5% annually), and what statistical level of significance is acceptable: alpha = 0.10 (10% chance of incorrectly rejecting the null hypothesis). Trends that meet the 90% power criteria are bold faced and marked with an asterisk in the column at the far right of Table 3. All others are left in plain text without an asterisk. The power figures shown were generated using the Monitor.exe shareware program written by James P. Gibbs and available on the National Biological Survey's Inventory and Monitoring website (http://www.mp1-pwrc.usgs.gov/powcase.html). Also available through this site is a more extended discussion of power and the rationale for the power and alpha values used here.

Table 2. A comparison of drift-fence data from the 1993 through 1998 field seasons at Mt. Mansfield, Underhill, Vermont. Data used are from two fences at 1,200 ft. and one fence at 2,200 ft. in elevation.

Species name	**# per trapping**[1]						**% of total catch**					
	93	94	95	96	97	98	93	94	95	96	97	98
Caudates (Salamanders)												
Spotted salamander	1.7	1.0	1.4	2.0	1.4	1.2	12%	10%	9%	12%	8%	6%
Dusky salamander	0.3	0.3	0.3	0.0	0.0	0.6	2%	3%	2%	0%	0%	3%
N. two-lined salamander	0.5	0.1	0.2	0.1	0.2	0.2	4%	1%	1%	1%	1%	1%
Spring salamander	< 0.1	0.0	0.0	0.1	0.0	0.0	< 1%	0%	0%	< 1%	0%	0%
Eastern newt	1.3	1.2	1.7	1.4	1.8	1.3	10%	12%	11%	8%	10%	7%
Redback salamander	1.2	4.2	1.3	2.5	3.3	5.4	9%	40%	9%	14%	18%	29%
Group totals	5.1	6.8	4.9	6.1	6.8	8.6	38%	66%	32%	36%	37%	46%
Anurans (Frogs and Toads)												
American toad	0.7	0.6	1.5	2.2	2.5	3.6	5%	5%	10%	13%	14%	19%
Gray treefrog	0.0	0.0	0.0	0.0	0.0	0.1	0%	0%	0%	0%	0%	< 1%
Spring peeper	1.7	1.1	2.2	0.9	0.3	1.1	13%	10%	14%	5%	2%	6%
Green frog	< 0.1	0.2	0.9	0.6	1.3	0.8	< 1%	2%	6%	3%	7%	4%
Pickerel frog	0.1	0.0	1.1	0.3	0.3	0.0	1%	0%	7%	2%	1%	0%
Wood frog	5.6	1.7	4.4	6.8	7.0	4.7	42%	16%	29%	40%	39%	25%
Group totals	8.2	3.6	10.1	10.8	11.3	10.1	62%	33%	66%	64%	63%	54%
Amphibian totals	13.4	10.4	15.0	16.8	18.1	18.7	100%	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, 12 in 1997, and 18 in 1998. Trappings counted were on those nights when at least two of the three traps were opened under appropriate weather conditions for amphibian movement.

Table 3. Statistical analyses of the Mt. Mansfield drift-fence data from 1993 through 1998. Percentages in bold type with asterisks are generated with a power greater than 90%.

Species name	**# per trapping[1]**						**Statistics[2], power[3], and trends[4]**						
	93	**94**	**95**	**96**	**97**	**98**	**SD**	**Mean**	**CV**	**P 6 yrs.**	**P 10 yrs.**	**Ann. ?**	**? %**
Caudates (Salamanders)													
Spotted salamander	1.7	1.0	1.4	2.0	1.4	1.2	0.36	1.45	0.25	0.98	1.00	-0.02	-1%
Dusky salamander	0.3	0.3	0.3	0.0	0.0	0.6	0.23	0.25	0.92	0.23	0.55	---	---
N. two-lined salamander	0.5	0.1	0.2	0.1	0.2	0.2	0.15	0.22	0.68	0.86	1.00	-0.04	**-12%***
Spring salamander	< 0.1	0.0	0.0	0.1	0.0	0.0	---	---	---	---	---	---	---
Eastern newt	1.3	1.2	1.7	1.4	1.8	1.3	0.24	1.45	0.17	1.00	1.00	+0.04	**+3%***
Redback salamander	1.2	4.2	1.3	2.5	3.3	5.4	1.65	2.98	0.55	0.16	0.28	+0.55	+36%
Group totals	5.1	6.8	4.9	6.1	6.8	8.6	1.36	6.38	0.21	0.98	1.00	+0.53	**+11%***
Anurans (Frogs and Toads)													
American toad	0.7	0.6	1.5	2.2	2.5	3.6	0.31	1.85	0.17	0.57	0.94	+0.60	**+167%***
Gray treefrog	0.0	0.0	0.0	0.0	0.0	0.1	---	---	---	---	---	---	---
Spring peeper	1.7	1.1	2.2	0.9	0.3	1.1	0.66	1.22	0.54	0.63	0.98	-0.19	**-11%***
Green frog	< 0.1	0.2	0.9	0.6	1.3	0.8	0.43	0.65	0.66	---	0.14	+0.19	+100%
Pickerel frog	0.1	0.0	1.1	0.3	0.3	0.0	0.41	0.30	1.37	---	0.10	---	---
Wood frog	5.6	1.7	4.4	6.8	7.0	4.7	1.95	5.03	0.39	0.70	1.00	+0.39	**+10%***
Group totals	8.2	3.6	10.1	10.8	11.3	10.1	2.85	9.02	0.32	0.71	1.00	+0.95	**+14%***
Amphibian totals	13.4	10.4	15.0	16.8	18.1	18.7	3.14	15.40	0.20	0.95	1.00	+1.47	**+13%***

[1] Number per trapping are rounded to the nearest 0.1. There were a total of 15 trappings counted in 1993, 14 in 1994, 18 in 1995, 17 in 1996, 12 in 1997, and 18 in 1998. Trappings counted were on those nights when at least two of the three traps were opened under appropriate weather conditions for amphibian movement.

[2] Standard deviation and coefficient of variation are generated from the data shown except for American toad. For American toad the standard deviation is generated from the residuals of a linear regression. For American toad only the standard deviation of the residuals is then used to generate the coefficient of variation.

[3] Power is determined through the use of the Monitor.exe freeware program using linear regressions (with an alpha of 0.10). The power shown is the power to detect a 5% annual decline with either six or ten years of data.

[4] Trends are taken from a linear regression. Annual change is shown in individuals per trap-night. Percentage of change is based on the percent of the starting population and rounded to the nearest whole number.

Standard deviation and coefficient of variation

The standard deviation of the means of the annual counts varies from a low of 0.15 for Northern two-lined salamanders to a high of 1.65 and 1.95 for Redback salamanders and Wood frogs respectively. Part of this difference is the result of the size of the indices generated (number caught). Consequently it is desirable to use a statistic that takes the mean number caught into consideration. The coefficient of variation (CV) does this. It is defined as the standard deviation divided by the mean. Given the data generated at Mt. Mansfield so far, the species that are the easiest to reliably monitor at these three fences (lowest CVs) are the Eastern newt (0.17), Spotted salamander (0.25), and Wood frog (0.39). The American toad also had a very low CV (0.17), but it was generated differently. In its case the standard deviation was generated by the residuals of a linear regression since it was showing such a large and steady annual increase in the numbers caught. Those species which are caught in very low numbers with an occasional spike showed a very high coefficient of variation: Dusky salamander (0.92) and Pickerel frog (1.37). These two species are therefore hard to monitor with any sensitivity at these fences.

Salamanders

Since most data plots most closely fit a linear regression, the average annual percent change for each species or group is based on a percentage of the starting index. The apparent decreasing trend (-1%) in Spotted salamander numbers shown over the last six years (Figure 1) is so small that I can not say with confidence that any trend actually exists, despite the relatively high power to show trends with this species. The Redback salamander index shows an apparent annual increase of 36% over the past six years. However, due to a very low starting index, the power to reliably detect a 10% annual increase is very weak, and the power to detect larger annual increases is not generated by the Monitor.exe program. Therefore, it is unclear how powerful the data are for this species. If the 1993 data are ignored and only the last five years of data are considered, a linear regression shows a 10% annual increase starting from a large enough population to generate a power greater than 90%. Although the Northern two-lined salamander index shows a 12% annual decrease within the limits of power designated (90%), it is based on such low annual catches that I am skeptical of its reliability. Figure 2 shows how much this apparent trend is influenced by the very high numbers caught in the first year of monitoring. I have more confidence in the 3% annual increase in the Eastern newt (Figure 3) and the 11% increase in salamanders overall (not graphed). No trends are listed in Table 3 for either Dusky or Spring salamander. Since they frequent other microhabitat types, neither of these species has been caught often enough to reliably monitor.

Frogs

Clearly I started monitoring at a low point in the American toad population at this site (Figure 4). The 167% annual increase in the index for this species fits a linear regression very well, $R^2 = .943$. The power of these data to detect any increase over 9% annually is 100 percent. It should be kept in mind that this increase is such a large percentage because it is based on a very small starting population. Still, it is the clearest and most impressive trend of all the species monitored. Although the trend of an 11% annual decline in Spring peepers is reliable, this species showed a large increase in 1998 (Figure 5), and the six-year decline could quickly disappear if capture numbers continue to increase at the same annual rate another year. The reverse is true for Wood frogs (Figure 5). Although their index has shown a 10% average annual increase over the past six years, it dropped precipitously in 1998, and another year of decline could easily even out the six-year trend. Although the graph for Green frogs suggests a pretty clear trend (Figure 3), the low starting population weakens the power to an unacceptable level this year. No trends are listed in Table

3 for either Gray treefrog or Pickerel frog. Due to their climbing ability it is unlikely that Gray treefrogs will ever be caught often enough to monitor. Pickerel frogs, however, are easily caught in the fences and once generated the relatively high index of 1.1 in 1995. Their erratic numbers at these fences generates such a high CV that at present no reliable trends can be shown. The indices for all frogs combined and all amphibians combined (not graphed) show an average annual increase over the last six years of 14% and 13% respectively.

Summary

The majority of amphibian species which can be reliably monitored at these fences at this time appear to be increasing in population. American toad shows the largest and most consistent increase. The apparent declines of two species (N. two-lined salamander and Spring peeper) are not yet convincing and would appear to be easily reversed. Pickerel frog disappeared entirely from the fences for the second time in six years. An apparent increase in the number of malformities needs to be watched. The statistical power of the data gathered over the past six years has been evaluated for the first time and shows that the data for six species and both species groups has reached acceptable power goals already. Each additional year of monitoring adds additional power to the evaluation of trends, as well as generating a great deal of other information such as average and maximum sizes, types and percentages of malformities, seasons of activity, and timing of metamorphosis which can then be added to the Vermont Reptile and Amphibian Database. Next year it will be very interesting to see whether Pickerel frog has reappeared, at what rate malformities continue to be found, and whether the apparent trends in these species continue.

Acknowledgments

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Amphibian Monitoring in the Lye Brook Wilderness Region of the Green Mountain National Forest
April - October 1998

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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 abnormalities, (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. Five 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 the 1995 VMC annual report.

Stream surveys and egg-mass counts

The stream surveys showed a decreasing pH until this year when the pH was much higher (5.0 compared with 3.8 in 1997, Table 1). However, the pH meter used to take this reading was malfunctioning at the time of the stream survey, so the field technicians returned three weeks after the survey to re-take the pH. In addition, only one measurement was taken, limiting the reliability of the reading. The numbers of Spring salamanders were up slightly from last year, and Two-lined salamanders held relatively constant. The egg-mass counts showed no clear trends in populations of Wood frogs or Spotted salamanders but numbers for two of the three sites were up compared to 1997 (Table 2). The previously noted decline in pH seems to have stopped in 1998 with all three sites showing a higher pH than in 1997. Again, however, these readings may not be reliable, as this was the same pH meter that was malfunctioning later in the year.

Upper drift-fences

Four 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 abundance of each species is still maintained (Tables 3 and 4). The Eastern newt continues to be the most frequently caught salamander, followed in order by the Spotted salamander, Redback salamander and Northern two-lined salamander. Spotted and Redback Salamander populations do not show any clear trends at this time (Figure 1). The fences are not in appropriate habitat to accurately monitor the populations of Northern two-lined salamanders, so it is possible that the apparent decline at the upper fences (Figure 2) is not reflective of population trends. Eastern newts appear to be declining at the upper fences (Figure 3), showing the lowest numbers ever in 1998.

Wood frogs continue to be the most frequently caught frog, followed by Green frog, Spring peeper, and American toad. American toads seem to be declining at the upper two fences, with the number of individuals caught per trapping dropping each year (Figure 4). 1998 showed the lowest number yet (1.1 per trapping), at approximately one-quarter of 1995's average number caught per trapping (4.3). This trend, however, is a local phenomenon; at the lower fence, American toads are holding relatively steady (Figure 5), and at drift-fences on Mt. Mansfield in northern Vermont, American toads show an increase in numbers. The Pickerel frog appeared at the upper fences for the first time in 1998. Wood Frogs have increased over the past three years at the upper fences (Figure 6), but this also appears to be a local phenomenon, as the lower fence shows no such increase (Figure 7).

Lower drift-fence

At the lower drift-fence there were very few young of the year caught (8% of the amphibian catch). This number was lower than the young of the year caught last year or the year before (26% and 36% of the amphibian catch, respectively). Redback salamander numbers more than quadrupled (Figure 8) and were again the most abundant species followed by the Eastern newt (Tables 5 and 6). The number of newts has dropped sharply at the lower fence, like at the upper fences (Figure 9). There appears to be a decline in this species at all of the Lye Brook fences. However, this is probably a local phenomenon; at drift-fences on Mt. Mansfield, newts are holding steady.

In 1998 there was a decline (by half to three-quarters) in the numbers of all frog species (Spring Peeper, Pickerel Frog, and Wood Frog) except Green frogs. Green frog numbers increased (Figure 9) but they still remain the least abundant frog at this fence. American toads were the most abundant anuran at the lower fence in 1998, but their numbers were about the same as last year (Figure 5). Spring peepers, the most abundant frog in 1997 (20 individuals), dropped to third place in 1998 (5 individuals). Pickerel frogs at the lower fence appear to be declining, with this year's catch lower than that of all previous years (Figure 5). However, the low numbers of this species caught make this data suggestive at best.

Abnormalities

There were no abnormalities observed out of a total of 987 (counting all nights) amphibians caught at the fences in 1998. One of the 157 Redback salamanders caught was an unusual all-red color (erythristic) phase but these are well described in the literature and I do not consider them an abnormality. Abnormalities are more commonly seen in the young of the year, because those individuals with abnormalities are weeded out through natural selection by adulthood. The fact that we caught so few young of the year at the lower fence could partially explain the lack of abnormalities this year. However, it should be kept in mind that low numbers of young are a more significant concern than abnormalities in the long run.

Summary

Over the past four years of data collection, we have established a strong baseline for looking at population trends. We have determined the amphibian species present at the fences, and now have a general idea of their relative abundances. Although trends can be suggested after four years, it is too early yet to verify them. Future years of monitoring should clarify these trends. The suggested decline of newts at all three fences needs to be watched, as does the declining pH at both the stream survey and egg-mass count sites, the decreasing numbers of young of the year caught at the lower fence, and the apparent decline of American toads at the upper two fences.

Acknowledgments

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Table 1. Results of three 50-meter stream-transects in Branch Pond Brook in the Lye Brook Wilderness Region from 1994-1998. 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 (N = 3)	17.4 (N = 1)	20
1995					
(7/24/95)	6	1	4.4 (N = 5)	17.4 (N = 3)	26
1996					
(8/6/96)	3	0	4.0 (N = 3)	16.1 (N = 3)	21
1997					
(7/11/97)	7	3	3.8 (N = 2)	15.6 (N = 3)	27
1998					
(7/14/98)[3]	11	5	5.0 (N = 1)	16.3 (N = 3)	26

[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.

[3] pH measurements were taken on August 5, 1998.

Table 2. Maximum counts of egg masses from monitoring locations in the Lye Brook Wilderness region from 1994 through 1998. 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 (N = 3)
1997 count dates[3]: 4/27, 5/5, 5/12	16	97	6.1 (N = 3)
1998 count dates[5,6]: 4/21, 4/28, 5/5	33	96	7.5 (N = 1)
North Alder Dam			
1994 count dates: 5/11, 5/25, 6/8	97	225	5.0 (N = 2)
1995 count dates: 4/24[2], 5/12, 6/9	292	3	5.1 (N = 2)
1996 count dates: 5/8, 5/15, 5/25	176	3	5.0 (N = 3)
1997 count dates[4]: 5/20, 5/27, 6/3	0	44	4.2 (N = 3)
1998 count dates[6]: 5/4, 5/12, 5/19	9	256	4.8 (N = 1)
Pond Near Drift-fence #2			
1994 count dates: 5/11, 5/25, 6/9	6	3	5.7 (N = 2)
1995 count dates: 4/24[2], 5/12, 6/9	70	152	5.6 (N = 2)
1996 count dates: 5/8, 5/15, 5/25	78	62	5.2 (N = 3)
1997 count dates: 5/20, 5/27, 6/3	55	77	5.0 (N = 3)
1998 count dates[6]: 5/4, 5/12, 5/19	13	30	5.5 (N = 1)

[1] Hatched by May 10

[2] All readings taken on April 24, 1995 were believed to be erroneous 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.

[5] Two flooded stream areas were included in the count along with the original site and the 3 puddles included last year.

[6] pH readings were taken on August 5, 1998.

Table 3. Monitoring results from the upper two drift-fences in the Lye Brook Wilderness Region during 1998. Traps were opened whenever conditions were appropriate for amphibian movement from April through October excluding August. The three most successful trappings per month (+/- 7 days) are included (15 out of 24 trappings). Data used are from May 2, 5, and 11; June 13, 17, and July 2; July 8, 21, and 24; Sept. 3, 8, and 16; Sept. 28, Oct. 9 and 29. Abnormality, maximum size, and first metamorph data are taken from all 24 trappings.

Common name	Scientific name	# of all ages	# of young of the year [1]	% young of the year	date of first metamorph [2]	largest adult (total length in mm)	# per trapping [3]	% of group	% of total catch	# abnormal/ total [4]
Salamanders										
Eastern newt	*Notophthalmus viridescens*	157	99	63%	Sep-3	86	10.5	48%	23%	0/201
Spotted salamander	*Ambystoma maculatum*	119	72	61%	Jul-24	198	7.9	36%	17%	0/129
Redback salamander	*Plethodon cinereus*	50	3	6%	Oct-9	100	3.3	15%	7%	1/58
Northern two-lined	*Eurycea bislineata*	3	0	0%	NA	98	0.2	1%	<1%	0/3
Group totals		329	174	53%	NA	NA	21.9	100%	48%	1/391
Frogs and Toads										
Wood frog	*Rana sylvatica*	201	163	81%	Jul-2	62	13.4	56%	29%	0/251
Green frog	*Rana clamitans*	109	105	96%	Jul-8	76	7.3	30%	16%	0/110
Spring peeper	*Pseudacris crucifer*	34	21	62%	Jul-21	35	2.3	9%	5%	0/34
American toad	*Bufo americanus*	16	0	0%	NA	72	1.1	4%	2%	0/17
Pickerel frog	*Rana palustris*	2	0	0%	NA	55	0.1	1%	<1%	0/2
Group totals		362	289	80%	NA	NA	24.1	100%	52%	0/414
Amphibian totals		691	463	67%	NA	NA	46.1	NA	100%	1/805

[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), D. fuscus (30 mm), E. bislineata (60 mm), N. viridescens (45 mm), P. cinereus (32 mm), B. americanus (23 mm), H. versicolor (26 mm), P. crucifer (20 mm), R. clamitans (44 mm), R. palustris (34 mm), and R. sylvatica (27 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] Numbers per trapping are rounded to the nearest 0.1. All other figures are rounded to the nearest whole number.

[4] These may contain old deformities (traumatic) as well as malformities (developmental). Salamanders missing all or portions of their tails are not included. The total number checked may contain specimens that were caught more than once.

Table 4. 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, 1997, and 1998 field seasons. Fences were opened at least three times per month.

Species Name	# Per Trapping [1]				% of Total Catch			
	95	96	97	98	95	96	97	98
Caudates (Salamanders)								
Blue-spotted Salamander Grou	0.0	0.0	0.1	0.0	0%	0%	<1%	0%
Spotted Salamander	8.7	4.7	5.7	7.9	20%	9%	14%	17%
Northern Two-lined Salamande	0.8	0.3	0.3	0.2	2%	6%	1%	<1%
Eastern Newt	12.7	29.5	19.4	10.5	29%	57%	49%	23%
Redback Salamander	2.0	3.3	1.5	3.3	5%	7%	4%	7%
Group Totals	24.2	37.1	27.1	21.9	56%	74%	68%	48%
Anurans (Frogs and Toads)								
American Toad	4.3	2.7	2.0	1.1	10%	5%	5%	2%
Spring Peeper	0.8	1.2	1.8	2.3	2%	2%	5%	5%
Green Frog	6.8	2.9	3.1	7.3	15%	6%	8%	16%
Pickerel Frog	0.0	0.0	0.0	0.1	0%	0%	0%	<1%
Wood Frog	8.2	6.3	6.0	13.4	18%	13%	15%	29%
Group Totals	20.0	13.1	12.8	24.1	45%	26%	32%	52%
Amphibian Totals	44.2	50.2	39.9	46.1	100%	100%	100%	100%

[1] Numbers 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, 15 in 1997, and 15 in 1998. Fence-nights counted are those nights where the upper traps were opened under appropriate weather conditions for amphibian movement.

Table 5. Monitoring results from the lower drift-fence in the Lye Brook Wilderness Region during 1998. Traps were opened whenever conditions were appropriate for amphibian movement from April through October excluding August. The three most successful trappings per month (+/- 7 days) are included (18 out of 28 trappings). Data used are from April 2, 17, and May 2; May 5, 22 and June 1; June 13, 17, and 27; July 2, 10, and 24; Sept. 3, 8, and16; Sept. 28, Oct. 9, and 29. Abnormality, maximum size, and first metamorph data are taken from all 28 trappings.

Common name	Scientific name	# of all ages	# of young of the year [1]	% young of the year	date of first metamorph [2]	largest adult (total length in mm)	# per trapping [3]	% of group	% of total catch	# abnormal/ total [4]
Salamanders										
Redback salamande	*Plethodon cinereus*	88	0	0%	NA	93	4.9	66%	54%	0/99
Eastern newt	*Notophthalmus viridesc*	38	5	13%	Sep-16	84	2.1	29%	23%	0/44
Spotted salamander	*Ambystoma maculatum*	6	4	67%	Sep-3	154	0.3	5%	4%	0/6
Northern two-lined	*Eurycea bislineata*	1	0	0%	NA	69	0.1	1%	1%	0/1
Group totals		133	9	7%	NA	NA	7.4	100%	82%	0/150
Frogs and Toads										
American toad	*Bufo americanus*	12	0	0%	NA	94	0.7	41%	7%	0/14
Wood frog	*Rana sylvatica*	5	0	0%	NA	62	0.3	17%	3%	0/5
Spring peeper	*Pseudacris crucifer*	5	0	0%	NA	32	0.3	17%	3%	0/6
Pickerel frog	*Rana palustris*	4	2	50%	Sep-3	35	0.2	14%	2%	0/4
Green frog	*Rana clamitans*	3	2	67%	Jul-24	45	0.2	10%	2%	0/3
Group totals		29	4	14%	NA	NA	1.6	100%	18%	0/32
Amphibian totals		162	13	8%	NA	NA	9.0	NA	100%	0/182

[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), D. fuscus (30 mm), E. bislineata (60 mm), N. viridescens (45 mm), P. cinereus (32 mm), B. americanus (23 mm), H. versicolor (26 mm), P. crucifer (20 mm), R. clamitans (44 mm), R. palustris (34 mm), and R. sylvatica (27 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] Numbers per trapping are rounded to the nearest 0.1. All other figures are rounded to the nearest whole number.

[4] These may contain old deformities (traumatic) as well as malformities (developmental). Salamanders missing all or portions of their tails are not included. The total number checked may contain specimens that were caught more than once.

Table 6. A comparison of data from the lower drift-fence in Lye Brook Wilderness, Manchester, Bennington County, Vermont. Data are taken from the 1995, 1996, 1997, and 1998 field seasons. Fences were opened at least three times per month.

Species Name	# Per Trapping [2]				% of Total Catch			
	95 [1]	96	97	98	95	96	97	98
Caudates (Salamanders)								
Spotted Salamander	0.4	0.2	0.3	0.3	3%	2%	3%	4%
Northern Two-lined Salamande	0.0	0.0	0.0	0.1	0%	0%	0%	1%
Eastern Newt	8.3	1.9	4.7	2.1	56%	28%	51%	23%
Redback Salamander	4.1	2.2	1.1	4.9	28%	32%	11%	54%
Group Totals	12.8	4.3	6.1	7.4	87%	62%	65%	82%
Anurans (Frogs and Toads)								
American Toad	0.4	0.7	0.7	0.7	3%	10%	7%	7%
Spring Peeper	0.1	0.2	1.1	0.3	<1%	3%	12%	3%
Green Frog	0.1	0.1	0.1	0.2	<1%	2%	1%	2%
Pickerel Frog	1.1	0.8	0.7	0.2	7%	12%	7%	2%
Wood Frog	0.4	0.8	0.7	0.3	3%	11%	8%	3%
Group Totals	2.1	2.6	3.3	1.7	13%	38%	35%	18%
Amphibian Totals	14.9	6.9	9.4	9.1	100%	100%	100%	100%

[1] In 1995, there were only 10 successful trappings. Dates used were April 20; June 16; July 1 and 18; September 10, 14, and 15; and October 6, 15, and 28.

[2] Numbers per trapping are rounded to the nearest 0.1. All other figures are rounded to the nearest whole number. There were a total of 10 trappings counted in 1995, 18 in 1996, 18 in 1997, and 18 in 1998. Fence-nights counted are those nights where the lower traps were opened under appropriate weather conditions for amphibian movement.

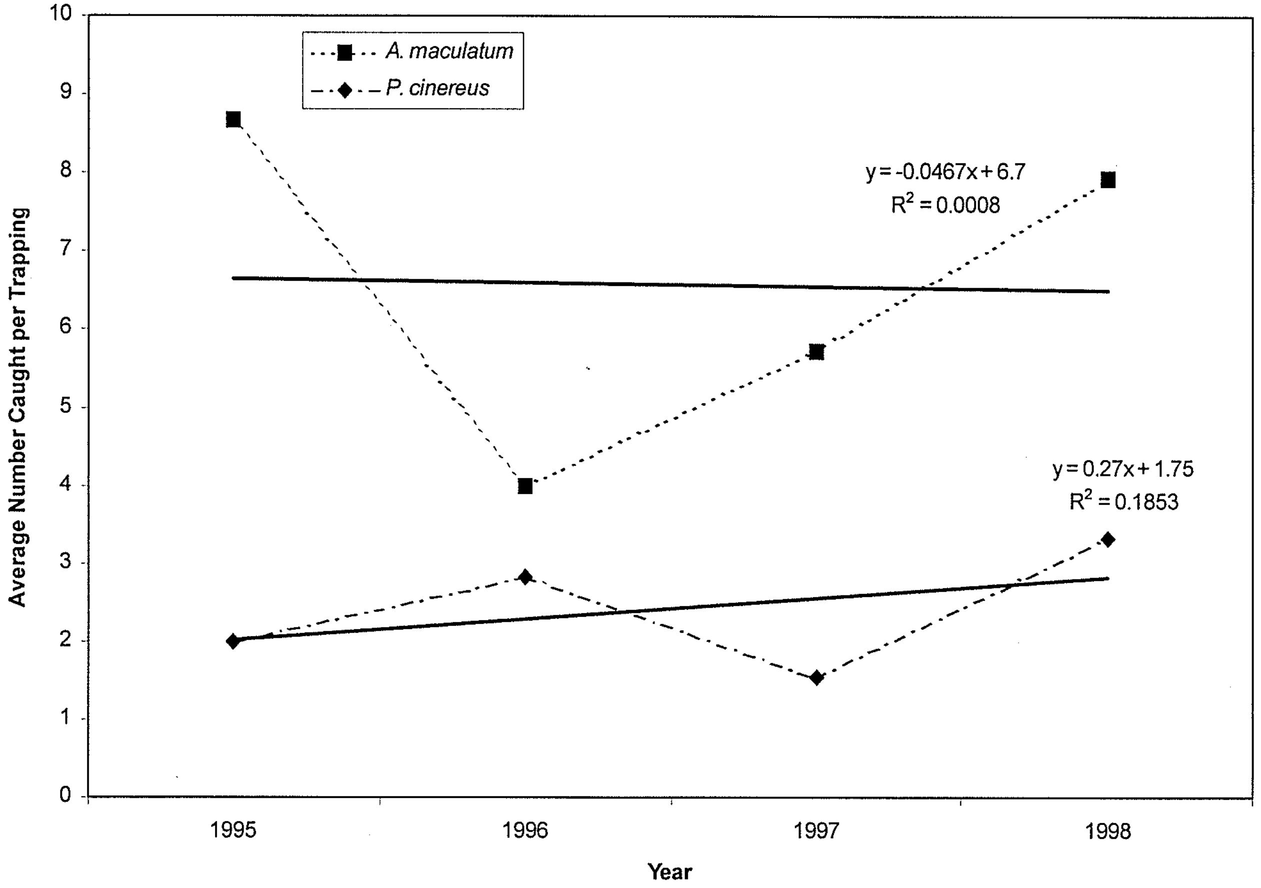

Figure 1. Spotted *(Ambystoma maculatum)* and Redback Salamander *(Plethodon cinereus)* population indices from the upper two drift-fences in the Lye Brook Wilderness, Sunderland, Vermont, 1995-1998.

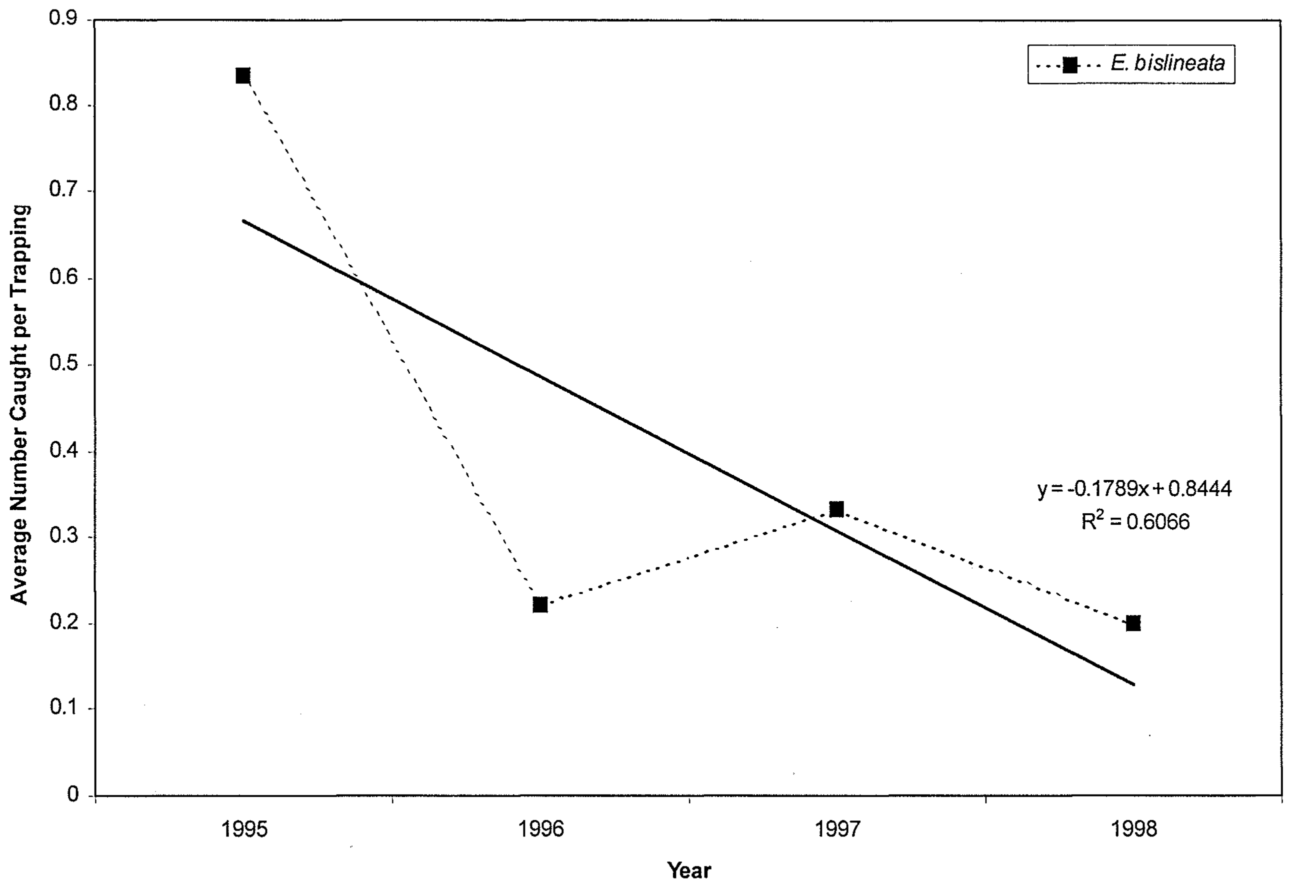

Figure 2. Northern Two-lined Salamander *(Eurycea bislineata)* population indices from the upper two drift-fences in the Lye Brook Wilderness, Sunderland, Vermont, 1995-1998.

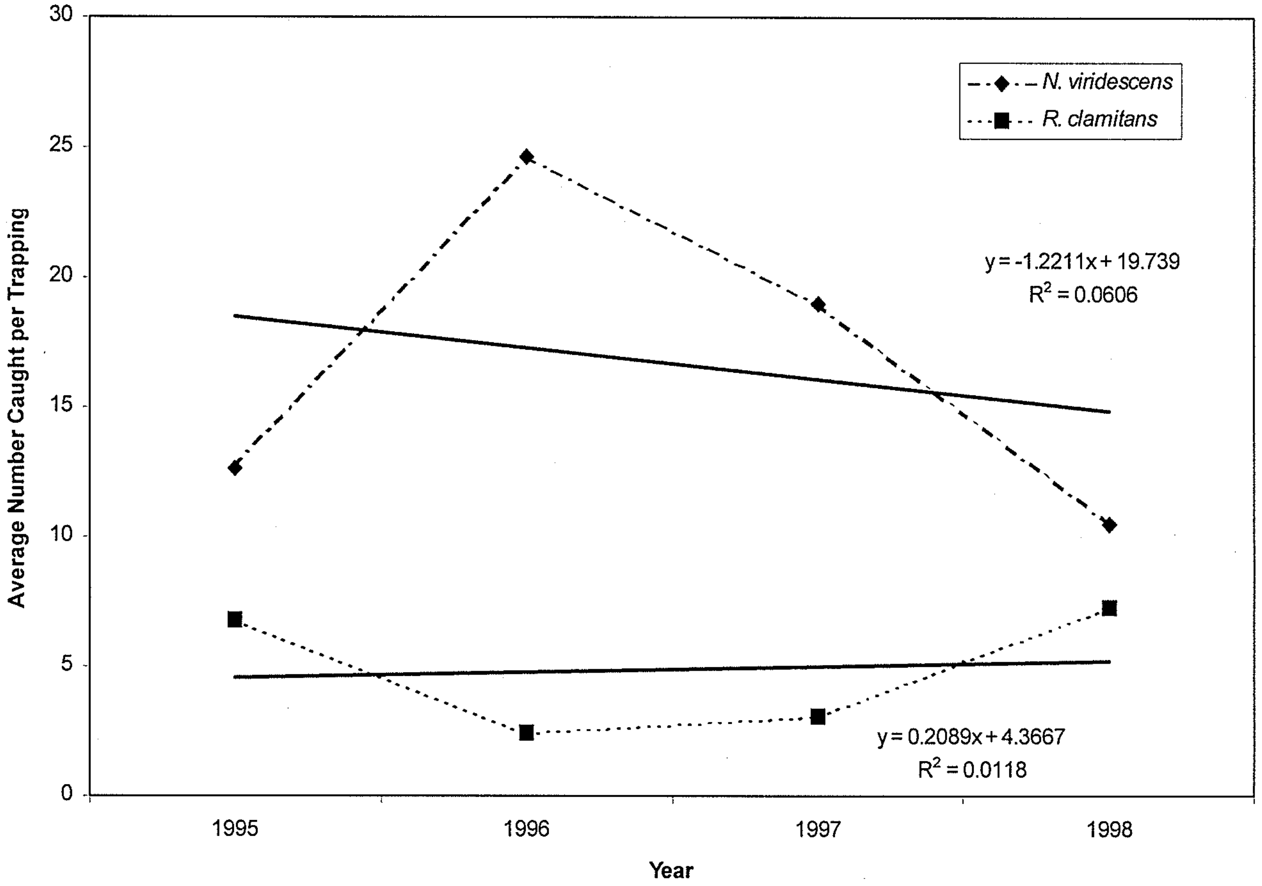

Figure 3. Eastern Newt *(Notophthalmus viridescens)* and Green Frog *(Rana clamitans)* population indices from the upper two drift-fences in the Lye Brook Wilderness, Sunderland, Vermont, 1995-1998.

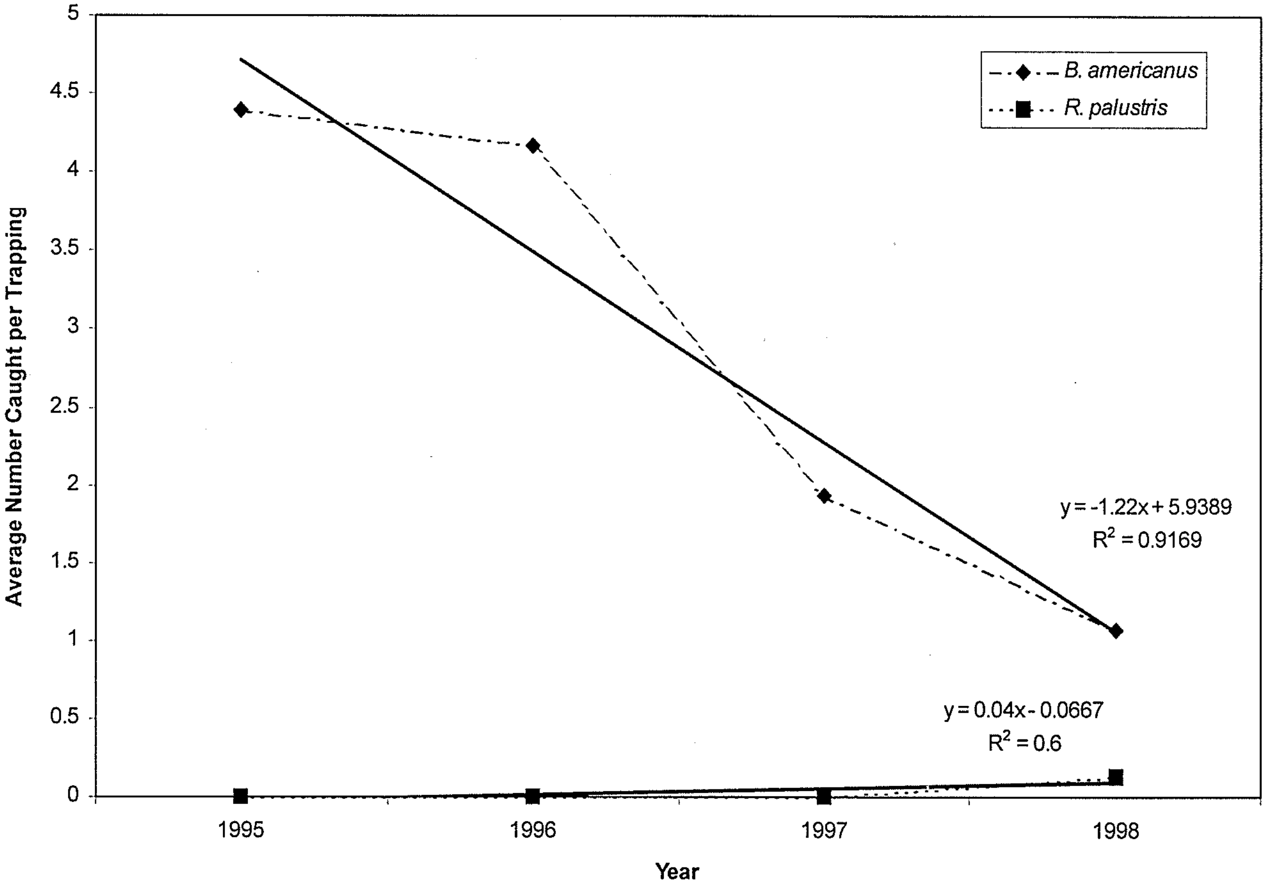

Figure 4. American Toad *(Bufo americanus)* and Pickerel Frog *(Rana palustris)* population indices from the upper two drift-fences in the Lye Brook Wilderness, Sunderland, Vermont, 1995-1998.

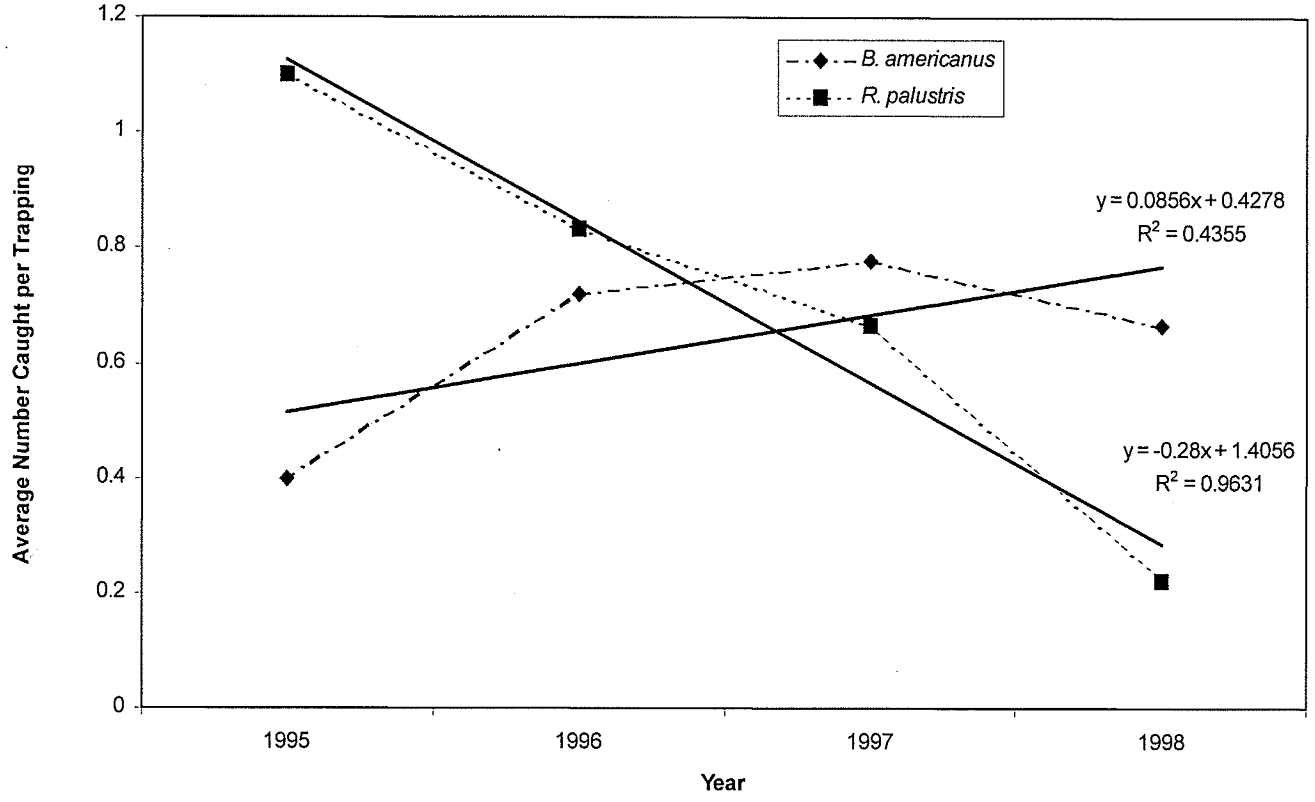

Figure 5. American Toad (Bufo americanus)and Pickerel Frog (Rana palustris)population indices from the lower drift-fence in the Lye Brook Wilderness, Manchester, Vermont, 1995-1998.

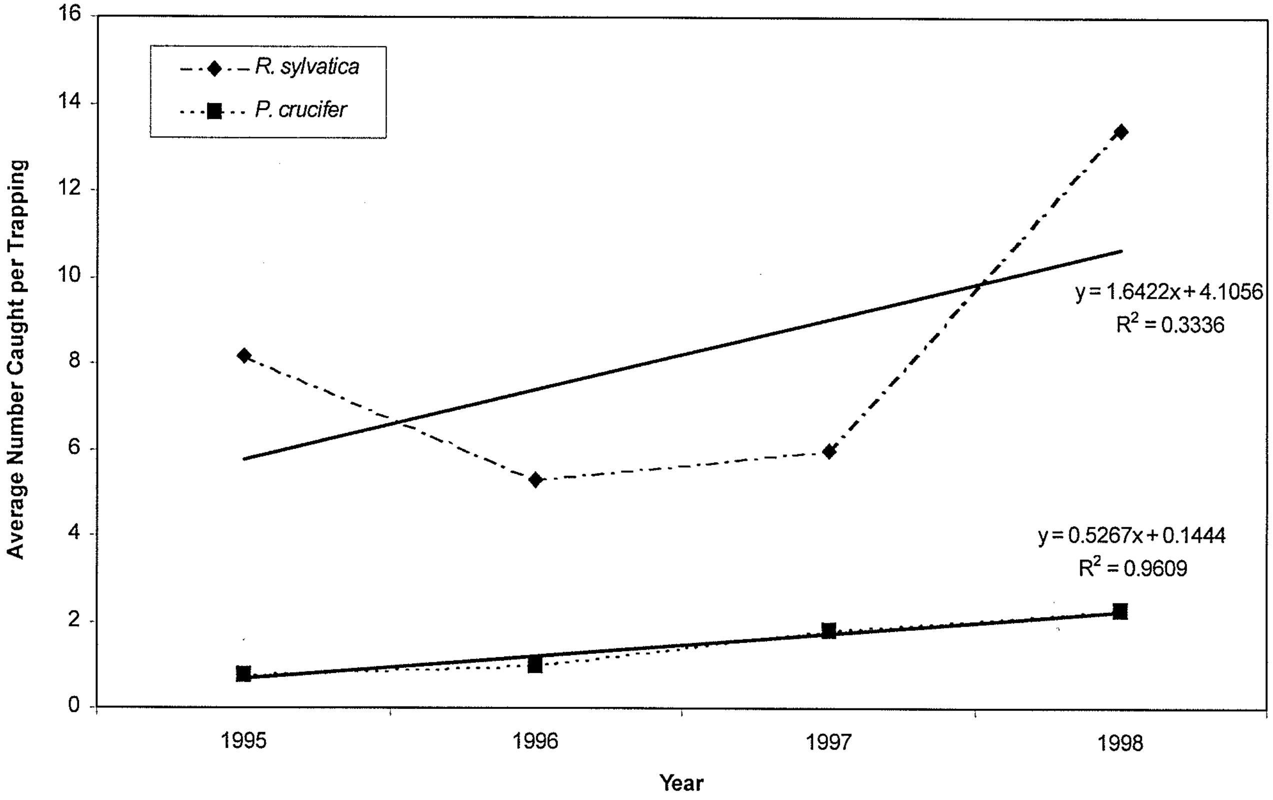

Figure 6. Wood Frog (Rana sylvatica)and Spring Peeper (Pseudacris crucifer)population indices from the upper two drift-fences in the Lye Brook Wilderness, Sunderland, Vermont, 1995-1998.

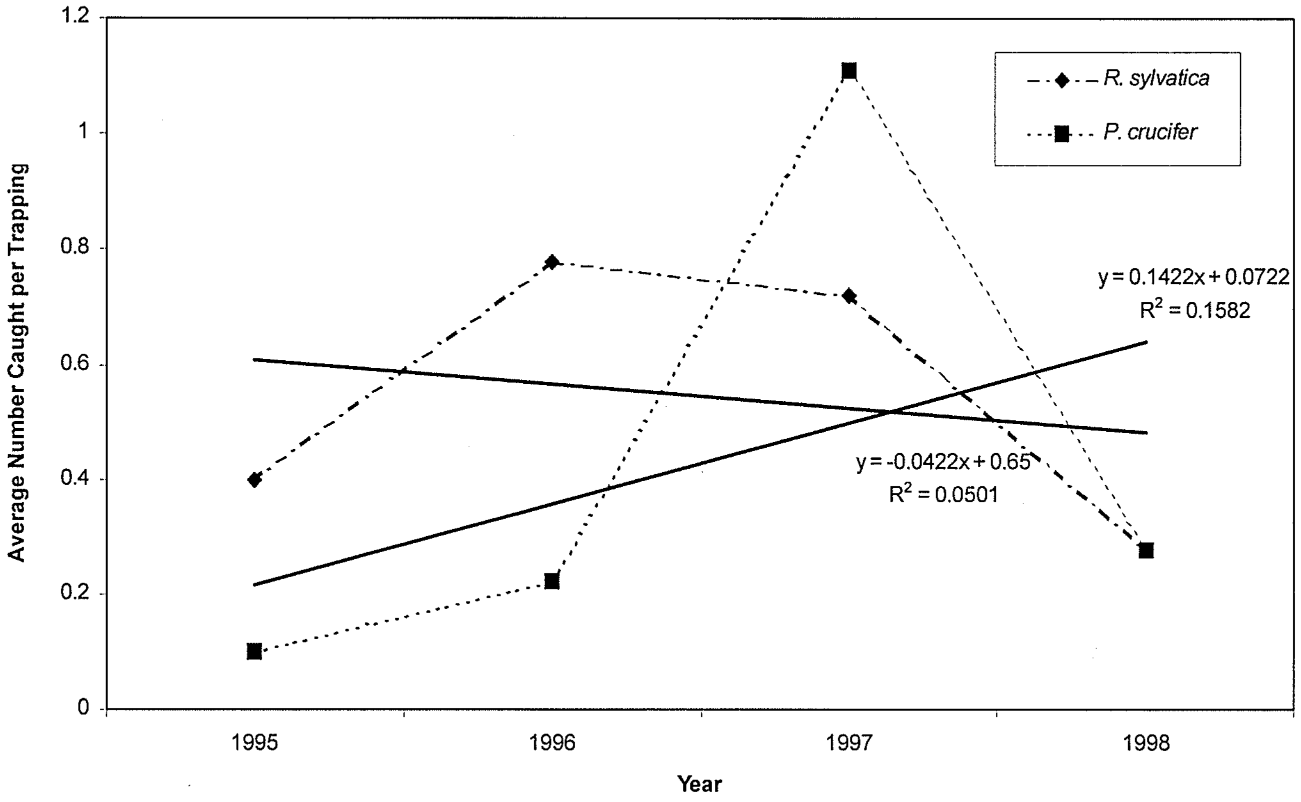

Figure 7. Wood Frog (Rana sylvatica)and Spring Peeper (Pseudacris crucifer)population indices from the lower drift-fence in the Lye Brook Wilderness, Manchester, Vermont, 1995-1998.

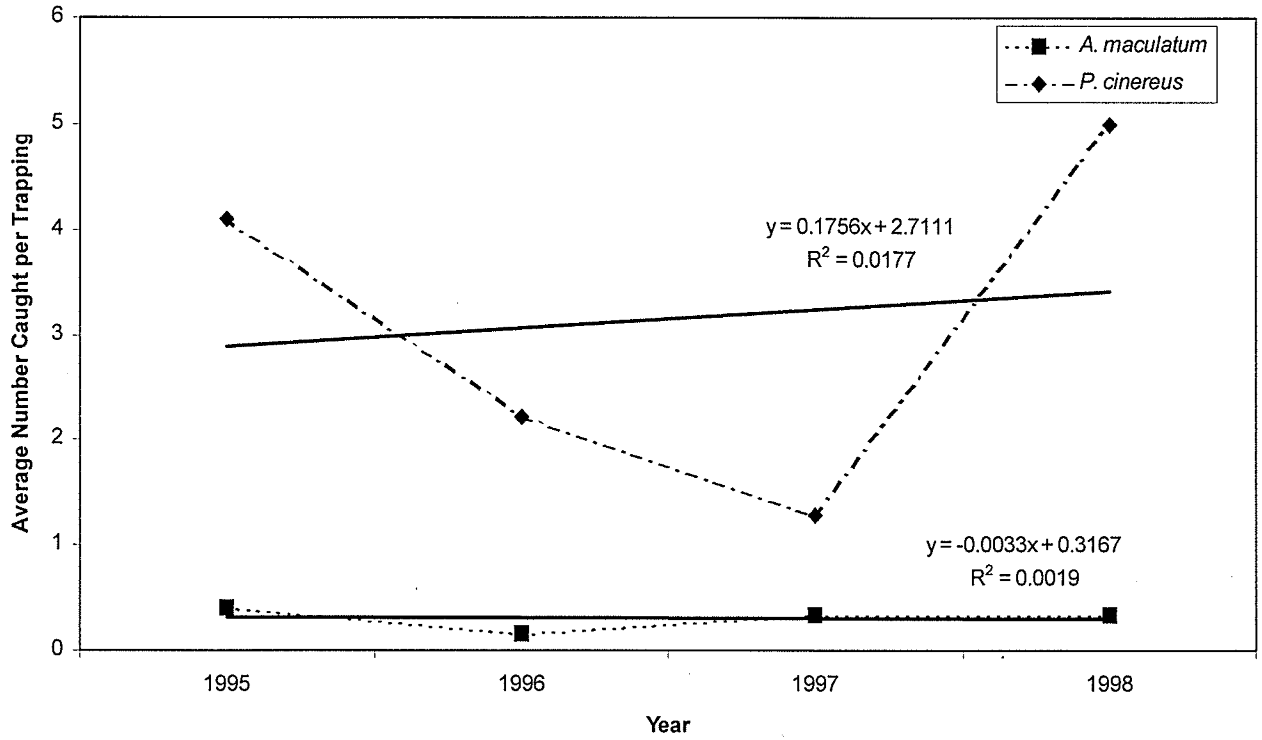

Figure 8. Spotted (Ambystoma maculatum)and Redback Salamander (Plethodon cinereus)population indices from the lower drift-fence in the Lye Brook Wilderness, Manchester, Vermont, 1995-1998.

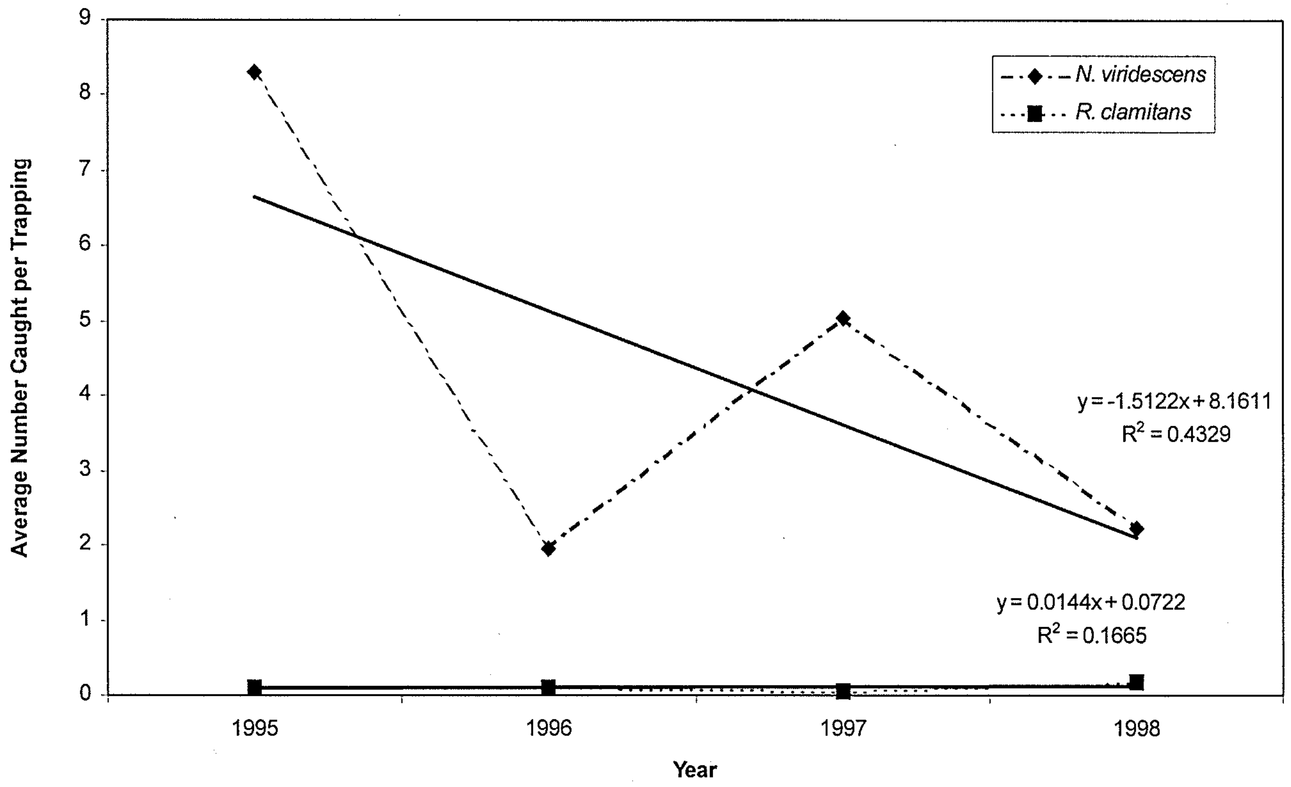

Figure 9. Eastern Newt (Notophthalmus viridescens)and Green Frog (Rana clamitans)population indices from the lower drift-fence in the Lye Brook Wilderness, Manchester, Vermont, 1995-1998.

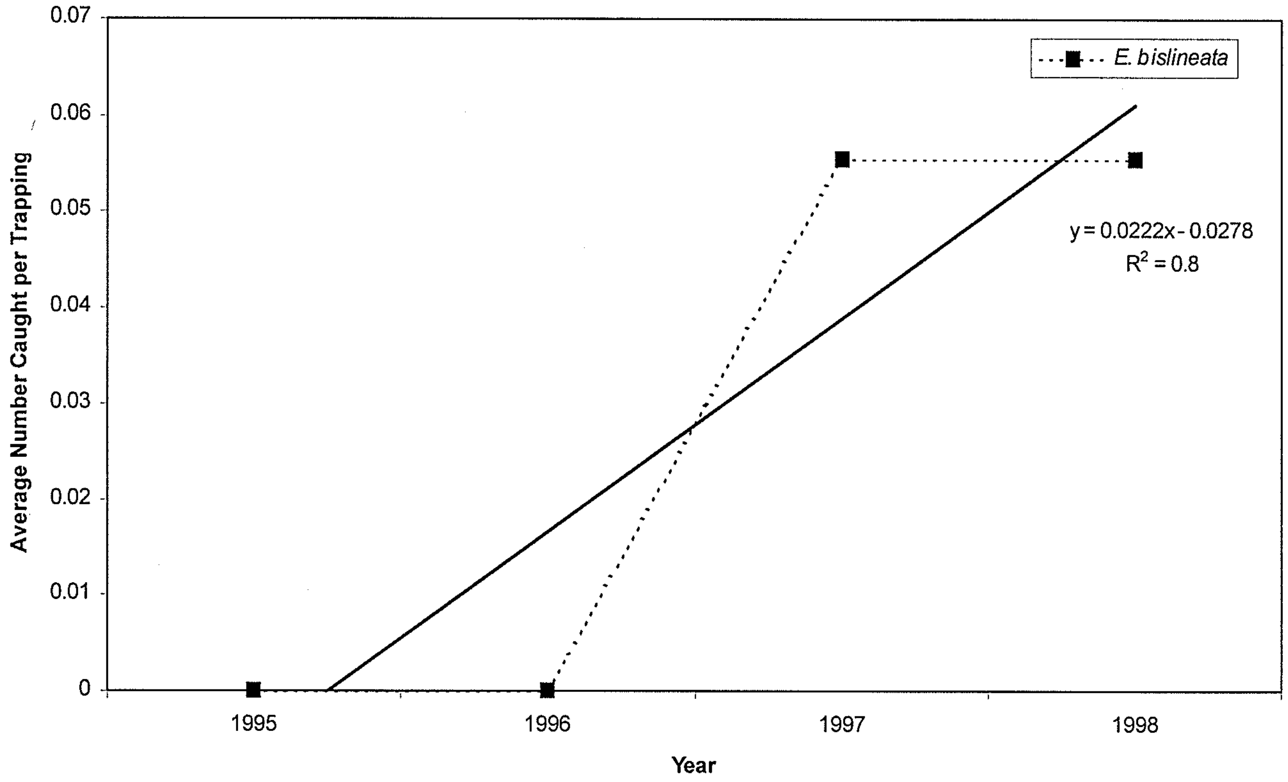

Figure 10. Northern Two-lined Salamander (Eurycea bislineata)population indices from the lower drift-fence in the Lye Brook Wilderness, Manchester, Vermont, 1995-1998.

Impacts of Ski Area Development on Montane Forest Birds

Progress Report

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The overall objective of this project is to investigate the use by montane forest birds of two existing ski areas in Vermont and to evaluate the impacts of ski area-related activities on avian breeding behavior and success. Intensive data collection has focused on Bicknell's Thrush *(Catharus bicknelli)*, a restricted specialist of the montane spruce-fir zone, and Blackpoll Warbler *(Dendroica striata)*. The project's findings will be used to formulate guidelines and recommendations to develop a conservation strategy for montane forest birds and their habitats in the northeastern United States. This progress report highlights project work completed between 1 April and 31 October 1998.

Study Areas: Four study plots were used in 1998, two each on Mt. Mansfield and Stratton Mountain. On Mt. Mansfield, an existing 20 hectare (50 acre) plot in the undeveloped Ranch Brook (RABR) watershed served as a control plot. Because of logistical difficulties, studies in the Nose Dive Pod area, the site of a planned major ski lift and trails expansion project on Mt. Mansfield, were discontinued. A new experimental plot was established in an existing developed area around the Octagon (OCTA), which encompasses a network of ski trails, ski lifts, a restaurant, a parking lot, and the Mt. Mansfield toll road. On Stratton Mountain, two 10 hectare (25 acre) plots established in 1997 were used in 1998. One plot is located on the north peak (STRB), in an area that is currently fragmented by ski area development, subject to summer recreational activities (mountain biking and hiking), and in which future construction of a 34,000 square foot year-round restaurant is planned. A second control plot (STRA) is situated on Stratton's south peak, which consists of undeveloped Green Mountain National Forest land bisected only by the Long Trail.

Baseline Avian Population Monitoring: Complete inventories of all breeding birds were conducted by territory mapping on the two Stratton Mountain plots in 1998. These data are currently being analyzed and compared both to similar data collected in 1997 and to 1998 radiotelemetry data (see below). For logistical reasons, territory mapping was discontinued on Mt. Mansfield in 1998. Two series of five 10-minute point counts were conducted twice on Mt. Mansfield, as part of long-term monitoring of montane forest bird populations at this site and throughout the northeastern United States.

Focused Demographic Studies: Intensive research on the breeding ecology and population dynamics of Bicknell's Thrush and Blackpoll Warbler was conducted on each plot. We attempted to capture and color band all known breeding individuals and juveniles, using both passive and active mist-netting. Nestlings were banded when possible. We obtained a combined total of 167 Bicknell's Thrush captures on Mt. Mansfield and Stratton Mountain in 1998 (Table 1). While a full demographic summary of these 167 captures is not yet possible, a substantial number of banded adults from previous years were captured, including at least two individuals on Mt. Mansfield originally banded as nestlings. We are in the process of analyzing return and survival rates using the MARK computer program. Our database of 1998 Blackpoll Warbler captures is currently being computerized.

Table 1. Numbers of Bicknell's Thrush captures on Mt. Mansfield and Stratton Mountain in 1998 (RABR = Ranch Brook, OCTA = Octagon, STRA = Stratton South, STRB = Stratton North).

Plot	Male	Female	Unknown Sex	Nestling	Total
RABR	10	5			15
OCTA	19	11	1	7	38
STRA	18	1	1	3	23
STRB	46	17	13	15	91
Total	93	34	15	25	167

We located and monitored a total of 69 nests of 10 species on Mt. Mansfield and 105 nests of 12 species on Stratton Mountain in 1998 (Table 2). We are currently computerizing these data and will calculate Mayfield estimates of nesting success. We will then compare nesting parameters and reproductive success between ski areas and natural forests to provide insights into population dynamics of various species in the two disturbance regimes.

Table 2. Nests monitored on Mt. Mansfield and Stratton Mountain in 1998.

Species	RABR	OCTA	STRA	STRB	Total
American Robin		6		9	15
Bicknell's Thrush	5	3	1	8	17
Black-capped Chickadee				1	1
Blackpoll Warbler	11	12	8	15	46
Catharus sp.			1	1	2
Cedar Waxwing		4			4
Chipping Sparrow				6	6
Golden-crowned Kinglet	1				1
Hermit Thrush			1		1
Lincoln's Sparrow				2	2
Magnolia Warbler	1	2	8	6	17
Myrtle Warbler	5	4	6	6	21
Slate-colored Junco		3	4	2	9
Swainson's Thrush	3		3		6
White-throated Sparrow	4	5	7	8	24
Yellow-bellied Flycatcher			2		2
Total	30	39	41	64	164

Radiotelemetry of Bicknell's Thrush: We radio-tracked 23 adult thrushes (15 males, 8 females) on Mt. Mansfield and 18 individuals (12 males, 6 females) on Stratton Mountain in June and July of 1998. Each bird received a 0.9 g transmitter attached to the top of the two central rectrices near the base of the rachis with a strand of dental floss. Observations of thrushes in the field and with video-taped nest observations indicated no obvious adverse reactions to the transmitters. We used 3-element Yagi antennas and portable receivers to locate transmitters. Tracking on Mt. Mansfield was done via simultaneous triangulations by 3 observers, to minimize errors and maximize accuracy. On the Stratton ski area plot, triangulations generally were not necessary because the forest was fragmented into small islands. Instead, birds were located by "local" triangulations and close-range fixes by one or two observers quickly circling an island that contained a bird to pinpoint its location. Locations were marked directly on 1:4,000 scale base maps in the field and graded from 0 (point exact) to 3 (point accurate within 30 meters). Most points were graded as 10-20m accuracy.

Analysis of the 1998 telemetry data is underway. A base map created in AutoCAD from aerial photographs and ground surveys was obtained from Stratton Mountain ski resort and imported into ArcView 3.1. Radio telemetry, color band resights, and capture points were digitized for each bird. All data were analyzed using Movement 1.1, a program extension written for ArcView that aids with analysis of animal movement data, and the Spatial Analyst 1.1 extension.

Preliminary analysis of telemetry data from the Stratton ski area plot was presented as a poster at the Association of Field Ornithologists annual meeting in October (Figures 1 and 2). Briefly, results showed: 1) much larger utilization distributions (estimated home ranges) than would be expected on the basis of territory mapping data; 2) significant overlap of utilization distributions; 3) multiple males singing and calling in overlap areas; and 4) more than one nest site typically incorporated within each male's estimated home range (Figure 1). Through careful observations and video taping, we documented multiple males feeding nestlings at several nests, both on Stratton and Mansfield (see below).

Although much additional analysis of our radio telemetry data remains to be done, including comparisons between birds on control and experimental plots, one important preliminary finding is that spot-mapping may not closely approximate actual densities of Bicknell's Thrush. Our intensive radio telemetry suggests that spot-mapping is not appropriate for estimating home range size or density of this species, counter to our earlier published findings. Bicknell's Thrush exhibit a high amount of overlap between their home ranges, which is contradictory to the assumptions of spot-mapping. However, spot-mapping coupled with fixed kernel density estimates can be used to find "hot spots" of activity (Figure 2). It may be possible to correlate these "hot spots" to habitat variables and other environmental data to help determine important conservation areas and issues.

Artificial Nest Predation Experiments: We conducted experiments on both Mt. Mansfield and Stratton Mountain in 1998. Two hundred and fifty artificial wicker nests were divided equally between five separate treatments on each mountain: 1) along foot trails (n=50); 2) along ski trail edges adjacent to unfragmented forest (n=50); 3) along the edges of islands in ski trails (n=50); 4) in the middle of small (n=25) and large (n=25) islands in ski trails; and 5) in undisturbed, unfragmented forest. Each nest was supplied with two Bobwhite *(Colinus virgianus)* eggs and one clay egg, was placed in a situation that closely approximated actual Bicknell's Thrush nest locations, and was checked after one week. Nest predation experiments were conducted first on Stratton Mountain in mid-June, then on Mt. Mansfield during late June. We were unable to deploy automatic cameras at nests, due to funding constraints. We are in the process of analyzing data from these 500 artificial nests, and we will compare them to those data collected at natural nests.

Videography of Bicknell's Thrush Nests: We conducted videography at 5 Bicknell's Thrush nests on Stratton Mountain and 7 nests on Mt. Mansfield, using a Sony Hi8 Handycam recorder. All nests were video-taped during the nestling period, so that identities of attending adults could be documented. At each nest, the camera was mounted to a tripod within a distance of 3-5 meters, with as unobstructed a view as possible of the nest rim and nestlings, and with care taken not to disturb the brooding female or feeding adults. Taping was conducted in 2-4 hour segments, and the camera was typically moved among several nests per day. Although the quality and clarity of tapes varied, due to factors such as lighting, weather, camera position, partial vegetation obstruction, and routes of nest approach and departure by attending adults, a great deal of valuable footage was obtained. We identified color-banded adults at each nest through a combination of video tape analysis, visual observations, and mist-netting.

We obtained a total of 23 hours and 29 minutes of video footage from 5 nests on Stratton Mountain and 44 hours and 14 minutes of footage from 7 nests on Mt. Mansfield. We recorded a total of 372 visits by adult Bicknell's Thrushes to these 12 nests, an average of 31 visits per nest (range = 6-85; Table 3). Although further detailed examination of these tapes remains to be done, preliminary analysis indicates that at least 4 of the 5 video-taped Stratton nests (3 on STRB, 1 on STRA) were attended by two males (Table 4). At one of these, 3 different males may have been feeding nestlings. On Mt. Mansfield, at least 2 of the 3 video-taped nests on the ski area (OCTA) plot were attended by 2 males, and 3 of the 4 nests on the undisturbed (RABR) plot had 2 males in attendance (Table 5). Two adjacent RABR nests (ca. 75 m apart) were apparently attended by the same 2 males, with each being the "primary" (as defined by relative frequency of visits) male at one of the 2 nests. One of these males was video-taped feeding nestlings at both nests, while the other was observed feeding nestlings from one nest and marked fledglings from the other, strongly suggesting that he had attended both nests. Nests on the STRB plot, in both 1997 (STRB97.4 and 97.8) and 1998 (STRB98.2 and 98.3), provided further evidence that some male Bicknell's Thrushes attend multiple nests (Table 4). The male in 1997 (YO/LBX) may have exhibited sequential polygyny, as its 2 nests were not known to be simultaneously active; however, the 1998 male (DBY/LGX) was documented feeding nestlings at 2 simultaneously active nests.

Our radio telemetry data confirm that most male home ranges encompass multiple nest sites (see above), and we believe that this phenomenon may be more common than documented by our limited videography in 1998. Our use of only a single camera, combined with frequent inclement weather during June and July and our relative inexperience in using the technique, resulted in incomplete coverage. We believe that videography has great potential for elucidating the complex social structure and behavioral ecology of Bicknell's Thrush, and we plan to expand our use of the technique in 1999. A thorough understanding of the apparently variable mating system of Bicknell's Thrush will be a prerequisite for modeling the population viability of this species, and for developing meaningful conservation strategies.

We are further convinced, based on nearly 70 hours of footage, that videography causes minimal disturbance, and thus poses little risk, to nests. All of the video-taped nests on both mountains successfully fledged young, and in no cases did we detect any obvious signs of disturbance or intolerance by brooding or feeding adults to the cameras. On several occasions, brooding females remained on the nest during our several minutes of camera set-up. An added benefit of videography was in enabling some assessment of the effects of human disturbance. Although we have not yet quantified results, one nest within 2 meters of the Mt. Mansfield toll road experienced frequent vehicle and foot traffic at close range. These appeared to be almost completely ignored by the brooding female and did not appear to affect food deliveries by the adults. This nest fledged 4 young. We will examine tapes more closely to investigate the responses of adults and chicks to human disturbances on both Mt. Mansfield and Stratton Mountain.

One suggestive result of our preliminary videography and nest observation work is that Bicknell's Thrush populations on Mt. Mansfield and Stratton Mountain may exhibit a male sex bias. Although analysis of our banding and recapture data is necessary to evaluate this hypothesis, if true, it raises some important and potentially troubling questions about the species' conservation status. If sex ratios are skewed towards males on the breeding grounds, this may indicate that females are experiencing reduced survival during the non-breeding phase of their annual cycle, either on the Caribbean wintering grounds or during migration, or both. VINS' field research in the Dominican Republic may soon be able to shed light on this. Briefly, our work to date suggests that "optimal" winter habitat consists of mature broadleaf montane forest, and we suspect that these habitats may be male-dominated. However, our distributional surveys have also documented that Bicknell's Thrushes occupy lower elevation, second-growth habitats in the Dominican Republic. If, as is known for other species of Nearctic-Neotropical migrants, males and females occupy different habitats and experience differential survival in those habitats, then female Bicknell's Thrushes might be inhabiting "lower quality" second growth habitats on the wintering grounds and experiencing higher mortality. This could explain, in part, a male sex bias on the breeding grounds. Because it is not possible to determine the sex of birds externally in winter, we do not yet have adequate demographic data to examine this. However, in November of 1998 we collected blood samples from 12 live Bicknell's Thrushes in the Bahoruco Mountains and will determine the sex of each sampled bird through laboratory analysis.

Much additional research and analysis of our existing data are necessary to evaluate this possible scenario, which remains purely speculative. Results obtained over the next few months should provide important preliminary insights on both winter and breeding season demographics, helping to guide future research and the development of conservation strategies.

Conservation Implications and Recommendations: Pending further analysis of our 1998 results, it is premature to provide concrete management recommendations. Two preliminary findings stand out, however: 1) based on radiotelemetry data, Bicknell's Thrushes appear to avoid areas within ski developments that are characterized by wide clearings ($\geq$ 50 m wide) (Figure 2). While thrushes readily cross narrow ski trails and other small artificial openings, home ranges generally do not encompass those trails and other openings $\geq$ 50 meters in width; 2) nesting Bicknell's Thrushes appear to be tolerant of a variety of human activities that may occur in close proximity to active nest sites. Evidence from videography and general observations suggests that motorized vehicle traffic, foot traffic, bicycle traffic, and human voices do not significantly disrupt thrush nesting behavior or adversely impact nesting success. It should be emphasized, however, that this result is based on a small sample of observations that have not yet been rigorously analyzed.

We believe that at least one additional field season of intensive research will be necessary to adequately evaluate the extent to which ski area-related activities and habitat fragmentation impact breeding bird populations. We will issue a preliminary set of recommendations based on our 1998 field data once analysis has been completed. A comprehensive report will be prepared after the 1999 field season.

Dissemination/Education: We initiated discussions regarding collaborative development of educational materials and interpretive displays at each ski area in 1998, and we expect to begin designing and assembling these in 1999. We regularly disseminated project information during the summer through informal discussions with hikers, birders, other recreationists, and summer camp groups. Our research was filmed by the Discovery Channel's Animal Planet "All Bird TV" program and aired on 4 and 5 December. We presented a poster paper titled "Home range overlap and movements by male Bicknell's Thrushes during the breeding period: implications for spot-mapping" at the Association of Field Ornithologists annual meeting in October. Finally, we participated in the third annual meeting of the U.S.-Canadian Bicknell's Thrush study group in Montreal during September.

Project Activities Planned for 1999

1. Refinement of demographic and behavioral ecology studies on Mt. Mansfield and Stratton Mountain, incorporating expanded radio telemetry, videography, and nest monitoring. Increased emphasis will be devoted to Bicknell's Thrush, relatively less to Blackpoll Warbler and other species.
2. Continued assessment of differences between ski area (experimental) and undisturbed (control) plots on each mountain.
3. Development of a report summarizing conservation issues at each site and proposing management recommendations to balance ski area development and viability of montane breeding bird populations.
4. Non-destructive sampling of blood from adult and nestling Bicknell's Thrushes to investigate paternity, sexual system, and social structure (samples were successfully collected from 15 males, 7 females, 1 adult of unknown sex, 11 nestlings from 4 nests, and 1 fledgling on Stratton Mountain in 1998, with no obvious adverse effects on subsequent behavior or survival. These are being analyzed by collaborator and former VINS staff biologist James Goetz at SUNY Syracuse).
5. Cooperative development of educational and informational resource materials for display at both ski areas.
6. Organization of a scientific paper session focused on Bicknell's Thrush at the 1999 American Ornithologists' Union meeting in Ithaca, New York.

Acknowledgments: We are extremely grateful to our 1998 field staff for their countless hours of dedicated work. They include Jim Goetz, Tim Redman, Jim Tietz, Colleen Dwyer, Jeff Farrington, Val Stori, Mark Pickering, Kristin Covert, Laura Gould, Eric Kruger, and Gabriel Colbeck. Collen Dwyer deserves special thanks for assistance with analysis of the Stratton radio telemetry data. We are also grateful for invaluable logistic support received from the Stratton Corporation and the Mt. Mansfield Company. The Hanover Food Coop and Food For Thought in Stowe provided much-appreciated donations of food for our Stratton and Mansfield field crews, respectively. Finally, we thank the organizations that helped to fund our 1998 work, including the National Fish and Wildlife Foundation, the Conservation and Research Foundation, the Philanthropic Collaborative, Inc., the Stratton Corporation, the Vermont Monitoring Cooperative, and the U.S. Fish and Wildlife Service.

Table 3. Results of videography at Bicknell's Thrush nests on Mt. Mansfield (OCTA and RABR) and Stratton Mt. (STRB). Bold indicates female.

Nest Identification	Color Band	Number of Visits
OCTA 98.1	**DBR/PUX**	26
	PUX/PUR	5
	YBK/LBX	22
	Unknown	7
	Total	60
OCTA 98.2	**YLG/BKX**	13
	OBK/BKX	5
	YBD/DBX	7
	Unknown	4
	Total	29
OCTA 98.3	**RW/BKX**	54
	RX/LBLB	18
	Unknown	13
	Total	85
RABR 98.2	**BKY/BKX**	2
	Unknown	11
	Total	13
RABR 98.3	**BKY/BKX**	2
	OPU/BKX	1
	Unknown	13
	Total	16
RABR 98.4	**DBO/BKX**	24
	RR/LBX	6
	W-RX/LBO	16
	Total	46
RABR 98.5	**LGDB/LBX**	23
	BKO/RX	1
	Unknown	1
	Total	25
SSTRB 98.3	**YY/DBX**	9
	BKR/LGX	6
	DBY/LGX	3
	Unknown	6
	Total	24
STRB 98.5	**LBPI/LGX**	3
	Unknown	3
	Total	6
STRB 98.6	**BKLB/DBX**	8
	OBK/DBX	9
	Unknown	8
	Total	25
STRB 98.7	**PIDB/LBX**	14
	Unknown	5
	Total	19
STRB 98.8	**RW/LGX**	1
	WO/LGX	5
	YO/LBX	2
	Unknown	16
	Total	24
Grand Total		372

Table 4. Identities of adult Bicknell's Thrushes attending nests on Stratton Mt. In 1997 and 1998.

Nest ID	Female (age)	Male 1 (age)	Male 2 (age)	Male 3 (age)	Obs.(1997)/ Video (1998) Time (min)	Comments	Nest Outcome
STRB97.1	**RO/LBX (ASY)**	**OW/DBX (SY)**	**YR/WX (ASY)**		0	Second male observed with fledglings	Fledged 2
STRB97.4	**RW/LGX (ASY)**	**BKO/LGX (ASY)**	**YO/LBX (ASY)**		1418	observed from blind	Fledged 2
STRB97.5	**YDB/LGX (ASY)**	**LGY/LGX (ASY)**	**DBY/LGX (ASY)**		120	Nest on edge, observed from trial	Fledged 3
STRB97.7	**LBPI/LGX (ASY)**	**DBR/LBX (ASY)**			1126	2nd nest for female	Fledged 2
STRB97.8	**PIY/LGX (SY)**	**YO/LBX (ASY)**	**PUO/LGX (ASY)**		1836	2nd male possible, not confirmed	Fledged 2
STRA98.1	**PIBK/OX (ASY)**	**LBO/LGX (ASY)**	**BKR/OX (ASY)**		0	all visual at nest	Fledged 3
STRA98.1					0	built and then abandoned	Failed during laying or building
STRA98.2	**YDB/LGX (ASY)**	**DBY/LGX (ASY)**			0		Fledged 2
STRA98.3	*YY/DBX (SY)*	***DBY/LGX (ASY)***	*BKR/LGX (TY)*		338		Fledged 3
STRA98.4	**BKLB/DBX (ASY)**				0	female ID not 100 confirmed	Depredated during incubation
STRA98.5	*LBPI/LGX (ASY)*	DBR/LGX (ASY)	OLB/LGX (ASY)	**OW/LGX (ASY)**	315	first two males captured at nest. Male 3 observed.	Fledged 1
STRA98.6	*BKLB/DBX (ASY)*	*OBK/DBX (ASY)*			371		Fledged 2
STRA98.7	***PIDB/LGX (ASY)***	*??/DBX*			241	unidentified adult came to nest with food while female brooding	Fledged 3
STRA98.8	***RW/LGX (ASY)***	*WO/LGX (ASY)*	*YO/LBX (ASY)*		143		Fledged 3
STRA98.9	**RR/OX (SY)**				0		Depredated-2yng, 1 egg

Note: **Bold = visual ID**, *italics = video id*, normal = captured at nest

Table 5. Identities of adult Bicknell's Thrushes attending nests on Mt. Mansfield in 1997 and 1998.

Nest ID	Female (age)	Male 1 (age)	Male 2 (age)	Obs.(1997)/Video (1998) Time (min)	Comments	Nest Outcome
RABR97.6	RY/DB-PIX (ASY)	**OPU/BKX (ASY)**		2326	from blind	Failed
MANS97.6	**BKPI/RX (ASY)**			1231	from blind	Failed
RABR 98.1	**OLG/PUX (ASY)**	LBY/PUX (ASY)		0	male 1 trapped and radio tracked near nest	Failed-- abandoned after 17 days of incubation
RABR98.2	*banded*	*BKY/BKX (ASY)*	**OPU/BKX (ASY)**		male 2 seen feeding recently fledged color-banded chicks.	Fledged 3
RABR 98.3	**LGDB/LGX (ASY)**	***OPU/BKX (ASY)***	*BKY/BKX (ASY)*	185		Probably fledged 3
RABR 98.4	*DBO/BKX (SY)*	*W-RX/LBO (ASY)*	*RR/LGX (ASY)*	361		Fledged 3
RABR98.5	**LGDB/LBX (ASY)**	**BKO/RX (ASY)**		207	filmed during incubation only	Failed-- female abandoned shortly before chicks hatched, male tried alone then left
OCTA 98.1	*DBR/PUX (ASY)*	*YBK/LBX (ASY)*	*PUX/PUR (ASY)*	482		Fledged 4
OCTA 98.2	*YLG/BKX (ASY)*	*YDB/DBX (ASY)*	*OBK/BKX (ASY)*	337		Fledged 3
OCTA 98.3	*RW/BKX (ASY)*	*RX/LBLB (ASY)*		746		Fledged 3

Note: **Bold = visual ID**, *italics = video id*, normal = captured at nest

Figure 1

1997

Color Bands	DBY/LGX	DBR/LBX	OLB/LGX	YDB/LBX	Mean	SD
Number of points	90	54	99	59		
Area (ha)	5.06	8.03	3.24	7.62	5.99	2.25

1998

Color Bands	YO/LBX	BKR/LGX	YDB/LBX	WO/LGX	PUPU/LGX	DBR/LBX	LGY/LGX	Mean	SD
Number of points	30	111	429	332	149	37	42		
Area (ha)	1.89	3.30	8.56	2.49	7.66	4.47	4.86	4.75	2.53

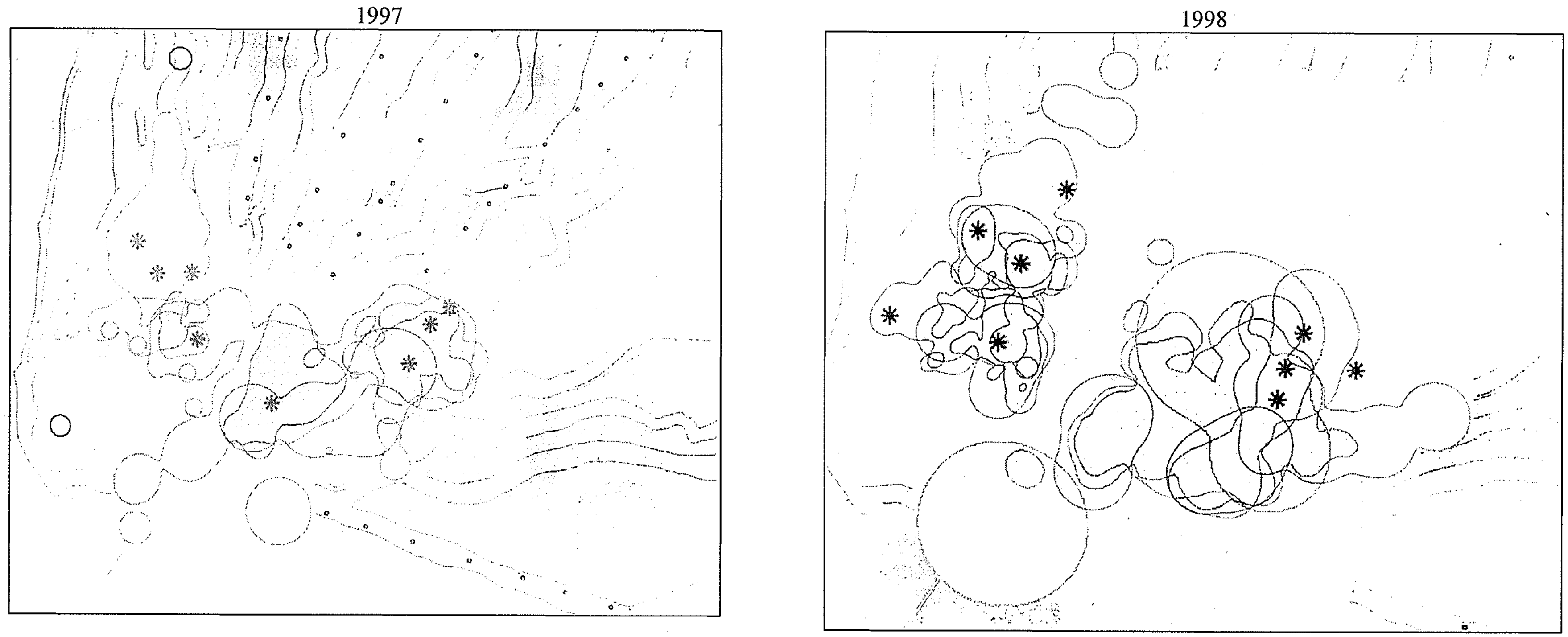
Home range estimates for male Bicknell's Thrush in 1997 and 1998.
A 95% probability estimate of the utilization area (UA) was calculated for each bird using a fixed kernel home range estimate as a grid coverage and a least squares cross validation to select a smoothing parameter (Silverman 1986, Worton 1989, Seaman and Powell 1996). The probability density estimates that were produced by fixed kernel methods may be directly interpreted as utilization distributions.

Legend

		BKR/LGX's Home Range	WO/LGX's Home Range
*	Nests	░ 25% UA	25% UA
☐	Forest Cover	▒ 50% UA	░ 50% UA
		▓ 95% UA	█ 95% UA

Home range estimates for two male Bicknell's Thrush in 1998.
To best illustrate home range size and overlap we chose two males with large location sample sizes in an area where we believe we discovered all nest sites. This amount of overlap of home ranges was typical for individuals on our study sites. Each male encompassed two nest sites (two different females). The second nest site was shared between each bird. In most cases individual high utilization areas correspond to nest locations.

Figure 2.



Legend
Male 95% Utilization Areas (UA)
Male 95% UA Overlap

Overlap in home ranges between 7 radio tagged Bicknell's Thrush in 1997 and 11 radio tagged Bicknell's Thrush in 1998.

Fixed kernel home ranges with 95% utilization areas were calculated for each radio tagged trush. The blue region is the areas of overlap between 2 or more individual home ranges. Mpst areas contained more than 2 overlapped home ranges. Because all individuals were not radio tagged and some individuals had small location sample sizes, the overlap regions (map) and the number of individuals overlapped (table) represent a minimum estimate.

1997

Color Bands	Minimum Number Overlap
DBY/LGX	2
BKO/LGX	2
DBR/LGX	3
DBR/LBX	4
OLB/LGX	4
YDB/LBX	5
PUPU/LGX	4
Mean (+/- SD)	3.43 (1.13)

1998

Color Bands	Minimum Number Over5lap
BKO/LGX	5
OLB/LGX	5
YO/LBX	4
OW/DBX	5
BKR/LGX	5
YDB/LBX	8
LGR/DBX	5
WO/LGX	5
PUPU/LGX	5
DBR/LBX	5
LGY/LGX	4
Mean (+/- SD)	5.09 (1.04)

Terrestrial Flora

An investigation of some factors that may influence the development of fall foliage color in Sugar Maple

Abby van den Berg
University of Vermont

The display of fall foliage color by sugar maple (Acer saccharum) in the northeast is valued highly by both residents and non-residents. In addition, this yearly event is responsible for generating much of the region's fall tourism revenue, including an estimated $140 million for the state of Vermont alone. Despite its many benefits, few substantiated data exist regarding the exact mechanisms of fall color development. If available, data relating to the causes of differential timing and brilliance of fall foliage color could be used to make more accurate predictions, and to possibly develop procedures for manipulating fall color development on selected trees.

Most of the basic physiological processes involved in color development are known. The chlorophyll molecule begins to break down in response to lower temperatures and shorter daylengths associated with the approaching winter months. As chlorophyll breaks down, the yellow and orange carotenoid pigments are revealed. These yellow pigments are present in leaves during the entire growing season, as they aid chlorophyll in light absorption. Their presence is masked, however, by the green chlorophyll pigment. What is unclear is the cause for the formation of the red anthocyanin pigments during the late summer and early fall. These pigments yield the highly valued mosaic of colors in fall leaves of species such as sugar maple. This part of the process of fall color development, the development of anthocyanins, was the focus of this study.

From September to October 1998, foliar samples were collected from 10 sugar maple trees located at the Proctor Maple Research Center in Underhill, Vermont. Samples were analyzed for micro and macronutrient concentrations, carbohydrate content and the extent of color development. Then, simple regression was used to detect relationships between the concentrations of leaf constituents and the extent of leaf coloration.

Leaves that had high percentages of red (anthocyanin) pigment also had high concentrations of aluminum and iron, and low concentrations of starch and xylose. Leaves that were mostly green exhibited the opposite relationships with these leaf constituents. Although the statistical relationships were strong, no conclusions could be drawn from these data. Because the analysis measured the strength of the relationship between the color of a leaf and it's chemical composition at the time of collection, the data do not provide information on whether a particular constituent would be useful in the prediction of how brilliant a particular tree's foliage might be. Thus, a far more rigorous study was necessary. The subsequent study focused on the variables identified as important in the initial study at the Underhill site, and was conducted at the US Forest Service Northeastern Research Station in South Burlington, Vermont from June to November 1999. Details of the study can be found in "Fall Foliage Color Development in Sugar Maple" by A.K. van den Berg, a master's thesis located in the Research Annex of the Bailey-Howe library at the University of Vermont.

This project was made possible by support from the Vermont Monitoring Cooperative, the Proctor Maple Research Center, the US Forest Service Northeastern Research Station and a SUGR/FAME grant from the University of Vermont. Completion of this project partially fulfilled requirements for a senior honors thesis for the forestry program of the University of Vermont School of Natural Resources.

Annual Assessment of Forest Health in the Lye Brook Wilderness Area
1998

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. The same methods is used to assess forest health on plots throughout Vermont.

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

Crown condition. In 1998, trees surveyed showed a trend towards poorer condition (Tables 1-4). Percent of trees healthy was 81.3% on 1400 foot plots, and 93.5% on 2200 foot plots (Table 4). When compared to 5 year averages, tree foliage was significantly thinner (foliage transparency increased) and crown density was lower at both elevations (Figures 1-2). Survey plots were not affected by the January 1998 ice storm, but a prevalence of leaf diseases due to wet summer conditions may have played a factor in reduced foliage and crown density. Species particularly affected were black cherry at 1400 feet, and balsam fir at 2200 feet.

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 - 1998.

Species	Elevation	1994	1995	1996	1997	1998
Balsam Fir	2200	1.0	1.8	2.9	2.2	6.6
Black Cherry	1400	6.5	12.5	12.5	6.0	9.5
Paper Birch	1400	*	*	4.5	1.5	5.0
Red Maple	1400	3.8	5.4	5.4	2.9	4.3
	2200	6.0	6.4	6.9	4.1	5.7
Red Spruce	2200	1.0	2.6	4.3	1.9	2.8
All Species	1400	5.2	7.1	6.7	3.5	6.2
	2200	3.4	4.2	5.1	3.2	5.3

* 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 - 1998.

Species	Elevation	1994	1995	1996	1997	1998
Balsam Fir	2200	48.3	44.2	50.6	51.8	38.2
Black Cherry	1400	45.5	42.5	38	48.5	33.5
Paper Birch	1400	*	*	54	51.5	45.0
Red Maple	1400	55.2	52.3	51.5	51.0	44.1
	2200	46.7	50.2	56.4	54.5	44.3
Red Spruce	2200	51.0	51.4	58.6	56.2	46.0
All Species	1400	53.0	52.4	50.3	51.8	42.2
	2200	48.3	48.7	55.2	53.7	43.1

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 - 1998. *indicates < 10 trees

Species	Elevation	1994	1995	1996	1997	1998
Balsam Fir	2200	18.3	24.4	16.7	19.3	28.1
Black Cherry	1400	25	*	26.5	25.5	29.5
Paper Birch	1400	*	*	20.5	17.5	23.8
Red Maple	1400	14.2	19.6	15	16.5	18.0
	2200	20.9	24.8	16.0	16.0	20.8
Red Spruce	2200	16.6	22.1	12.9	15.6	19.7
All Species	1400	17.0	23.1	18.2	17.9	21.5
	2200	18.9	24.1	15.3	17.0	23.0

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 - 1998. *indicates < 10 trees

Species	Elevation	1994	1995	1996	1997	1998
Balsam Fir	2200	100	100	91.7	100	89.2
Black Cherry	1400	100	*	80	100	70.0
Paper Birch	1400	*	*	100	100	100
Red Maple	1400	100	100	100	95.8	87.0
	2200	93.1	96.8	90	100	95.2
Red Spruce	2200	100	100	100	100	94.7
All Species	1400	98.1	92.2	94.0	94.6	81.3
	2200	98.6	97.6	92.7	100	93.5

Figure 1. Overstory tree health in 1998 compared to 5 year averages (baseline) for survey plots at 1400 feet in the Lye Brook Wilderness Area. * = significantly different

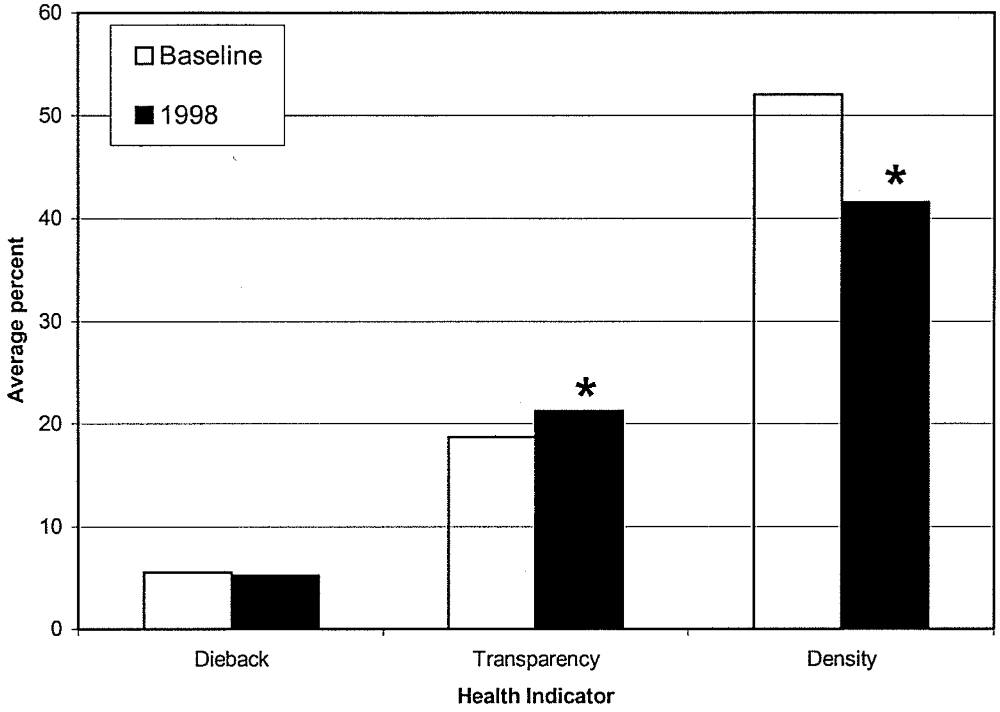


Figure 2. Overstory tree health in 1998 compared to 5 year averages (baseline) for survey plots at 2200 feet in the Lye Brook Wilderness Area. * = significantly different

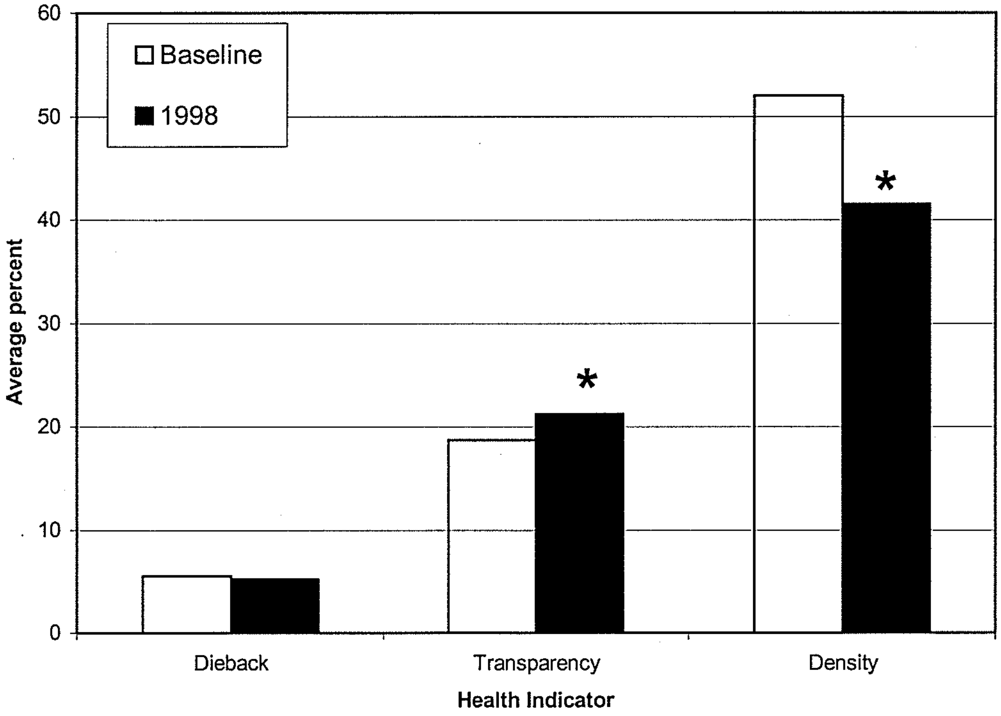


Table 5. Percent of overstory trees affected by different types of tree damages in 1998.

Elevation	Percent of trees damaged	Percent of damaged trees affected by types of damage
1400	20 %	23.6 % with indicators of decay 3.6 % with open wounds (size > 20% of circumference) 3.6 % with dead or broken top 1.8 % with broken or dead branches
2200	25.5 %	13.1 % with indicators of decay 8.0 % with dead or broken top 2.9 % with open wounds 1.5 % with broken/dead branches 1.4 % with cankers 0.7 % with brooming

Tree damages. Results on the incidence of damages that have the potential to significantly affect tree growth and vigor show that 20% of trees on the 1400 foot elevation plots and 25.5% of trees on the 2200 foot elevation plots have some sort of damage (**Table 5**). The most common type of damage is "indicator of decay". At the 2200 foot elevation, dead or broken tops are also common.

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. 1998 version.

Annual Assessment of Forest Health on Mount Mansfield

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 plots 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

Plot establishment, site characterization and annual tree evaluations follow standardized NAMP protocols (Cooke et al, 1998) 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 (i.e. crown dieback, foliage transparency, tree vigor, bole damage, taphole closure) and foliage damage (i.e. defoliation) 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.

A special ice injury assessment was conducted in May to quantify the extent and severity of ice injury from a January 1998 ice storm that affected forests throughout Vermont and the region. This survey was developed by the international NAMP project leaders for implementation in the U.S. and Canada. Measurements collected included the amount and location of crown, bole and root breakage; and bole wounds within and below the crown. Regeneration assessments were made during the regular summer visit to establish a baseline for seedling and sapling abundance in each stand, so that regeneration changes resulting from the ice storm could be assessed as they compare with stands unaffected by the ice storm. One mil-acre plot 12 ft. from plot center was established in each of the 5 plots. Number of sugar maple, other hardwoods and conifers were counted in 3 size classes: seedlings less than 1m, seedlings 1 m height to < 1 cm DBH, and saplings 1 – 3.9 cm DBH.

NAMP Plot Results and Discussion

The NAMP plot on Mount Mansfield was not affected by the January ice storm. No significant change in sugar maple dieback (7.8%) or percent of trees healthy (94.9%) was measured in 1998 and no new mortality occurred. An increase in foliage transparency (12.6%) reflects a similar statewide trend, and may be related to light defoliation by maple leaf cutter, pear thrips, and maple trumpet skeletonizer. Baseline regeneration results shows the presence of sugar maple regeneration at all stages: 9 seedlings class I, 3 seedlings class II, and 5 saplings were recorded.

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 (%)	Foliage Transparency (%)	New Dead (%)	Trees healthy (%)
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	10.88	0	94.9
1998	7.8	12.6	0	94.6

Forest Health Monitoring 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.

A special survey was conducted in May to assess tree injury from a January 1998 ice storm that affected forests throughout Vermont, and the region. The amount and location of crown, bole and root breakage was assessed. Bole wounds within and below the crown were recorded.

Forest Health Plot Results and Discussion

The January 1998 ice storm coated trees on Mount Mansfield. The west slope icing was found in 2 bands: one occurring between the elevations of 2,300 feet and 3,000 feet, the second at the ridgeline. On the east slope, icing occurred throughout Ranch Valley at all elevations. Injury in the form of branch and bole breakage was not prevalent on forest health plots on the west slope, but did affect trees on plots at 2,200 and 3,000 feet on the east slope, and at the summit (3800 feet). Tree recovery was aided by favorable growing season weather, with abundant precipitation.

West slope plot results

Trends in tree health indicators varied according to elevation. Trees on survey plots at 1400 and 2200 feet showed little change from past years, and 100% and 89% of overstory trees were considered healthy (≤15% dieback), respectively (Figures 1-7). On 3000 foot elevation plots, trees improved foliage transparency in 1998 over other years, and 86% of trees were healthy. These trees, however have significantly lower crown density ratings than trees at all other elevations. At the highest elevation, crown density of trees improved in 1998, but only 66% of trees are considered healthy. These trees continue to have significantly higher dieback than trees at all other elevations. New mortality occurred only on the 3800 foot plots, where the mortality rate was 3.0%.

Heavy seed crops were common on many species and may have affected the density of foliage. Species especially affected were yellow birch, paper birch and balsam fir.

Damages to trees can play a significant role in tree health. 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 summit plots, where extreme winter weather can adversely affect trees, dead or broken tops was the most common type of damage. The number of trees with significant damage varied with elevation, with trees at the 2200 foot plots having the highest frequency of damage (63%) and trees at 1400 foot plots having the lowest frequency of damage (27%).

Figures 1-3. Trend in health indicators at 4 elevations on Mount Mansfield: Crown Density (Figure 1), Crown Dieback (Figure 2) and Foliage Transparency (Figure 3).

Figure 1. Crown Density.

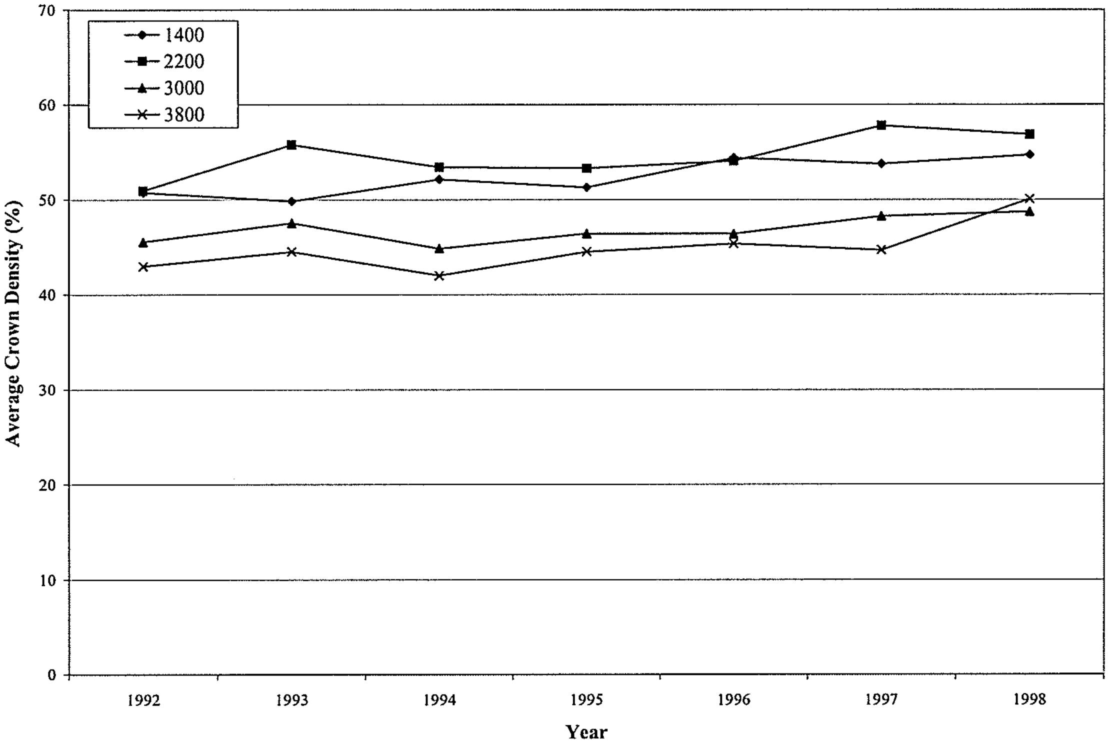


Figure 2. Crown Dieback.

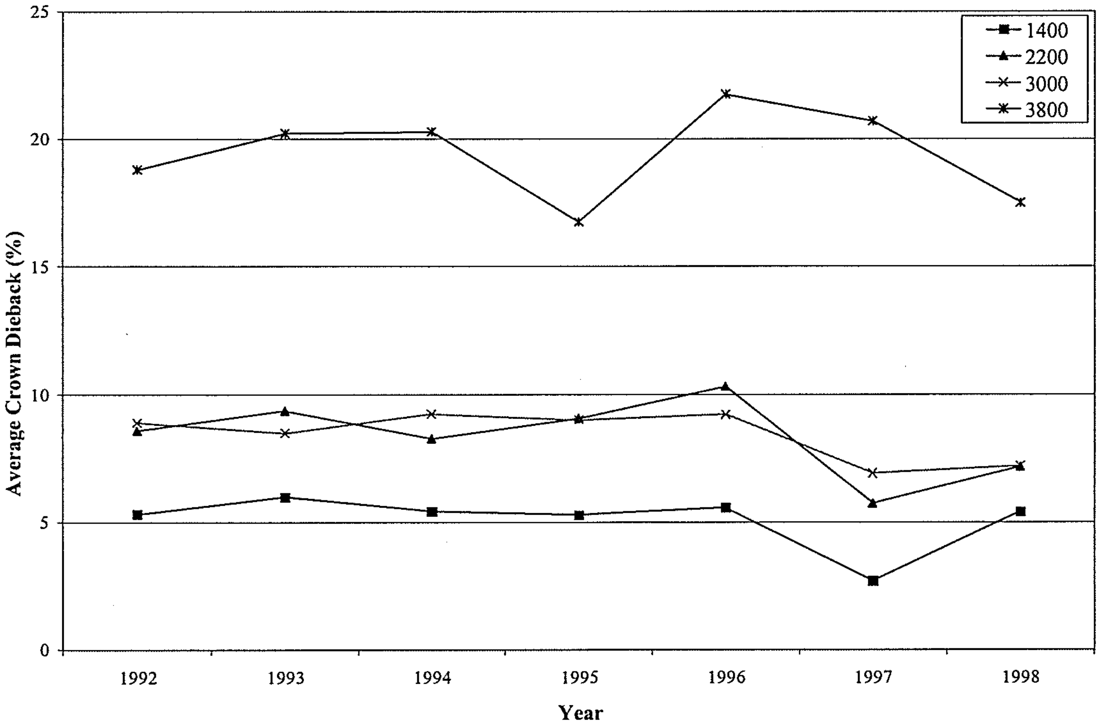
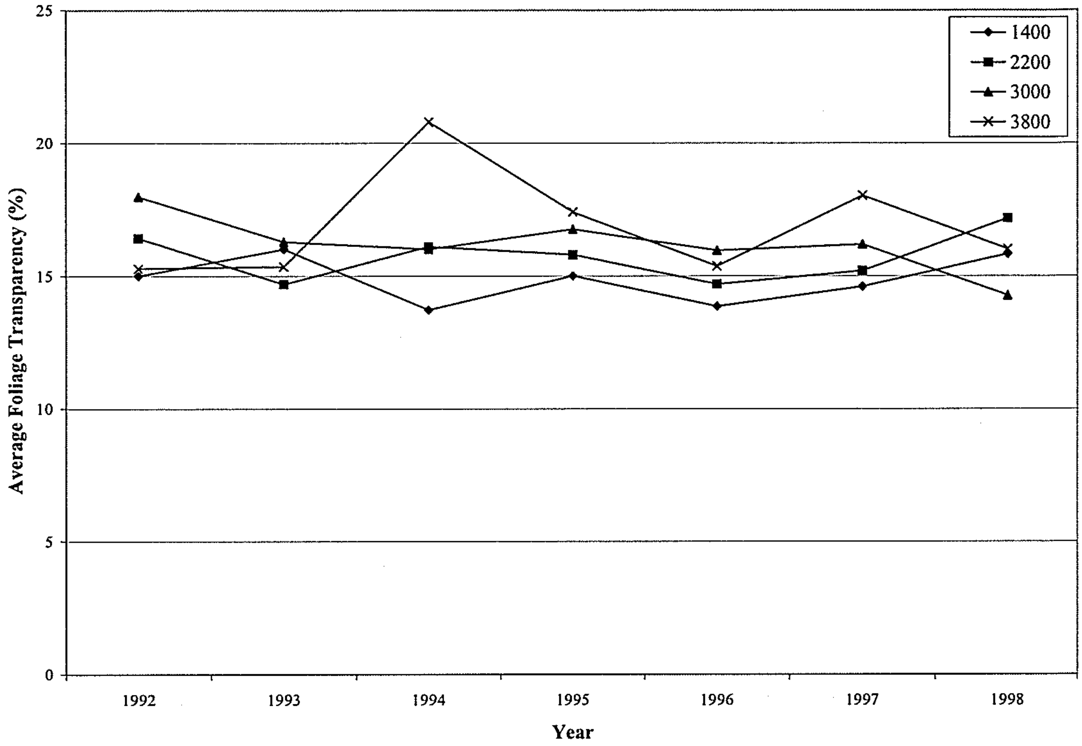


Figure 3. Foliage Transparency.



Figures 4-7. Overstory tree health in 1998 compared to 6 year averages (baseline) for survey plots at 4 elevations on the west slope of Mount Mansfield: 1400 feet (Figure 4), 2200 feet (Figure 5), 3000 feet (Figure 6) and 3800 feet (Figure 7).

Figure 4. 1400 feet.

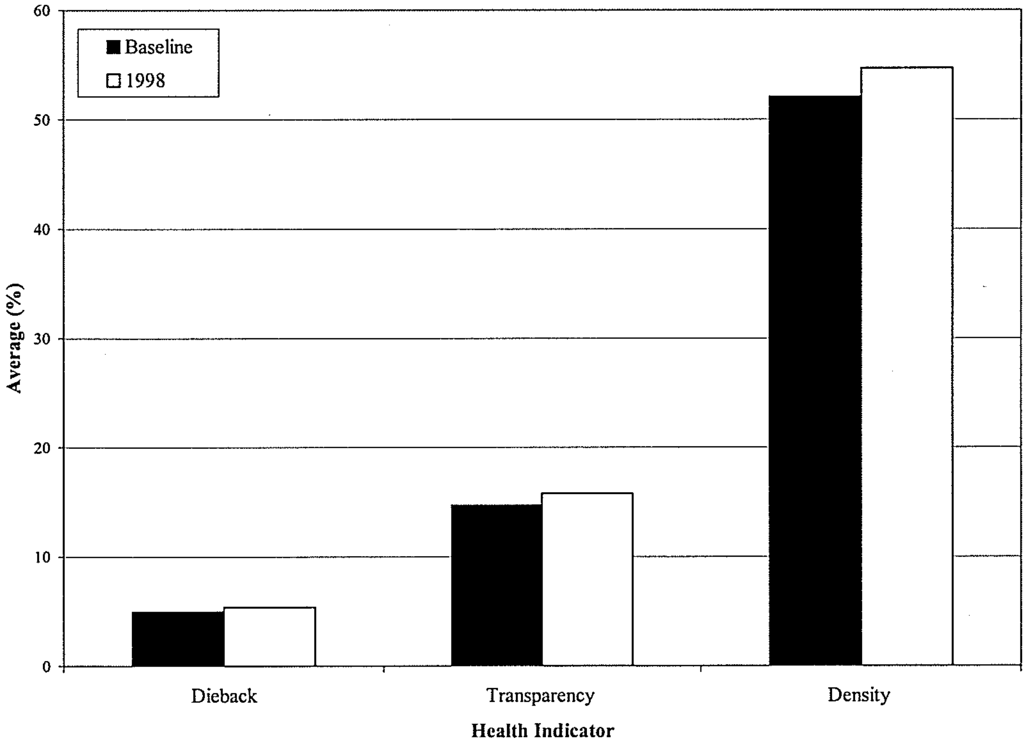


Figure 5. 2200 feet

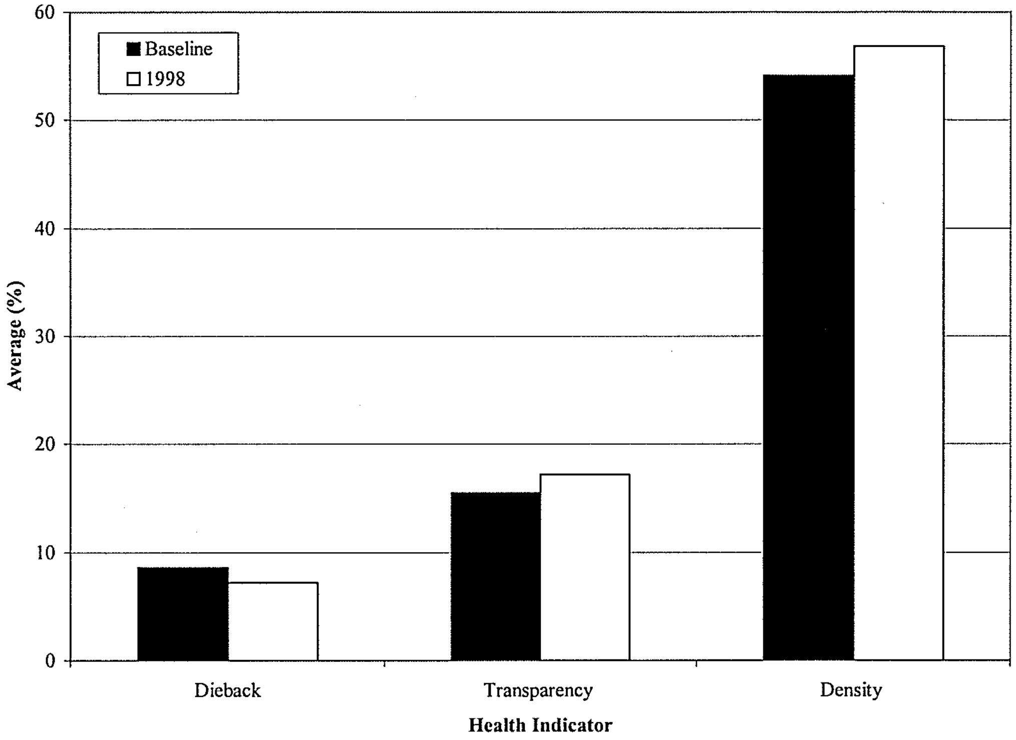


Figure 6. 3000 feet.

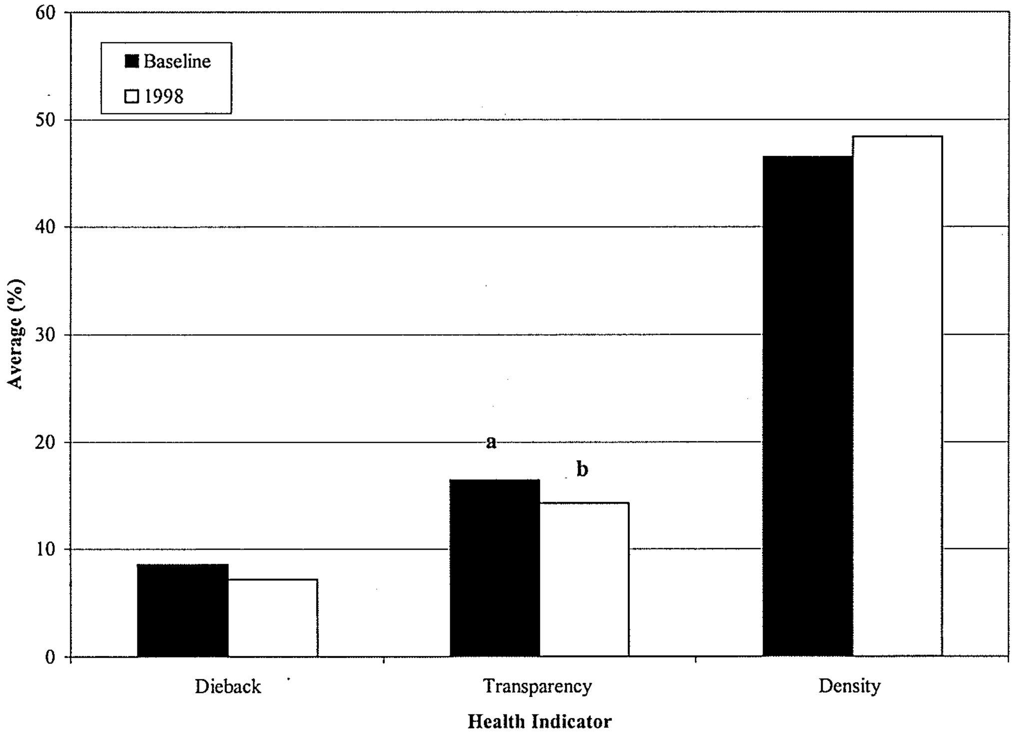
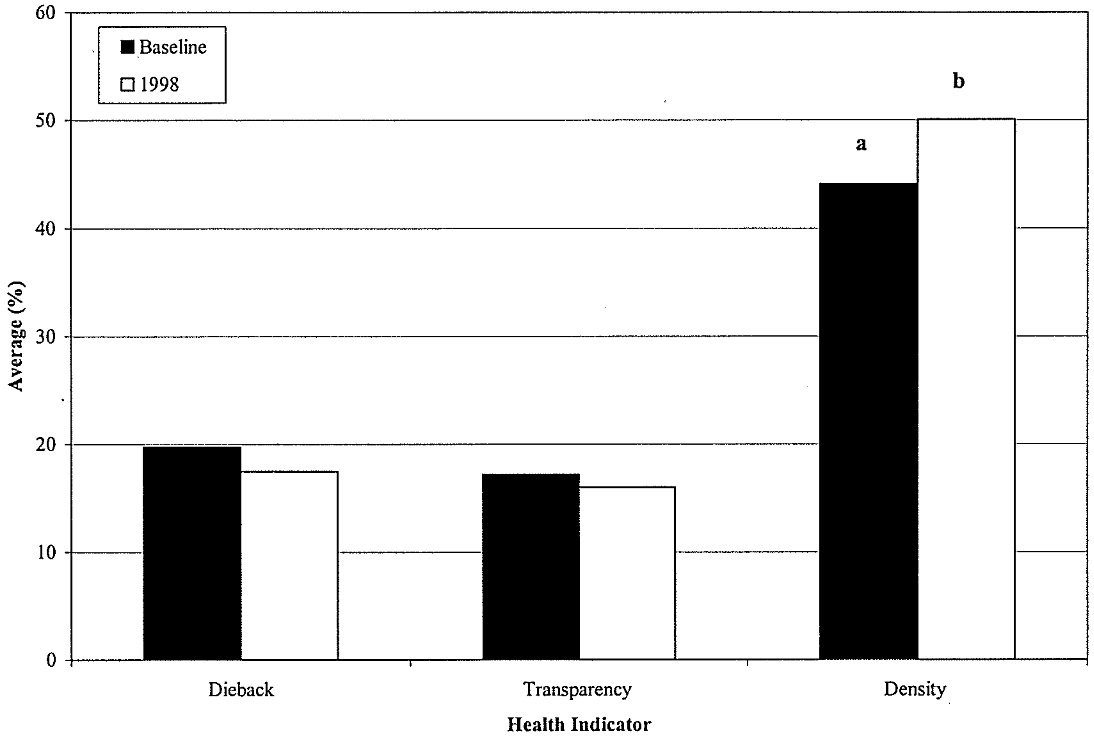


Figure 7. 3800 feet.



East slope results and comparison with west slope

Trees on the east slope of Mount Mansfield were injured by the 1998 ice storm Most of the injury resulted in crown loss (Figure 8). Tree condition during the summer following the ice storm is best illustrated using the crown density indicator (Figure 9). Results show a loss in crown density, with branches and twigs broken off, and a reduced amount of foliage. The severity of injury (percent crown loss) varied with elevation; none to light injury occurred on 1400 foot plots, moderate injury occurred at 2200 feet, and light injury occurred on 3000 foot plots (Figure10). Health conditions before the ice storm (1997) and after (1998) characterize the initial injury. Mortality of overstory trees was 2% at 2200 feet, and 9% at 3000 feet. Tree condition measurements over time will show the full impact in terms of mortality, or recovery.

Table 2. Percent of trees on west slope plots affected by significant damages in 1998. 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	27%	23% Indicator of decay
		7% Canker
		7% Dead or broken top
		2% Other
2200	63%	66% Indicator of decay
		7% Canker
		11% Open wound
		9% Damaged buds, foliage or shoots
		8% Other
		2% Dead or broken top
3000	37%	22% Indicator of decay
		11% Canker
		7% Open wound
		5% Dead or broken top
		5% Broken branches
		2% Other
3800	52%	32% Dead or broken top
		13% Indicator of decay
		12% Broken branches
		5% Open wounds
		3% Broken bole or roots
		1% Other

Figure 8. Types of tree injury caused by the June 1998 ice storm, expressed as a percent of total trees injured.

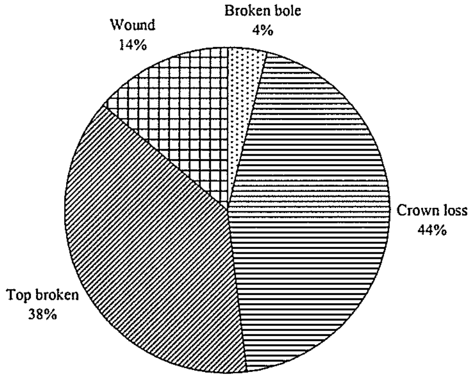


Figure 9. Crown density of trees in the summer following the ice storm, grouped by the severity of crown loss.

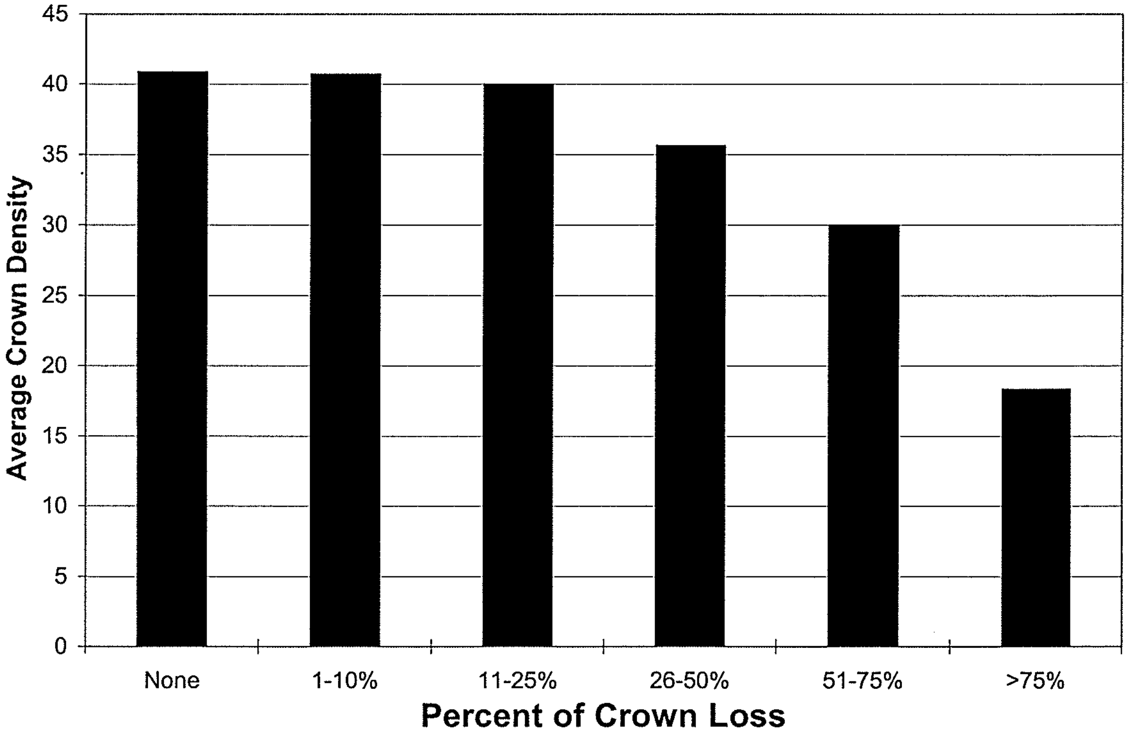
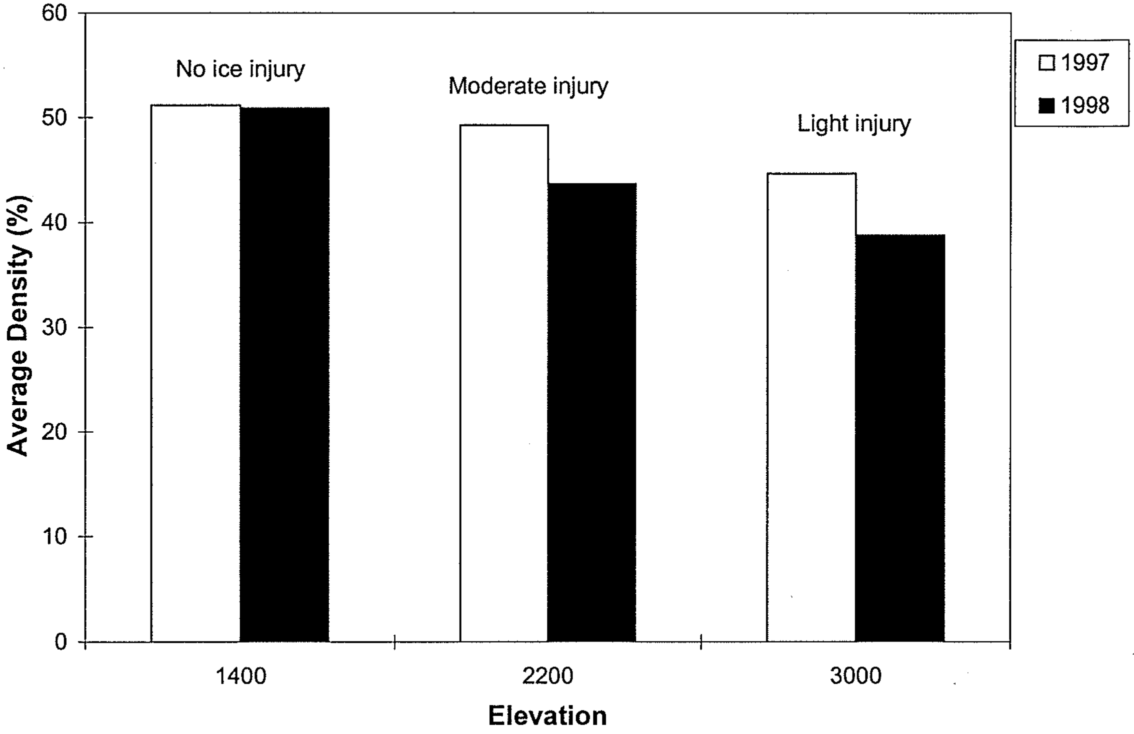


Figure 10. Crown density of trees at 3 elevations on Mount Mansfield, before and after the 1998 ice storm. Level of injury due to ice loads is based on percent of crown lost.



The most common type of damage to trees on the east slope at all elevations was indicators of decay. Other common damage types were cankers, and dead or broken tops. Injury from the ice storm was not fully captured by these damage measurements, but future ramifications from the initial injury may create trees less vigorous and more vulnerable to pathogens or mechanical injury.

Table 3. Percent of trees on east slope plots affected by significant damages in 1998. 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	47%	35% Indicator of decay
		10% Canker
		3% Dead or broken top
		11% Other
2200	53%	26% Indicator of decay
		23% Canker
		21% Dead or broken top
		11% Other
3000	39%	18% Indicator of decay
		13% Dead or broken top
		10% Canker
		6% Broken branches
		5% Open wound
		3% Other

Trees on the west slope plots at 1400 and 2200 foot elevation show higher dieback than on the east slope. Otherwise, health indicators show poorer health on the east slope for foliage transparency and crown density. The 3000 foot plots on the east slope show a greater impact from the ice storm, possibly due to poor initial health, and a lower resiliency. Relatively high dieback (11.8%), low percent of trees healthy (71%), and high mortality rate (8.8%) at this elevation on the east slope show the initial impact from the ice storm. Since half the trees on these plots are paper birch, which is susceptible to environmental stresses such as drought or ice damage, the recovery of trees at this elevation may be less successful than trees at lower elevations.

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

Health indicator	**West Slope**			**East Slope**		
	1400	**2200**	**3000**	**1400**	**2200**	**3000**
Dieback	5.4	7.2	7.2	4.6	5.8	11.8
Transparency	15.8	17.2	14.2	20.3	19.9	22.4
Density	54.7	56.8	48.7	50.9	43.7	38.8
Percent healthy	100	89	86	96	98	71
Mortality	0	0	0	0	2.2	8.8

References

Cooke, R., D., Lachance, W. Burkman & D. Allen. 1998. 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.

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

1998

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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.

Weather played an important role in forest ecosystems in 1998. It was the 5th warmest winter, the second wettest summer, and experienced heavy rains causing localized flooding. But of major importance was the January ice storm, which coated trees causing significant ice loads on Mount Mansfield from elevations beginning at about 1800'. Weather effects at Lye Brook resulted in anthracnose leaf diseases at various locations.

At Mount Mansfield, populations of most major forest insect pests were at low levels. Of the major forest insect pests monitored, forest tent caterpillar was below detection limits, spruce budworm populations remained low with no visible defoliation, and pear thrips populations as measured in the soil and emerging in the spring were lower than in 1997. A total of 491 thrips were caught on sticky traps, a decrease from 618 in 1997. Light defoliation was observed on scattered regeneration.

Surveys of ozone sensitive bioindicator plants in both northern and southern Vermont continue to detect plants with symptoms of ozone injury. In 1998, symptoms were more severe at the northern Vermont site. Both sites had cumulative SUM60 ozone exposures greater than 200 ppb-hrs when symptoms were evaluated.

Introduction

Damage to forest trees from insects, diseases and weather has played a major role in widespread tree declines in the past. Monitoring of 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 1998, the forest insects 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. Ground level ozone injury to sensitive plants is monitored at both study sites.

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, 1998).

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.

<u>Soil samples</u> 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 10 soil samples, using a bulb planter collecting tool, and in the following spring these trees are assessed for defoliation.

<u>Yellow sticky traps</u> 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, 1998). 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 2 week period of maximum ozone accumulation, mid-August, 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, pin cherry 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 a large (>3 acres) forest opening containing plants sensitive to ozone has 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 7 years, with no moths trapped. Spruce budworm populations continue at low levels, with no visible defoliation detected (Figure 1). The statewide average was 6.6 moths per trap. Pear thrips populations remained higher in 1998 than in the period from 1994-1996, but are still relatively low (Figure 2). A total of 491 thrips were caught on sticky traps, a decrease from 618 in 1997. Light defoliation was observed on scattered regeneration and trees. Southern Vermont experienced significant pear thrips defoliation, affecting over 36,000 acres.

Mount Mansfield and Lye Brook Wilderness Area
Results And Discussion

Ozone injury symptoms were confirmed at both northern and southern Vermont sites. Although southern Vermont received higher cumulative ozone levels, injury symptoms at the northern Vermont site were heavy (Figure 3). Severity of injury to sensitive plants was light to moderate at the southern Vermont site, and ranged from light (on black cherry and milkweed) to heavy (on blackberry).

Results from aerial surveys to map areas of defoliation and decline at the Lye Brook Site detected damage from anthracnose fungus at various locations in and surrounding the wilderness area (Figure 4). This summer was unusually wet, resulting in fungal diseases on many species. Sugar maple, paper birch and yellow birch showed the heaviest damage from fungal attacks. Statewide, nearly 250,000 acres of anthracnose damage was detected.

Mount Mansfield forests were affected by the January ice storm that coated branches and twigs with thick ice, 1-5 inches of ice accumulation (Figure 5). Statewide, 940,000 acres of forest land were affected by ice. While ice on the west slope of the mountain began melting within a few days, trees on the east slope remained laden with ice for several weeks. Extensive ice loads to trees were mapped on both the east and west slopes of the mountain. Most of the injury occurred above 2300 feet on the west slope, and above 1800 feet on the east slope of the mountain. Ground surveys showed that most of the injury was due to crown breakage, especially to hardwood trees.

Acknowledgments

Aerial survey and ground plot data collection was conducted by dedicated Forest Resource Protection staff. GIS maps of aerial survey data was provided by Tom Luther of the USDA Forest Service, Northeastern Area State & Private Forestry in Durham, NH. Ozone data has been generously provided by the Vermont Air Pollution Control Division. Financial support has been provided in part by the USDA Forest Service, Northeastern Area State & Private Forestry, the National Forest Health Monitoring Program and through the State of Vermont.

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

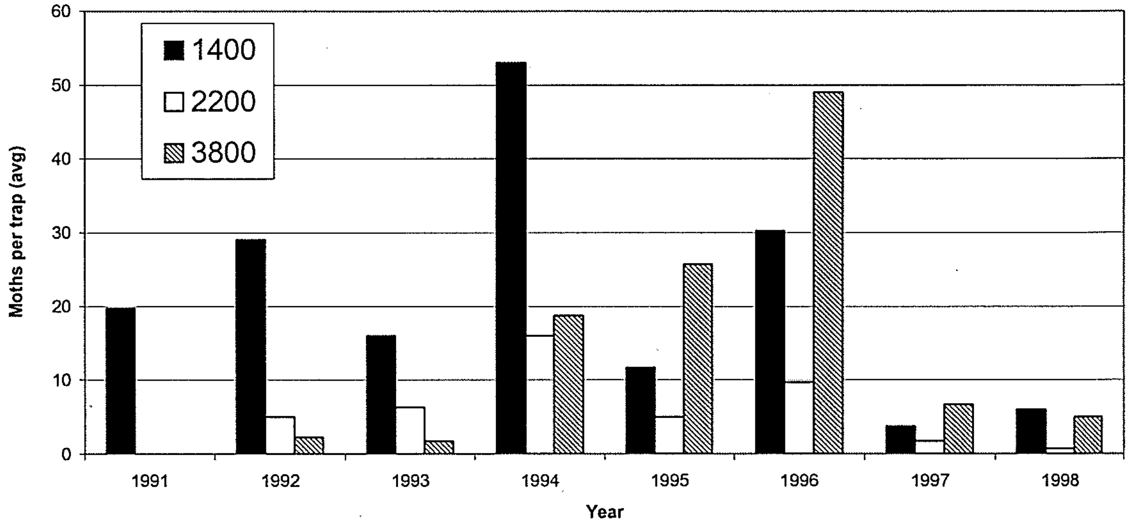


Figure 2. Pear thrips population monitoring on Mount Mansfield at 1400 feet. Comparison of overwintering soil population and emerging adult population.

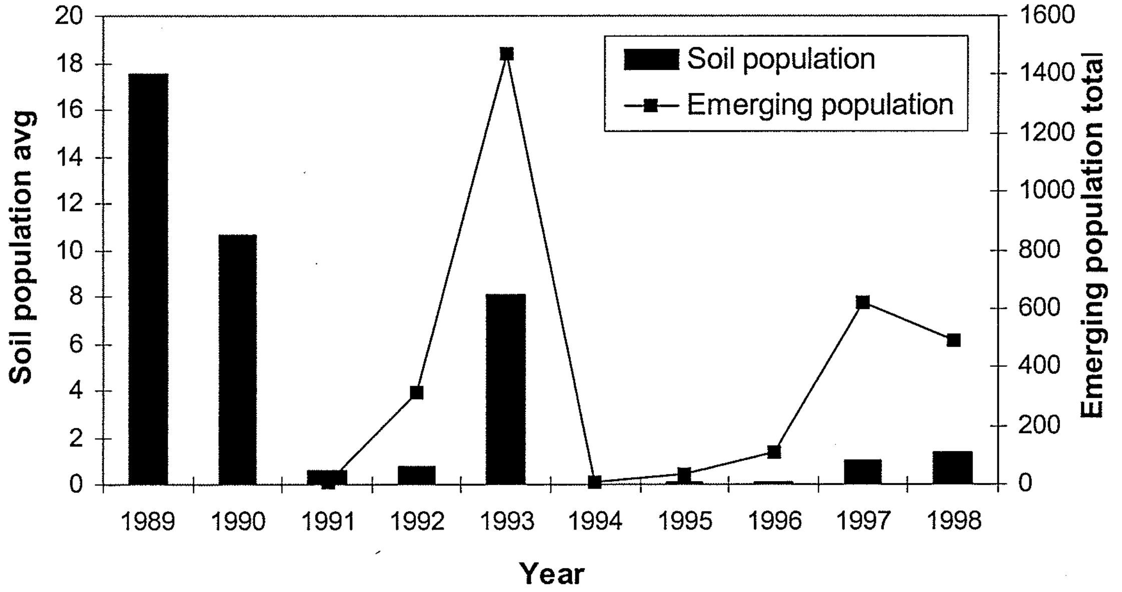


Figure 3. Weekly cumulative ozone exposures (expressed as cumulative sum60 ozone based on 24 hour period) representing the Mount Mansfield (Underhill) and Lye Brook (Bennington) study sites compared with injury to ozone sensitive bioindicator plants surveyed at Underhill and Rupert (Bennington County). 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%. Plant injury symptoms were present at both sites.Injury symptoms at the southern Vermont site were moderate, while heavy at the northern Vermont site.

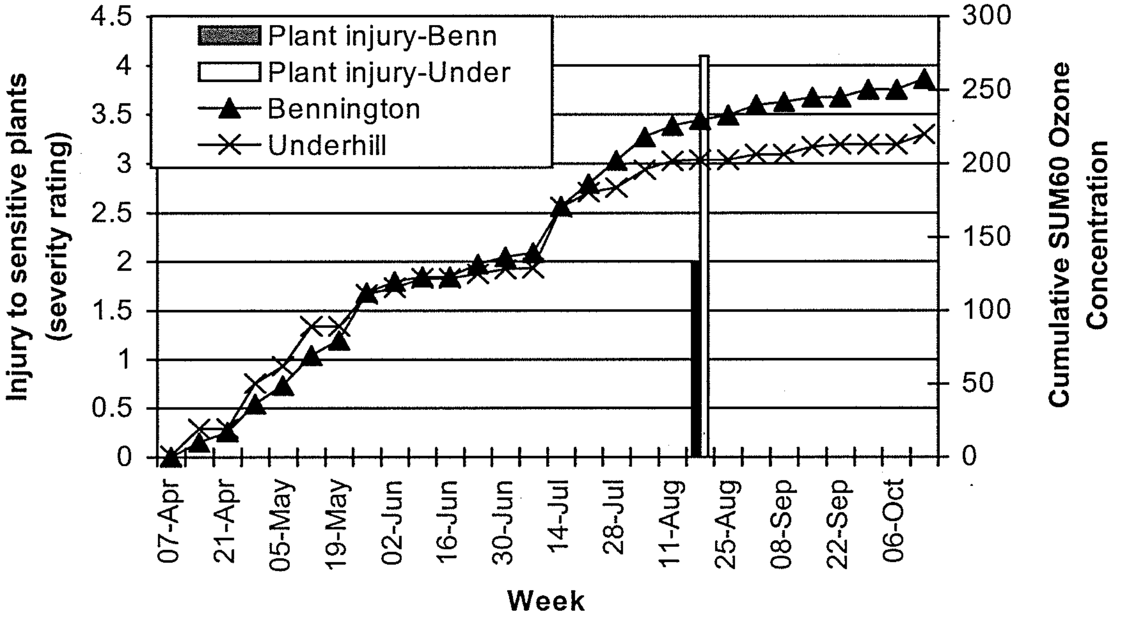


Figure 4. Forest damage mapped in Lye Brook Wilderness Area, 1998.

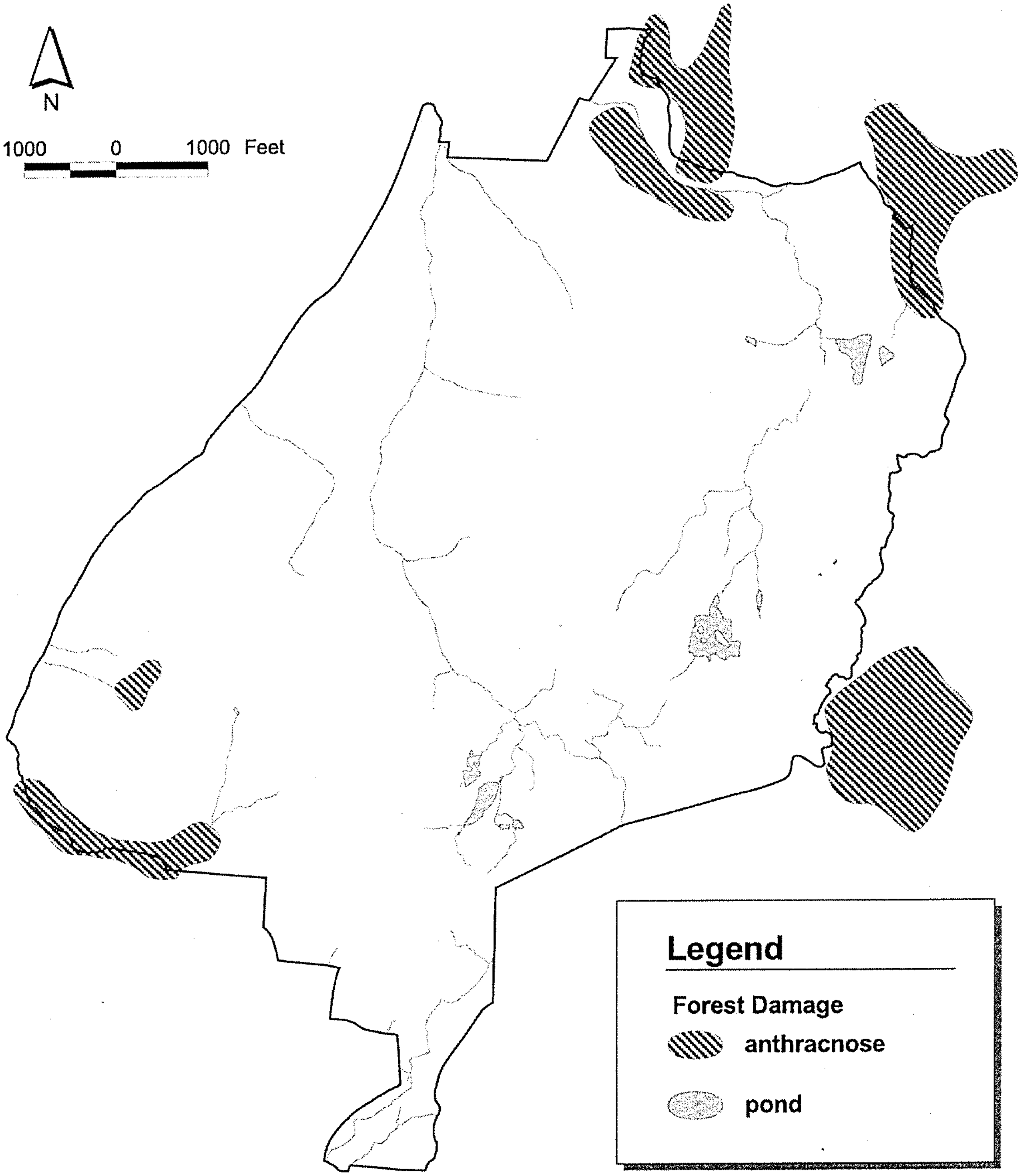
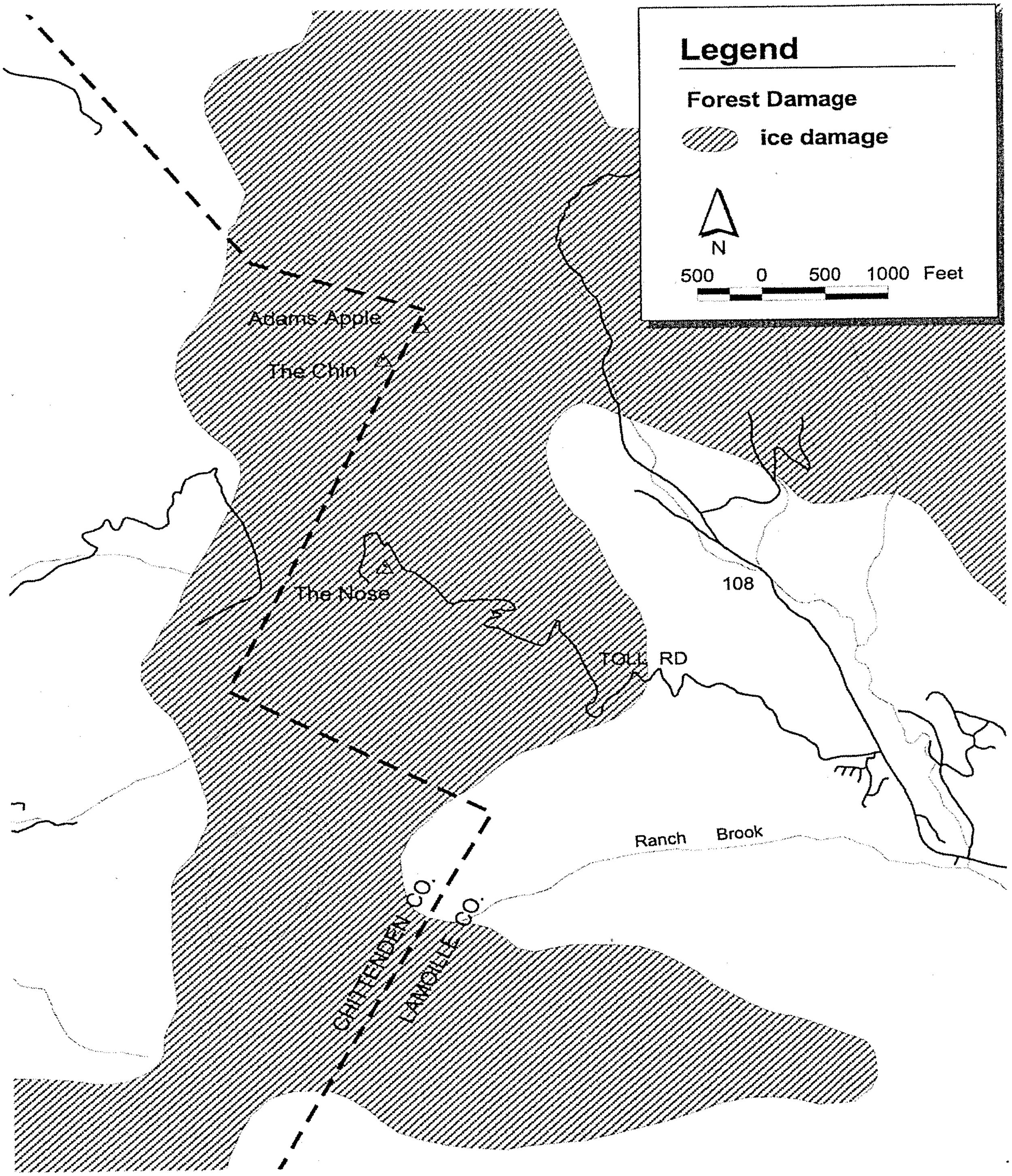


Figure 5 . Forest damage mapped on Mt. Mansfield, 1998.



Landscape fall color assessments and development of a monitoring protocol

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Introduction

The timing, duration, and quality of fall color have been used for years as indicators of tree health on an individual tree basis. At the same time, these fall color elements are important to Vermont's tourist industry. Vermont foresters evaluate fall color each year and report their findings regularly to the Department of Travel and Marketing. Slightly different methods, terminology, and categories of color quality have been used by each individual making tree assessments. The purpose of this study, which began in 1997, was to compile information on techniques currently being used by foresters in fall foliage spotting for tourism and evaluations for forest health, and determine if a more systematic standardized approach could be developed.

Objectives

1. Compile information from County Foresters, Fall Foliage Spotters, and other professional foresters on techniques used to assess the timing, duration, and quality of fall color and leaf drop.
2. Develop a method for collecting data on the timing and duration of fall color and leaf drop to be used on forested landscapes for forest health assessments.
3. Make recommendations on a standardized method for data collection on the timing, duration and description of fall color for use by County Foresters and others who gather data annually on fall color for "viewing" purposes.

The methods and recommendations used for assessing fall color for "viewers" vs "forest health" are quite different, so will be examined separately.

Assessments for Fall Color Viewing

Methods:

Currently, each County Foresters working for the Department of Forests, Parks & Recreation is responsible for gathering information on fall color conditions in their area throughout the foliage season. This is done formally (i.e. repeatedly visiting certain key viewing spots or routes, or using a data sheet developed a number of years ago by the Travel Division), and informally (i.e. making observations during travels throughout the county). Information gathered is forwarded to the Department of Travel and Marketing twice weekly. Types of information that are valuable to this process include:

1. Where to find good foliage (i.e. certain routes, swamps vs hillsides, upper elevation vs lower elevation, etc).
2. Categories used to rate foliage viewing (i.e. early color, peak color, etc).
3. Descriptive words for color quality (i.e. brilliant, pastel, flashy, etc.).
4. Knowledge of factors that contribute to good fall color.
5. Range of dates for viewing that is specific for each area.

In October, 1997, a questionnaire was sent to each county to determine how these factors were being used by each forester, and to aid in developing standard methods for the future.

Survey Results:

Color Quality.

The quality of fall color can vary between years and between locations. All foliage spotters agreed that having brilliant colors was the most important factor for color quality (Table 1). The second most important factor, having to do with specific locations, was a contrast of tree species with good color. The third most important factor was to have good viewing weather (sunshine). Many of the respondents agreed that good color quality means greater than half the trees with color, and very little leaf drop.

Table 1. Results from a survey of "fall foliage spotters" on what they feel the most important factors in fall color quality are at a location or in a given year.

Most important factors in color quality at a location or in a given year.	**Percent of respondents**
Brilliant colors	100
Contrast of species with good color	85
Viewing weather is good	62
Greater than half the trees have turned color, and with very little leaf drop	54
Mix of color stages	46
Tree turn color all at the same time	46
Significant color lasts for longer than usual	31
Trees turn color at varying times	23

Definition of "peak color"

The definition used on the Foliage Spotter data forms defines peak color as: "brilliant, full color, 100%" (Table 2). Yet, there seems to be a wide range of opinions on what the definition should be. When asked if "peak" were based on a percent of the hillside with color, what should it be, the range was 50 to 100%. When asked if "peak" were based on a percent color and a percent leaf drop, what should it be, the range was even greater (40-100% color and 5-60% leaf drop). Most people felt that peak (or best viewing) should include some color, some green, and little leaf drop (Table 2).

Table 2. Foliage Spotter Data Form definitions of fall color stages.

Foliage Stage	**Description**	**Percent color**
Early	Color starting to appear	0-40%
Mid	Half-way to peak	40-60%
Near Peak	Almost full color	60-90%
Peak	Brilliant, full color	100%
Past peak	But still generally colorful	
Isolated color	Spotty conditions	

Table 3. Results from a survey of "fall foliage spotters" on how they would define the "Peak Color Stage".

Color range	Leaf drop range	Other Comments
70-100	5-30	Peak viewing should be based on a date for that area.
80-90	10	Peak viewing should be based on a date for that area, and be 5 days before and after that date.
50-60	10	Highest % of trees have changed color just before leaves start falling noticeably.
80	60	Some green is necessary; by the time green is gone, some trees have dropped leaves.
40-100	5-30	Color changes rapidly after you near 50%; if peak is 50%, color will last long enough for enjoyment.
50-100	Not important	When largest number of trees are at their most brilliant (even though some are still green and some have gone by).
70-100	5-40	Peak is when color is its best; the % varies from year to year.
90-100	5-20	Peak should refer to an expected percent color for that site, so requires an observer to know what to expect from different reference locations.
70	20	Peak is when all trees are brilliant, no browning, and no twigs are visible.
70	5-20	Peak foliage can be seen on individual trees long after the whole panorama has past peak.

Descriptive words for fall color

The survey asked foresters for words they use to describe fall color. Results are as follows:

"Brilliant, intense, awesome, bright, flashy, gorgeous, sharp, crisp, exceptional, radiant, on-fire, florescent, dramatic, superb, stunning, muted, dull, mottled, dark, light, pastel, gentle, spotty, pumpkin, russett, bronze, washed-out."

One respondent suggested that a plant tissue color chart could be used to standardize descriptions of colors statewide. This would facilitate description consistency between years.

Recommendations

For the purposes of fall foliage viewing, the two most important factors (data) needed to provide viewer satisfaction are: 1) routes or viewing locations where visitors can see high quality foliage, and 2)communicating this information to the Department of Travel and Marketing where the public can gain access to the information. The definitions and methods used by each individual vary greatly. Additional information on viewer satisfaction would be needed to determine which definitions and methods are most successful. Since all foliage spotters share the goal of providing information on where the best foliage can be viewed, it is possible to achieve statewide success without standardizing. If there is a need to standardize, a survey of foliage viewers would be needed to determine appropriate standards.

While this study was not successful in developing one standardized method for foliage spotters, the compilation of color descriptions, definitions of variables, and methods used for collecting data should provide a foundation for current and future foliage spotters to assess their individual techniques.

If, in conjunction with annual foliage reporting, foliage spotters are interested in collecting data to monitor differences between years at a given location, a method such as that for the forest health monitoring system should be implemented.

Forest Health Monitoring System

Individual tree monitoring of fall color and leaf drop on Mount Mansfield has been ongoing since 1990 as part of the Forestry Division's forest health monitoring efforts under the Vermont Monitoring Cooperative. While this monitoring effort has provided valuable information on tree stress effects on fall color, some landscape-level stress effects were not always captured on individual trees. This project attempts to complement existing individual tree monitoring by expanding it to a landscape-level, where addition species and site characteristics can be evaluated.

Methods

In selecting sites to use for forest health evaluations, the following factors were considered: 1. sites where hillsides or a large forested area can be viewed and photographed from easily accessible locations, 2. numerous sites (3-5) selected that represent a range of landscape characteristics (swamps, low elevation, high elevation) and forest types (northern hardwood, birch, etc), and 3. sites with predominantly hardwood trees (more than 85%). Other factors that were considered in site selection were: stand age, species composition, elevation span, aspect, drainage, and disturbance history.

Eight locations were selected on and around Mount Mansfield, representing a range of elevations and aspects (Table 5). Most viewing sites were roadside. Detailed descriptions of survey points were made to make it possible to view and photograph from the same locations each time. A tripod, level, and compass were used to repeat the viewing and photographing locations. The initial photos were used as a guide for viewing and photographing consistency.

The first year of monitoring determined the beginning and ending dates for future monitoring in each area. For monitoring at Mount Mansfield, monitoring was conducted from the end of August through October. Ratings and photographs were done weekly during the first year to establish color and leaf drop timing. Every other week ratings were used during the second year.

At each visit, the date, percent color, percent green, percent leaf drop, species changing color, color quality or brilliance, "foliage spotters description" and notes were recorded, and a photograph was taken. Color and leaf drop are visual ratings based on area affected, and recorded in 5% intervals (0=0, 5=1-5%, 10=6-10%, etc). Percent color is defined as the amount of forest foliage with color other than green. Percent green is the amount of forest foliage that is green. Leaf drop is based on branches without leaves (gray area), so is the amount of forest foliage dropped from trees. Percent color, green and leaf drop combined total 100. Percent color and leaf drop are added together in data analysis to reflect the area of a hillside that has changed color with or without leaf drop. Recording the species that are showing significant color aids in identifying which species do or do not have brilliant colors for a given year. For forest health monitoring, these 4 measurements are the most critical.

Color quality is a totally subjective rating that attempts to capture color brilliance and beauty. A numeric rating is given, from 1 to 10, where 10 is a once in a life-time color scene. Factors contributing to quality rating include: a variety of colors, sharpness of crowns shape, lack of leaf drop, strong colors, and weather conditions at the time of viewing (sunny, cloudy, hazy). Besides allowing a comparison of fall color between years, this information helps to interpret the effects of wind, rain, snow or other environmental conditions on fall color and leaf drop.

A rating of "foliage spotters stages" was also recorded to learn how this system relates to the other measurements recorded (Table 2). Notes on color descriptions, stress agents involved in early color or leaf drop, and other assessments provided a valuable data supplement.

Special requirements were needed for photographs. Sunny, haze-free days were provided to secure the best photo representations of what was seen visually. Any low clouds shaded areas of the hillside making them too dark in photos. The sun also had to be high enough above the horizon to prevent photos being taken into the sun. As day length diminishes in October late day visits had to be avoided. When possible distinctive landscape features were used in the photographs to aid in replicating the same view (telephone poles, houses, fence posts).

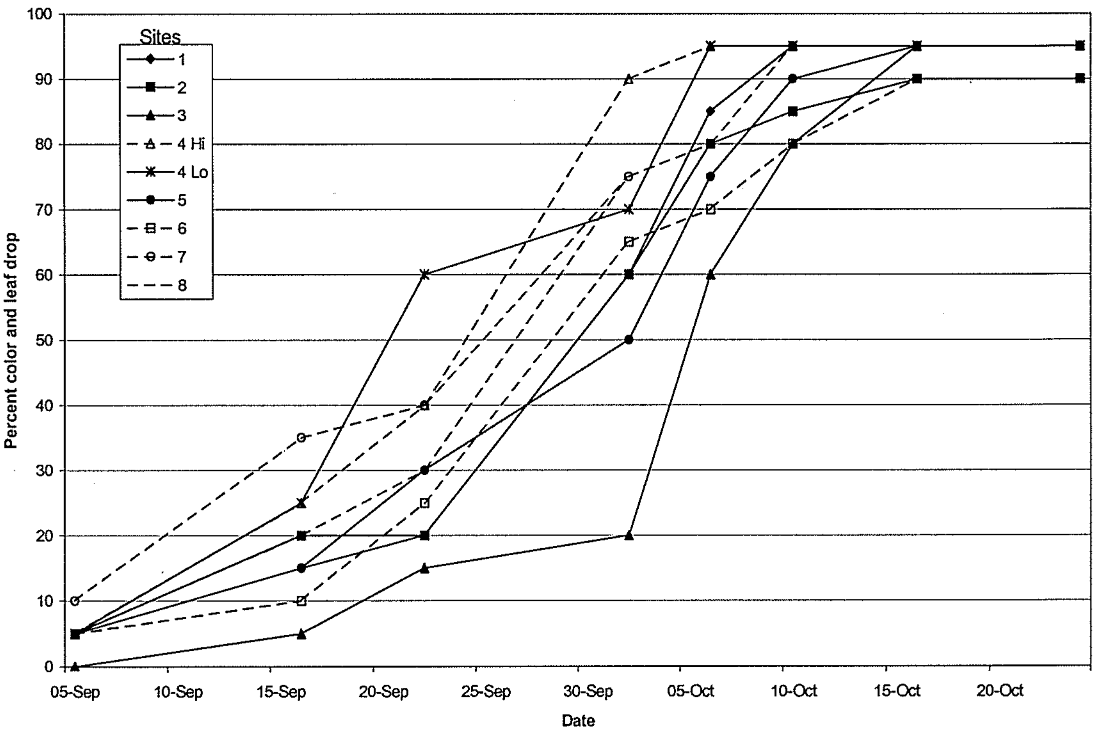
Table 5. Site descriptions of the eight landscape fall color monitoring locations on and around Mount Mansfield.

Site	Elevation range (ft)	Aspect	Forest Type	Predominant Species	Notes
1	900 – 1800	East	Northern Hardwoods	Red maple, sugar maple, birch, aspen	
2	1100 - 1700	Northwest	Northern Hardwoods	Sugar maple, beech, birch, aspen	Recently logged
3	1000 – 1500	Northeast	Hardwoods	Beech, birch, poplar	
4	1000 – 3000	West	Mixed: high elevation yellow birch, low elevation hardwood	Yellow birch; red maple	mid-elevation recently logged
5	1000 – 1800	South	Northern Hardwoods	Maples	
6	1100 – 1500	Southwest	Northern Hardwoods		
7	1100 – 2500	Southwest	Northern Hardwoods	Sugar maple	
8	1100	East	Northern Hardwoods	Red maple, sugar maple, poplar	

Results

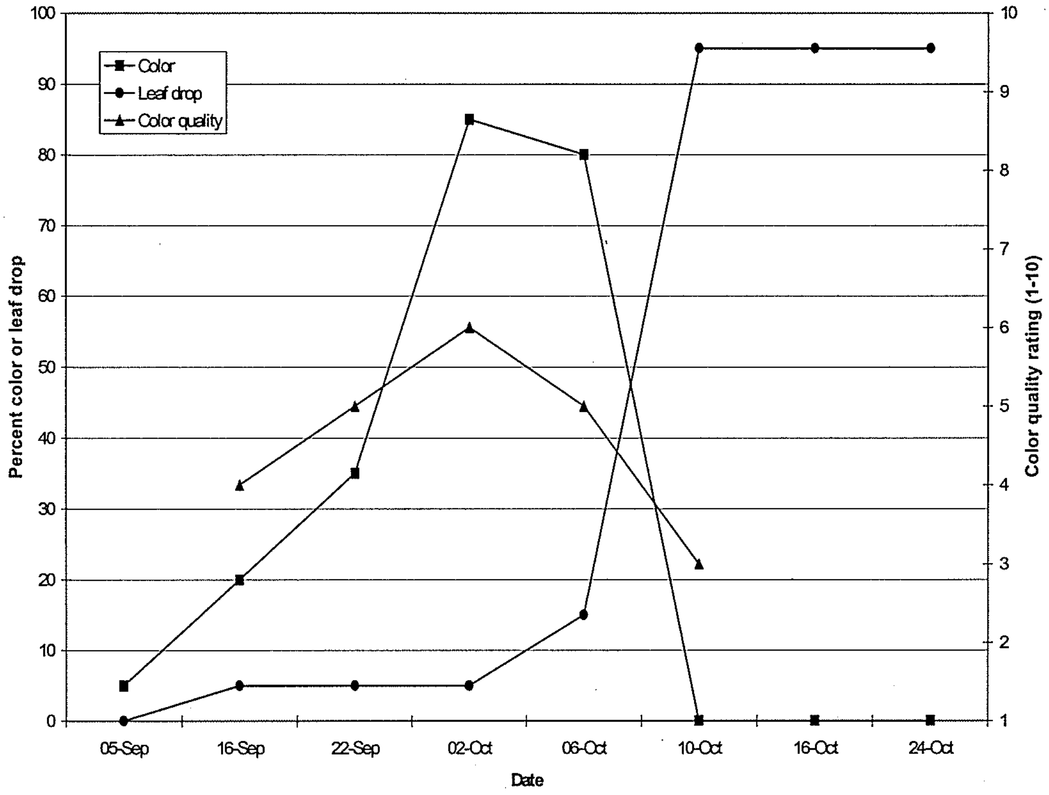
Variation between sites. The timing of leaf color and drop varied greatly between the eight sites monitored (Figure 1). The two extremes were Sites 3 & 4. In early October 1997, Site 4 had 90% color and leaf drop, while Site 3 had only 20%. The sites selected represent the range of elevations found in the Green Mountain Biophysical Region: high elevation sites (Sites 4 & 7), and low-to-average elevations (Sites 1, 2, 3, 5, 6, & 8). These sites do not include red maple swamps, oak forests, as well as other unique landscape-forest type situations, but they do represent many of the forested conditions typical of this biophysical region. While more data are needed to establish a baseline of "normal" fall color timing and duration, the absence of significant stress in 1997 could be interpreted as what should occur during normal years.

Figure 1. Fall color and leaf drop ratings from 8 sites on and around Mount Mansfield for 1997. There is a wide range in the timing of color and leaf drop between sites.



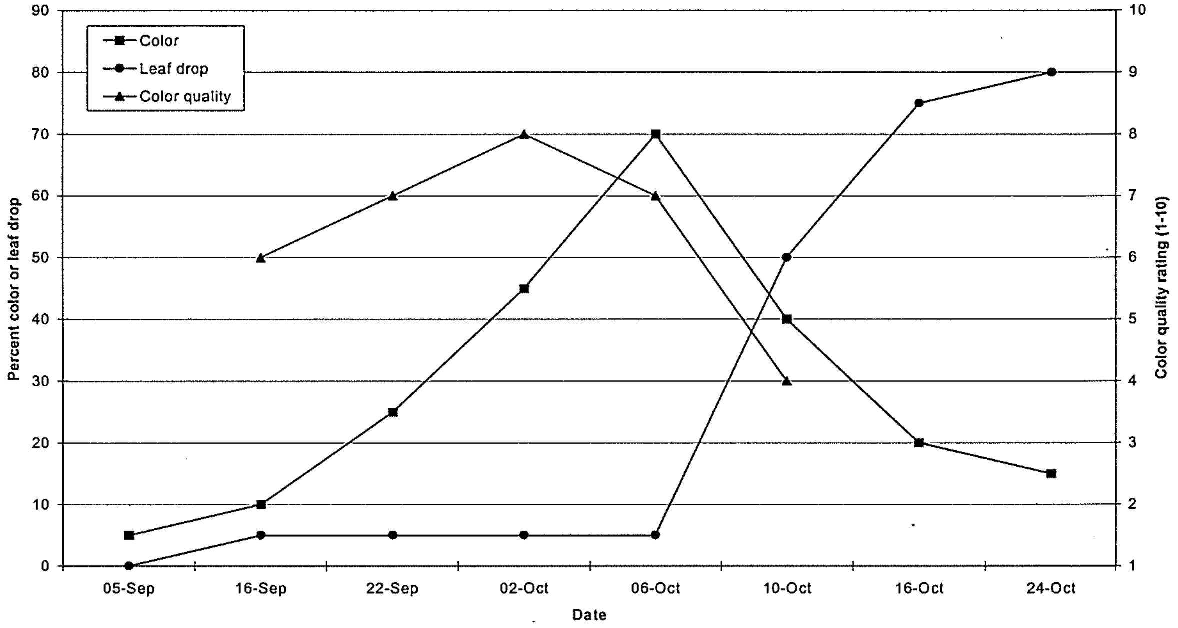
Comparison of measurements. Each of the measurements: fall color, leaf drop and color quality; can provide valuable information on the impact of stress events on tree health. Early color is common on individual stressed trees (e.g. tree decline from beech bark disease, drought impacts). In extreme stress situations, leaf drop can be premature. And color quality can be affected by significant insect defoliation, browning from leaf diseases or scorched leaves, as well as from weather events during fall color season (e.g. frost). The interpretation of results for each year should vary depending on current and past stress events, site conditions, and species. For 1997, growing conditions were favorable to tree health, so few trees had early color or leaf drop. A long gradual fall color season where color improved but leaf drop was delayed produced one of the best viewing seasons in recent history (according to veteran fall foliage spotters) (Figure 2). Using one site (Site 4) as an example of the interaction of measurements, peak color quality occurred on October 2nd, with nearly 85% of the hillside with fall color and 5% leaf drop. There was a slight decrease in color quality on October 6th, as leaf drop increased to 15%. By October 10th, full leaf drop had occurred, and with it, tree dormancy for the year.

Figure 2. Fall color, leaf drop and color quality measurements for one site on Mount Mansfield (Site 4) in 1997. Color quality was at its peak on October 2nd when nearly 85% of the hillside had fall color, and less than 5% of leaves had dropped.



Relationship between color and weather. Seasonal weather also plays a role in the timing and duration of color and leaf drop, as well as color quality. In 1997 at Site 5, color and color quality advanced to October 2nd (Figure 3). Between October 2nd and 6th, a snow storm coating foliage reduced the brilliance of color quality, but did not affect leaf drop. Between October 6th and 10th, a wind event triggered significant leaf drop.

Figure 3. Fall color, leaf drop and color quality measurements for one site on Mount Mansfield (Site 5) in 1997. Color quality was affected by early season snow accumulation between October 2nd and October 6th that reduced foliage brilliance, but did not affect leaf drop.



Comparison between years. The Mount Mansfield area data shows that fall color began earlier in 1998 than in 1997 (Figures 4 and 5). During the third and fourth weeks of September, significant color was observed in 1998, while only early color was observed during the same time period in 1997. Early fall color can be an indication of tree stress. The spring of 1998 was dry, followed by an over-abundance of precipitation during the summer months, creating a favorable environment for many leaf diseases. These two factors may have contributed to stress-induced early coloring. However, with two years of monitoring data it is premature to make conclusions about one year being early or late.

Many foliage spotters reported better than usual fall colors in 1997. While the "color quality ratings" for 1997 and 1998 are similar (indicating the difficulty and subjective nature of the rating), the viewing period was longer in 1997 because leaf drop was nearly a week later than in 1998.

Figure 4. Comparison of 1997 and 1998 fall color and leaf drop combined for all 8 sites monitored at Mount Mansfield.

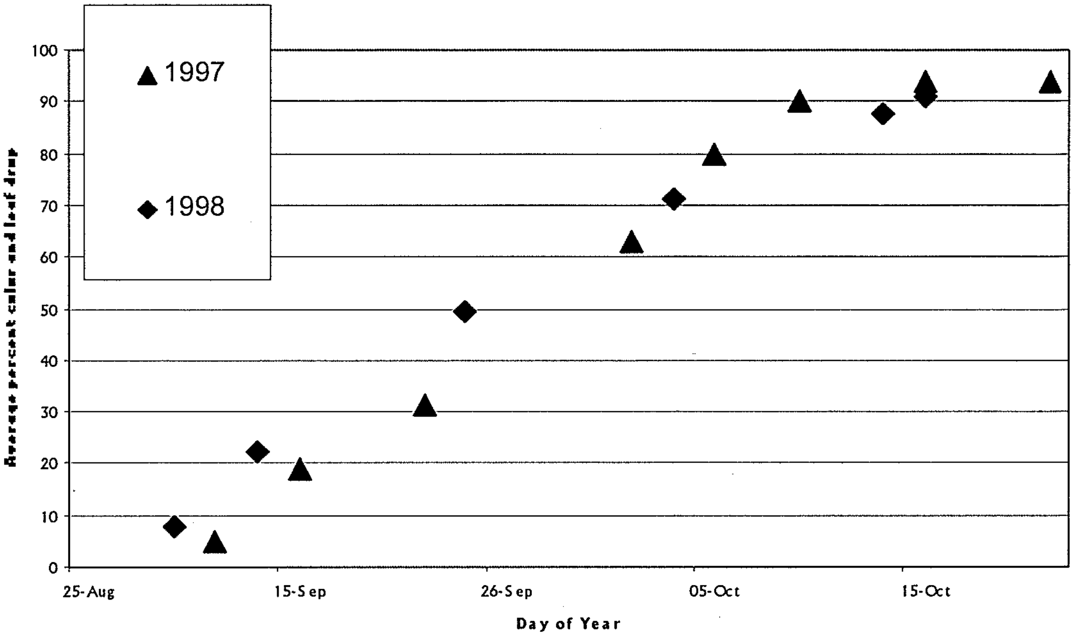
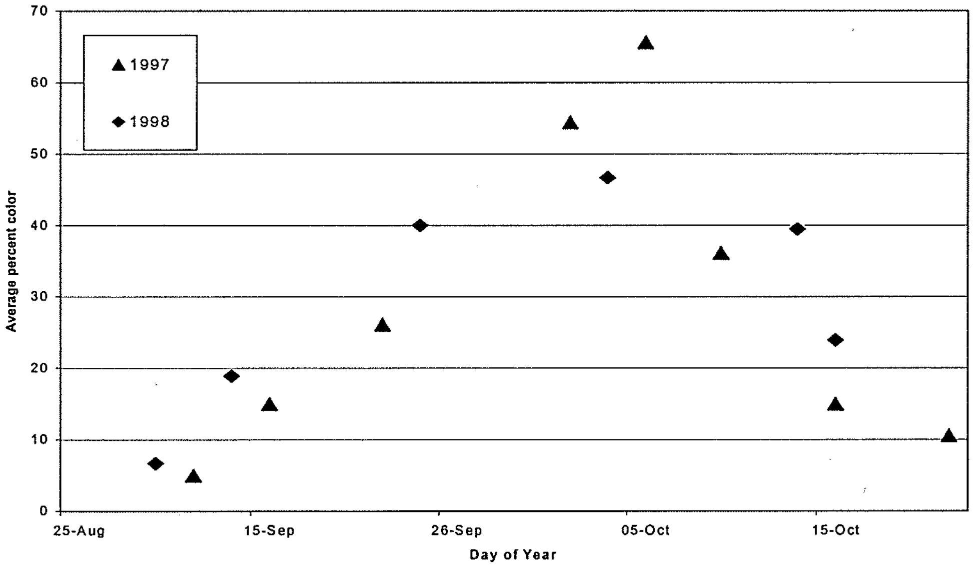


Figure 5. Comparison of 1997 and 1998 fall color for all 8 sites monitored at Mount Mansfield.



Discussion

The most difficult part of this monitoring technique is the choice of locations to monitor. The interpretation of results will depend on site characteristics (wet or dry, high of low elevation, etc) and tree species composition. The locations chosen at Mount Mansfield seem to capture a wide range of site characteristics representative of this biophysical region. Two years of using the methods described here has illustrated differences between years in how stress events affect fall color and leaf drop. This visual procedure is difficult, but was aided by past work rating individual trees for fall color. Remeasurement of these data in 1998 by an independent rater showed that the measurements of color and leaf drop were consistently within

0-10% at each site. The color quality rating was more difficult to reliably repeat, but seems valuable especially where stress agents can influence fall color in ways other than timing and duration.

The advantage of this monitoring system compared to current foliage spotter's techniques is that the same locations are used throughout the season and between years, providing data to support observational information. Due to the limited geographic spread of this method, however, it will not satisfy many of the needs for fall foliage spotter information.

Plans for the future include more extensive characterization of each of the sites (soil depth, slope, tree species composition and age, etc), investigation into computer software packages that could calculate color and leaf drop, and further testing of these methods by other foresters in a statewide pilot project.

Temporal and Spatial Patterns of Stomatal Conductance, Ozone Concentration, and Ozone Uptake in a Sugar Maple Canopy (Thesis Excerpts)

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University of Vermont

Abstract

Tropospheric ozone is considered to be a contributory factor in widespread forest decline due to its phototoxicity and oxidizing capacity. Data from monitoring sites in the northeastern United States indicate that high ozone episodes are frequent in rural forested areas distant from ozone precursor sources. To develop a better description of potential ozone interactions in forest canopies, temporal and spatial patterns of stomatal conductance (g_s), ozone concentration (O_3), and other environmental variables were studied at five heights on a tower in an Acer saccharum Marsh canopy in Underhill, Vennont for 11 days. Both g_s and O_3 decreased with increasing depth in the canopy, with an average difference of 25% and 22% between the upper and lower canopy, respectively. Significant differences across time were found for both g_s and O_3. Both show a similar diurnal pattern reaching maxima in the early afternoon and decreasing in the evening. Regression analyses suggest that quantum flux density is the principal driving force for temporal and spatial patterns of g_s. Temperature was also found to influence both O_3 and g_s. Vertical differences in O_3 uptake per unit leaf area were a function of differences in g_s, while vertical variation in cumulative O_3 uptake was found to be a result of differences in leaf area density between heights. Uptake per unit leaf area ranged from 0.2 mmol $m^{-2} h^{-1}$ to 34 mmol $m^{-2} h^{-1}$, and cumulative uptake ranged from 0.05 mmol $ha^{-1} h^{-1}$ to 1000 mmol $ha^{-1} h^{-1}$. in the upper canopy. A large proportion (85%) of the total canopy 0_3 uptake was observed in the upper crown (>10m) where the bulk (86%) of the total carbon gain in a sugar maple canopy occurs. Thus, the combined effect of higher O_3 and g_s in the upper canopy may result in decreases in carbon gain as O_3 and its precursors (NOx and VOC's) increase in the United States, as they are predicted to do. From this detailed evaluation of canopy processes it can be shown that scaling up from values of g_s and O_3 at one height and time underestimated total canopy ozone uptake by 50%.

Data Analysis

Data were analyzed using the general linear models procedure and regression techniques of Statistical Analysis Systems (SAS, Inc., 1996, Cary, North Carolina, USA). To test for differences across heights and time for stomatal conductance, ozone concentration, ozone uptake, and meteorological data, a 3-way repeated measures ANOV A was used. It was assumed that compound symmetry was not a problem since the covariance for each observation would not have been constant due to efforts made to avoid re-sampling of leaves. The Student-Neuman-Kuels test was used to assess pair-wise differences when main or interactive effects were significant. When interaction between height and time was observed the error term for height x time x date was used. When data did not meet the assumption of normality they were ranked and a non-parametric test was usued to test for differences, and normality plots were examined for all variables. The level of significance is $p \sim 0.05$ for all reported statistical differences.

Table 1. Sums of Squares and probabilities associated with g_s, O_3, and uptake (per unit leaf area and cumulative) across heights and times (N=315).

Variable	**Type III SS**	**F-Value**	**Pr > F**
a. Stomatal Conductance (g_s)			
Height	299579	298.34	0.0001
Time	236508	121.50	0.0001
Height x Time	32987	10.5	0.0001
b. Ozone Concentration (O_3)			
Height	62356.3	58.65	0.0002
Time	16417.82	6.7	0.0001
Height x Time	79591.7	19.81	0.0001
c. Uptake per unit leaf area			
Height	303.2	35.54	0.0001
Time	172.2	30.99	0.0001
Height x Time	44.22	9.02	0.0001
d. Cumulative Uptake			
Height	4296.5	32.8	0.0001
Time	473.56	29.64	0.0001
Height x Time	655.58	655.6	0.0001

Table 2. Relationships between stomatal conductance (g_s) (mmol m^{-2} s^{-1}), ozone (O_3) (ppb), and ozone uptake (per unit leaf area [μmol m^{-2} h^{-1}]) and meteorological variables in a sugar maple canopy.

Independent Variable	**(a) g_s**	**(b) Ozone**	**(c) Ozone Uptake**
PPFD (Photosynthetic Photon Flux Density)	r^2=0.482, p=0.0001	r^2=0.0033, p=0.001	r^2=0.384, p=0.0001
Air Temperature	not significant	r^2=0.412, p=0.0001	r^2=0.416, p=0.0001
Wind Speed	r^2=0.1, p=0.0001	r^2=0.101,p=0.0001	r^2=0.087, p=0.0001

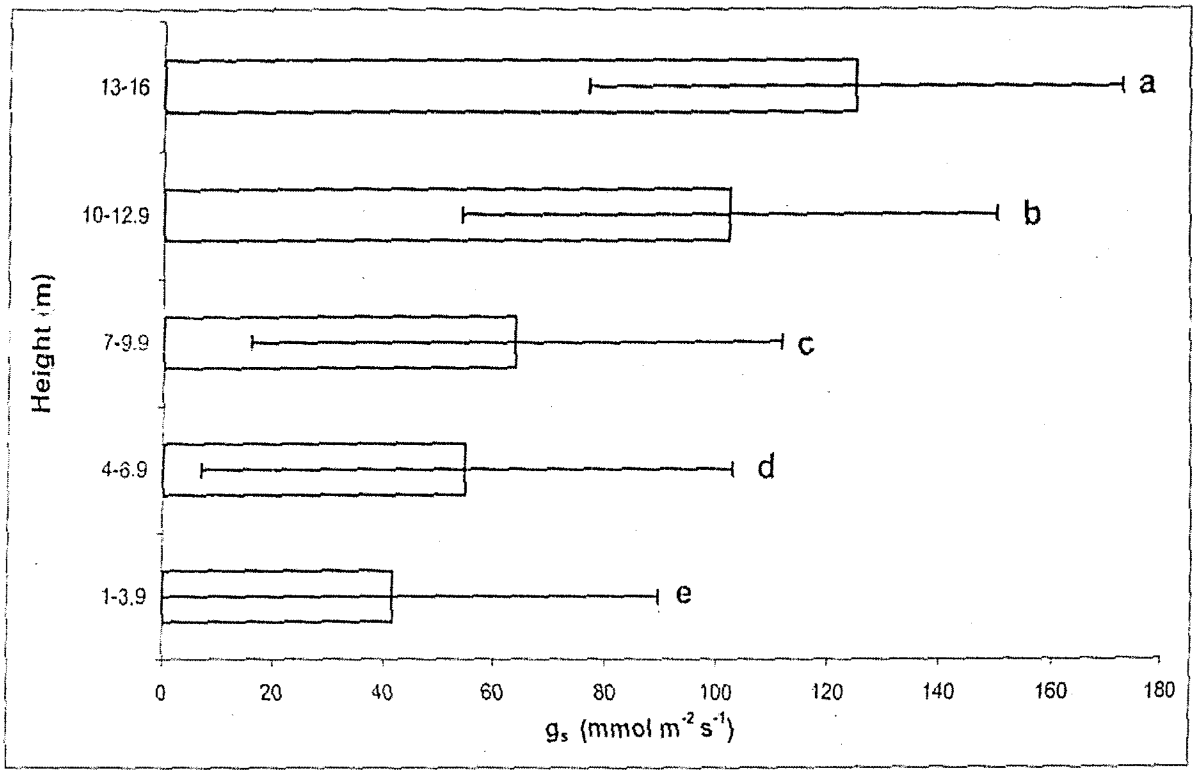


Figure 1. Average g_s (mmol $m^{-2}s^{-1}$) for 11 days at 5 heights in a sugar maple canopy (N=~65 for each height), July-August 1998. Error bars represent one standard deviation, distinct letters identify significant differences in g_s between canopy layers.

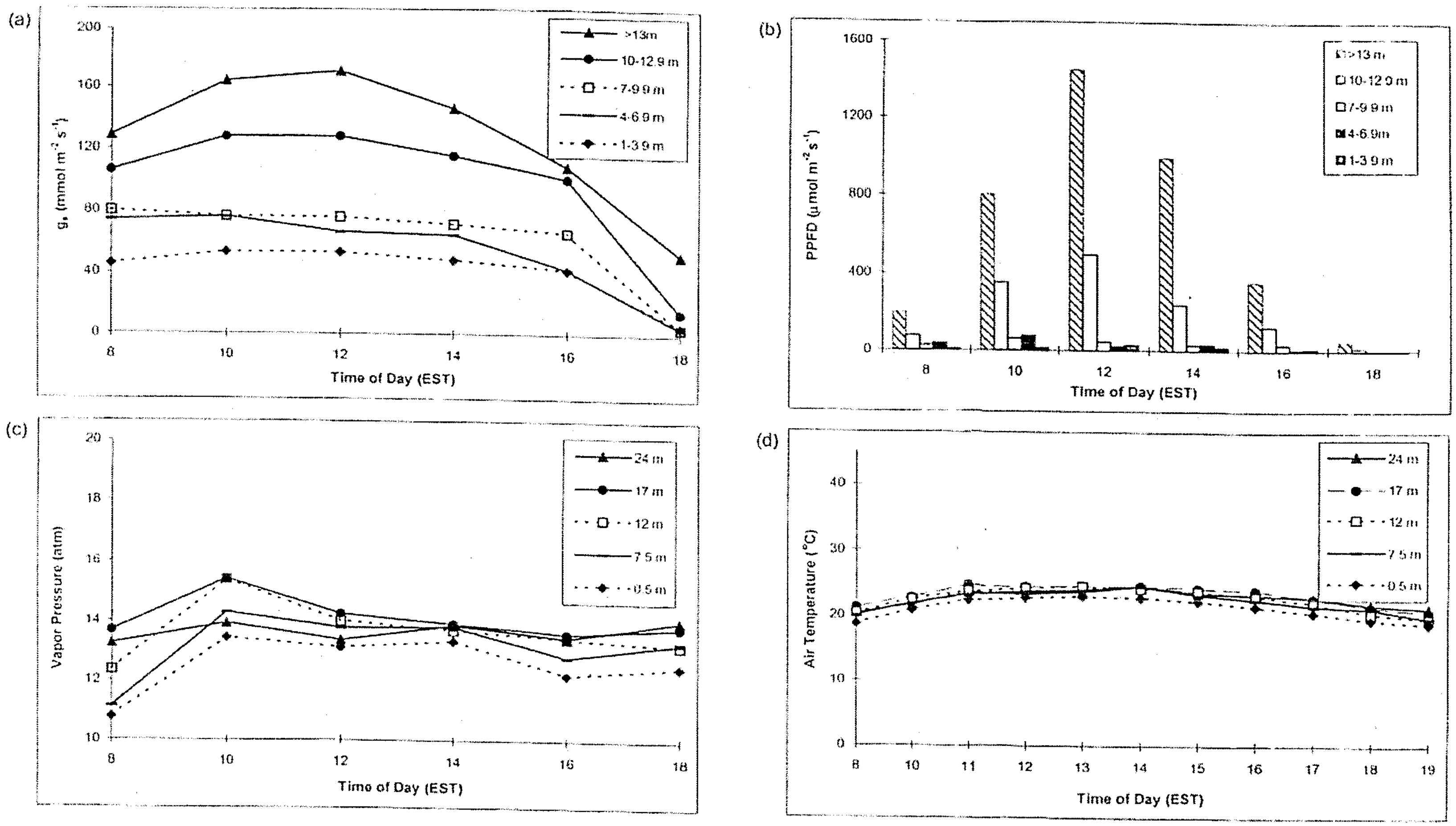


Figure 2. Average diurnal patterns for 11 days at 5 heights in a sugar maple canopy of (a) g_s (mmol m^{-2} s^{-1}), (b) PPFD (mmol m^{-2} s^{-1}), (c) partial pressure of water vapor (atm), and (d) air temperature (°C).

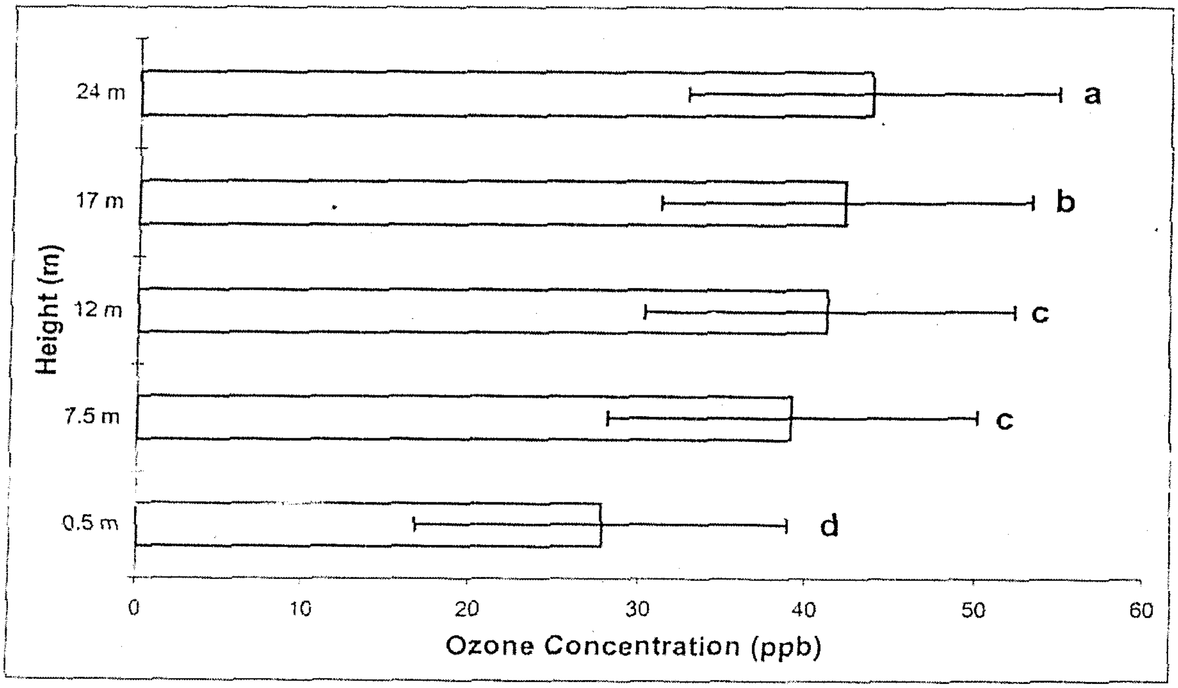


Figure 3. Average ozone concentration (ppb) at 5 heights in a sugar maple canopy for June-August 1998. Error bars represent one standard deviation, letters identify significant differences in O_3 among heights over the 11 days of study.

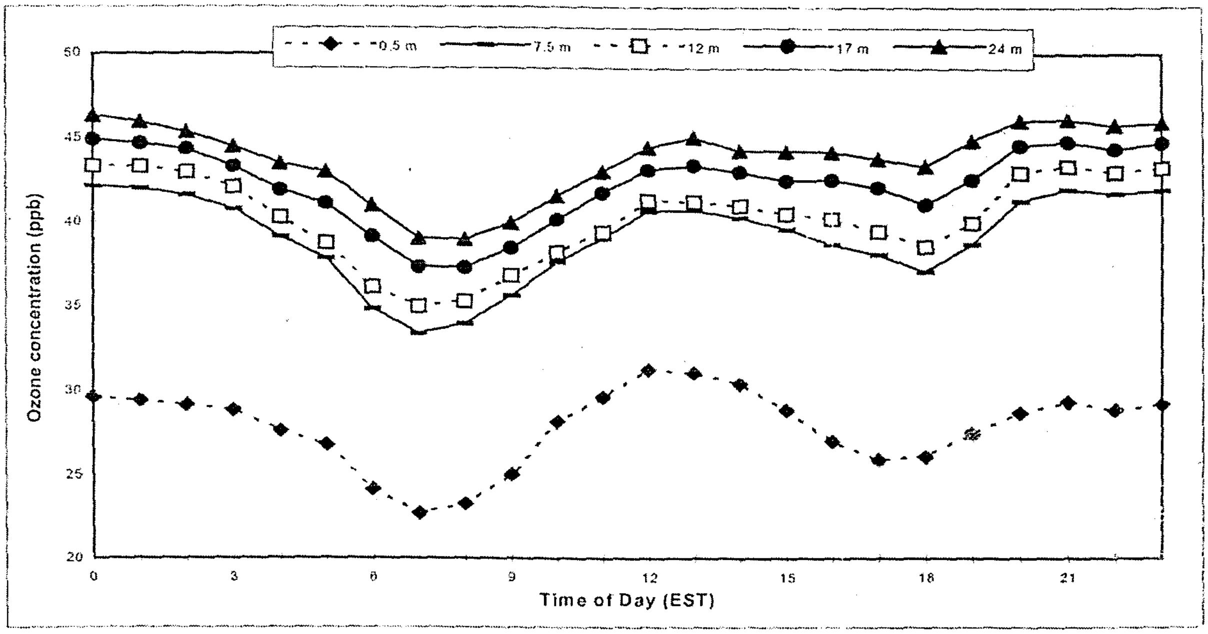


Figure 4. Diurnal pattern of average ozone concentration at 5 heights in a sugar maple canopy, June-July 1998.

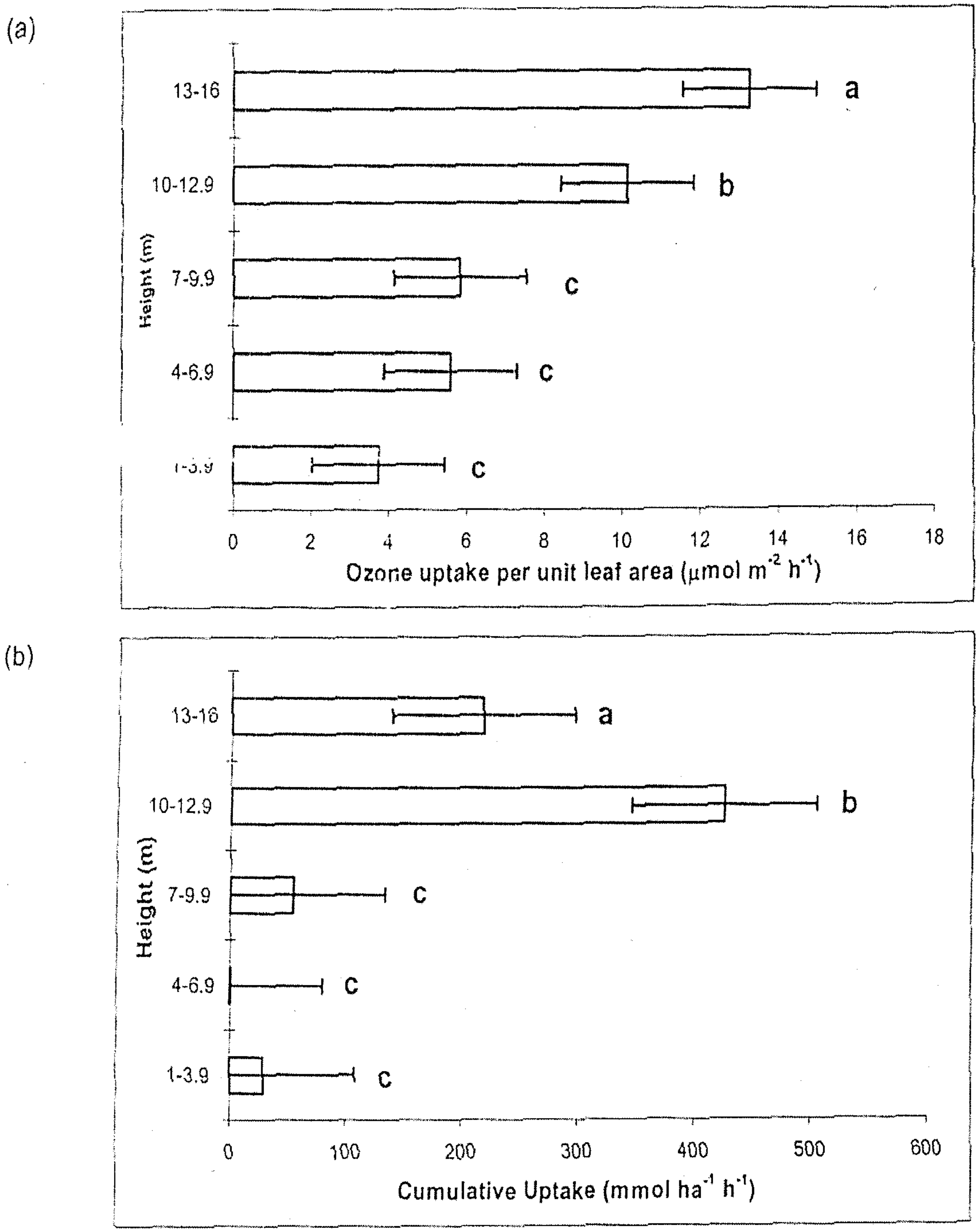


Figure 5. (a) Average uptake per unit leaf area (µmol m^{-2} h^{-1}) and (b) cumulative uptake (mmol ha^{-1} h^{-1}) of 11 days at 5 heights in a sugar maple canopy, July-August 1998 (N=~65 at each height). Error bars represent one standard deviation, distinct letters identify significant differences in uptake between heights.

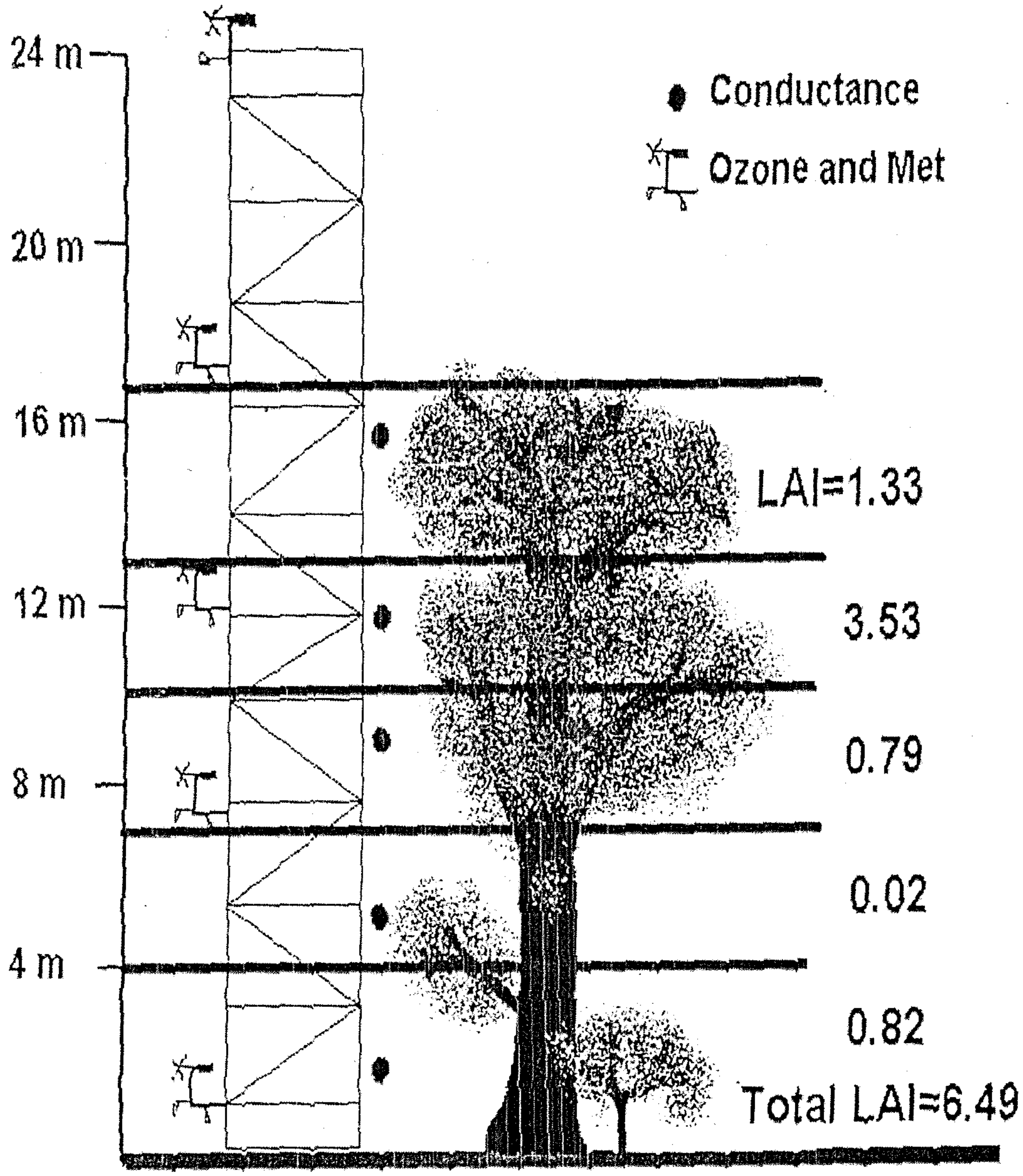


Figure 6. Schematic diagram of tower and corresponding heights where stomatal conductance, ozone, and meteorological data were measured, and LAI was calculated.

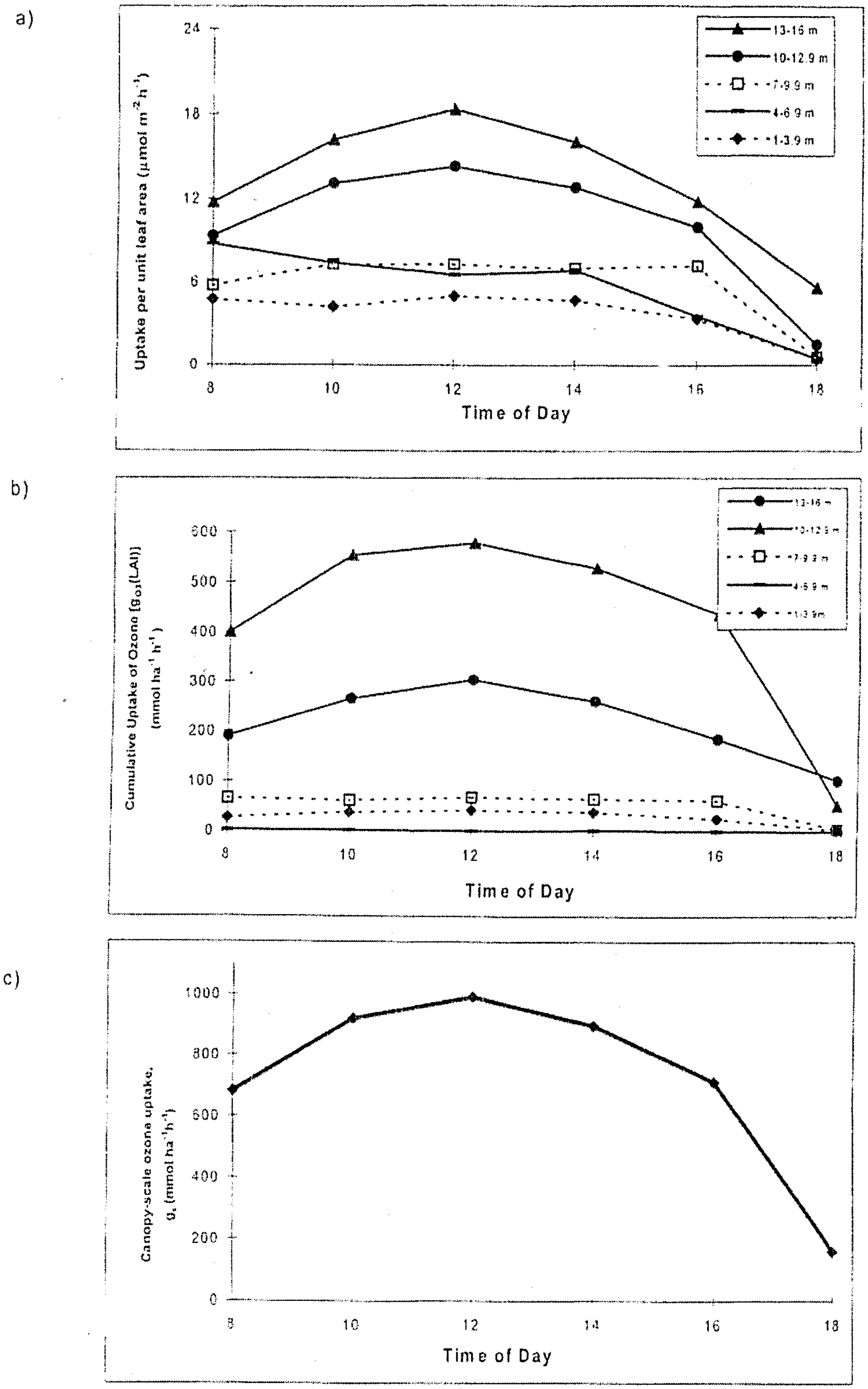
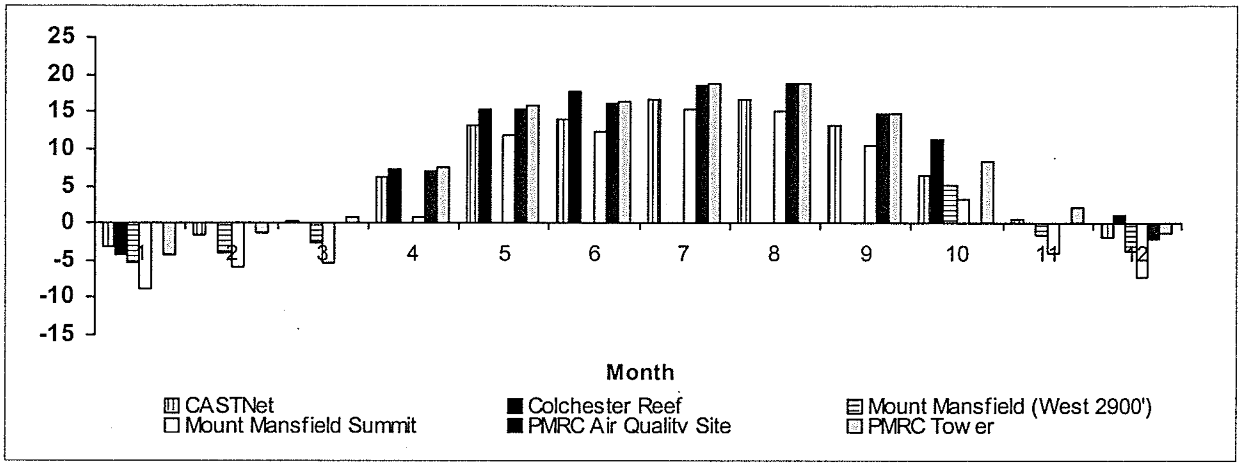


Figure 7. Average diurnal pattern of (a) uptake per unit leaf area (µmol m^{-2} h^{-1}), (b) cumulative uptake (mmol ha^{-1} h^{-1}), and (c) canopy uptake (mmol ha^{-1} h^{-1}) for 11 days at 5 heights, July-August 1998.

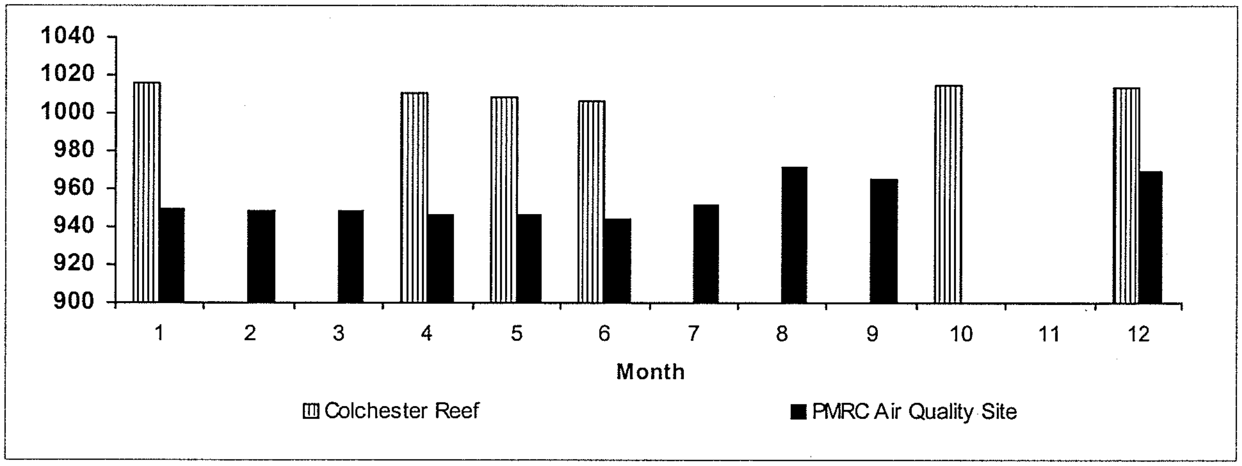
Appendix A
Meteorological

Meteorological Variables Summarized By Month - All Sites Combined

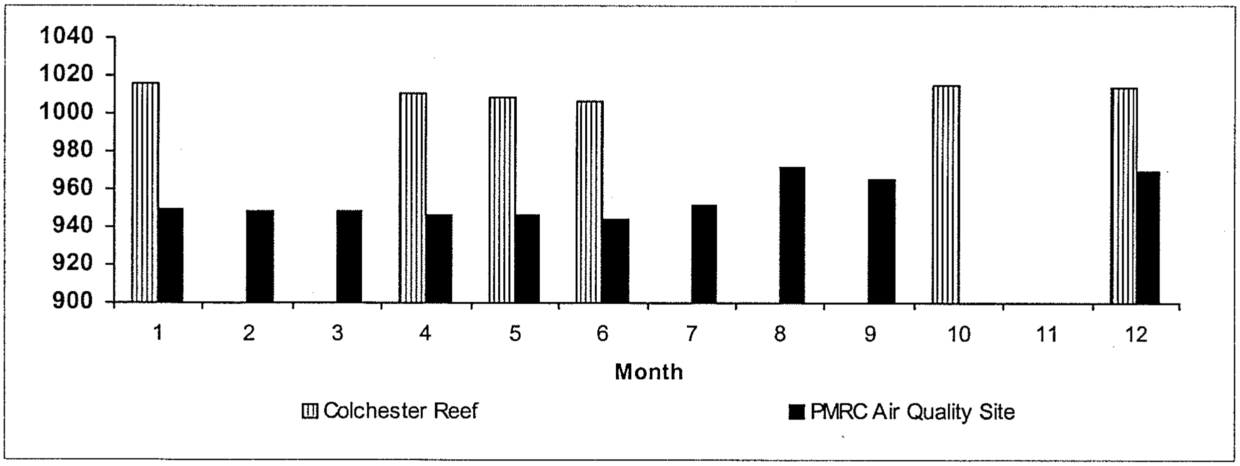
Mean Air Temperature (degrees C)



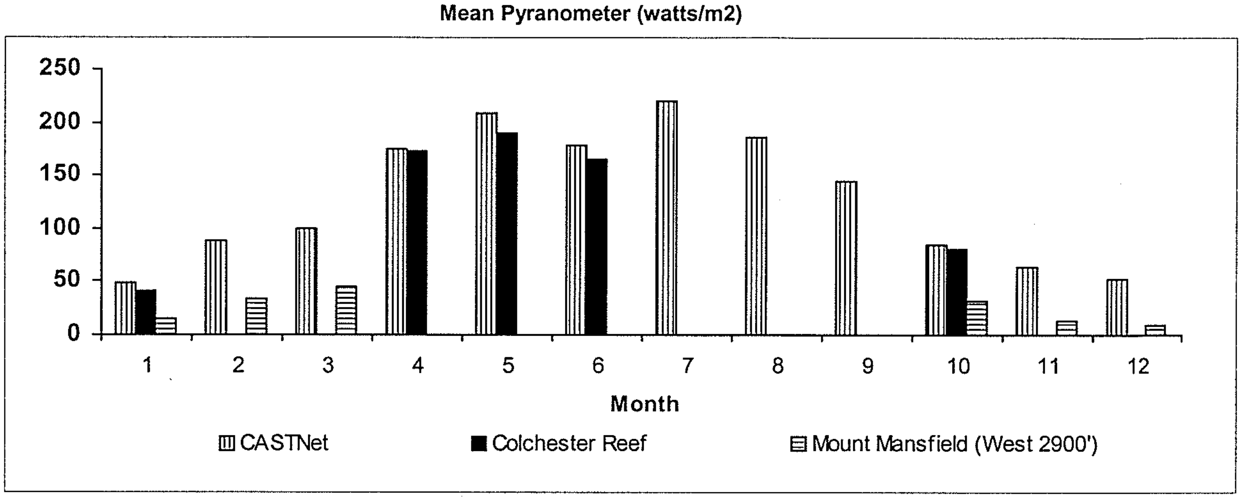
Mean Barometric Pressure (mb)

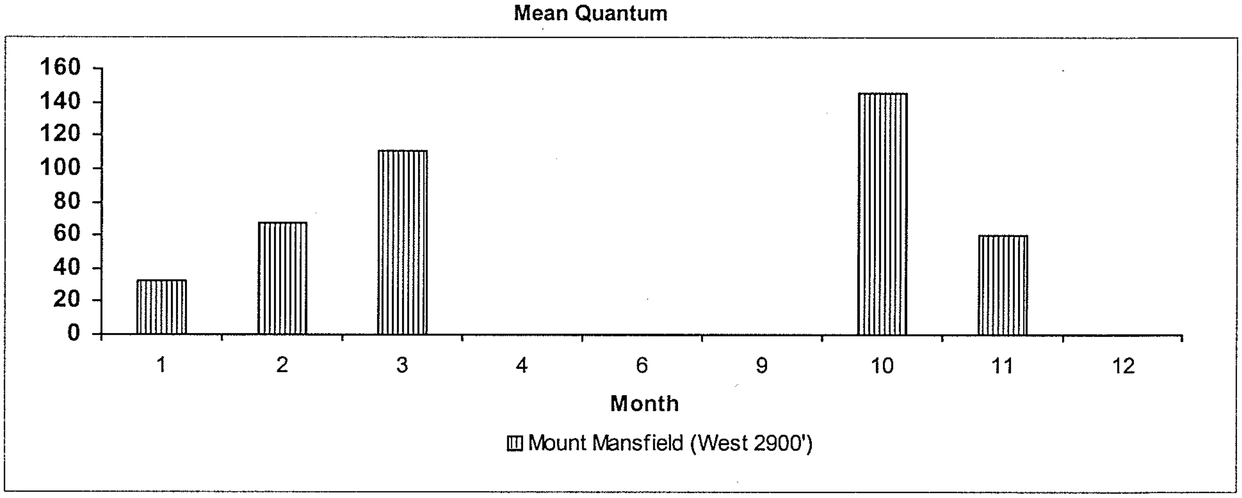


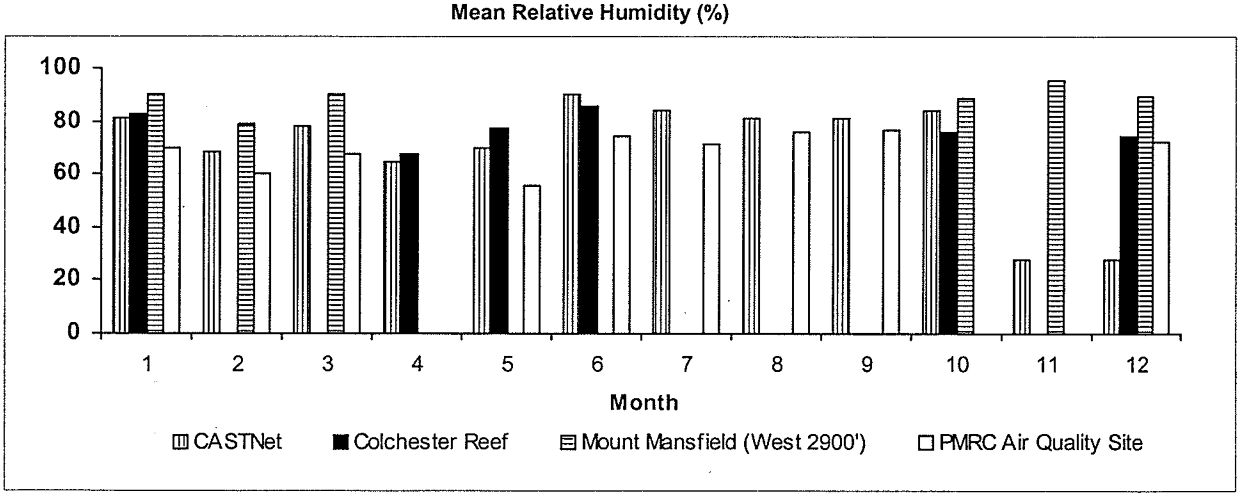
Mean Horizontal Wind Speed (m/s)



Meteorological Variables Summarized By Month - All Sites Combined

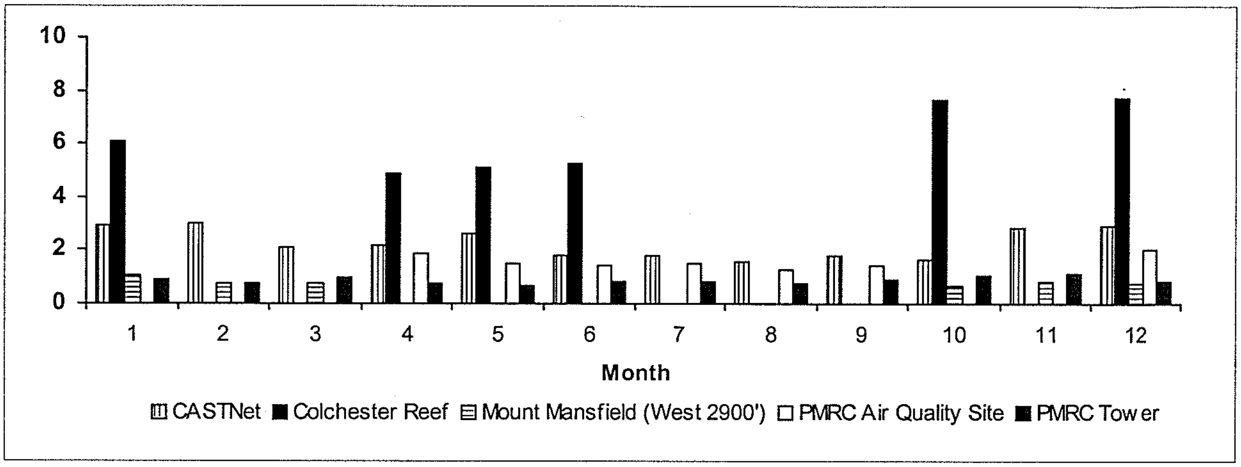




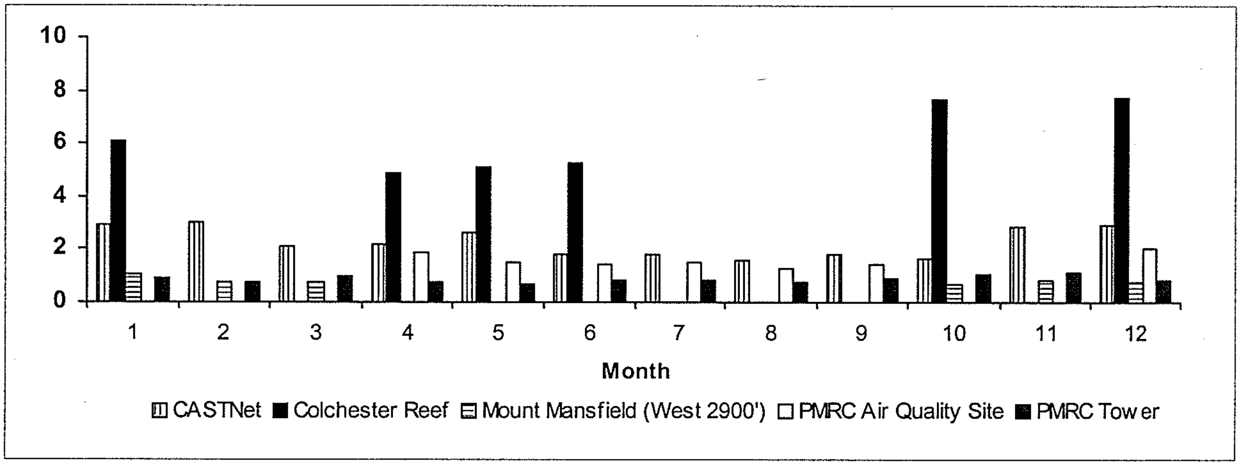


Meteorological Variables Summarized By Month - All Sites Combined

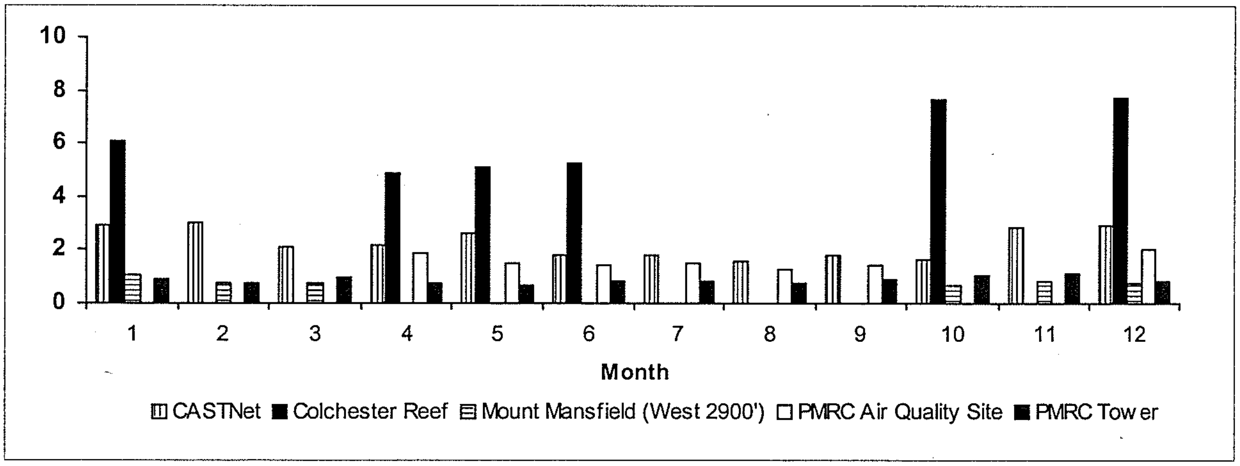
Mean Resultant Wind Speed (m/s)



Mean Snow Depth (mm)

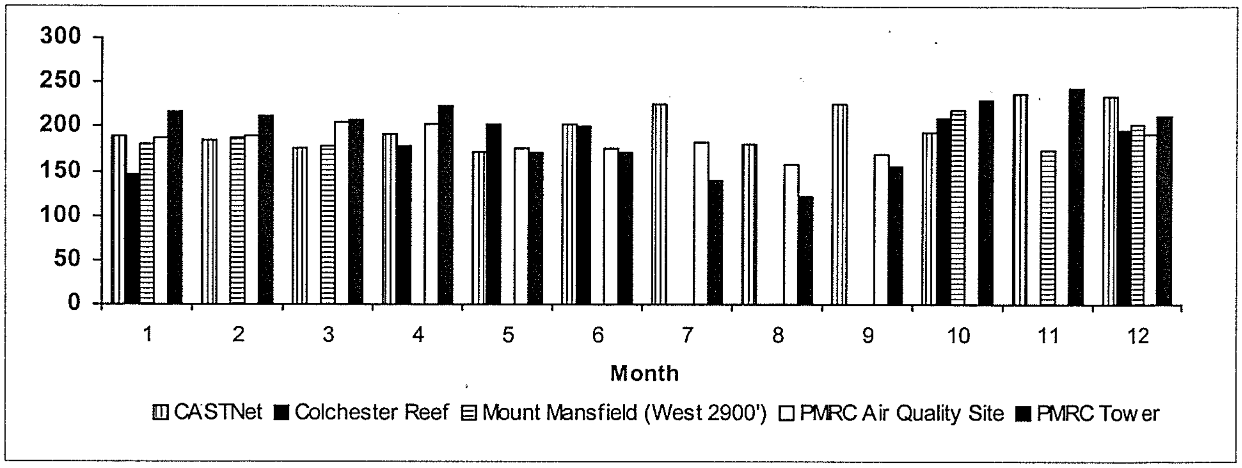


Mean Water Temperature (degrees C)

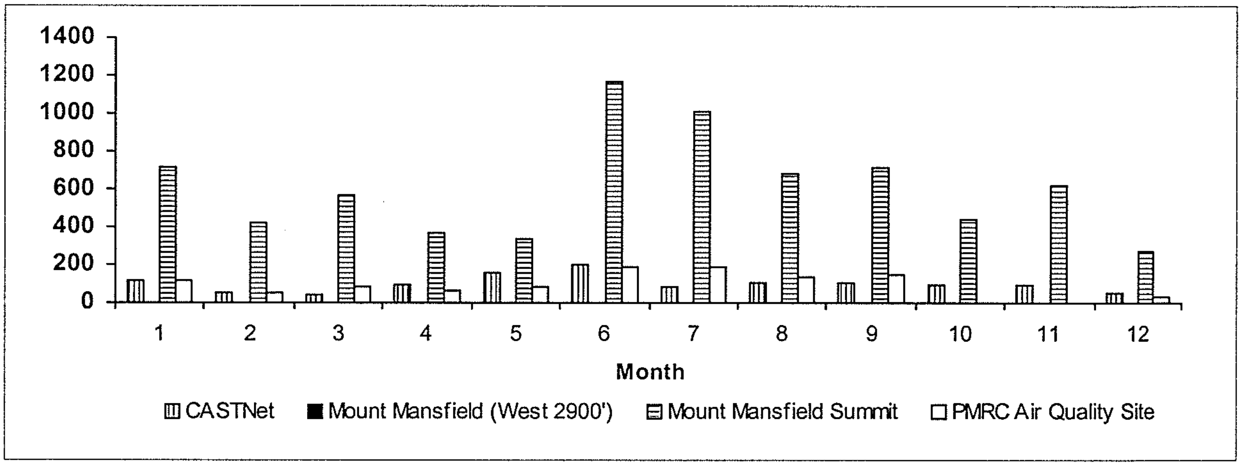


Meteorological Variables Summarized By Month - All Sites Combined

Mean Wind Direction (degrees)



Total Precipitation (mm)



Total Daily Precipitation

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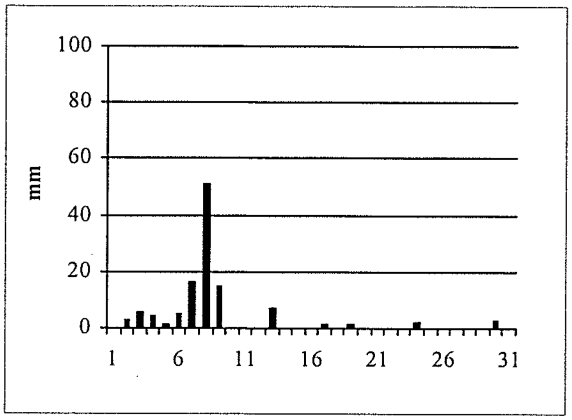

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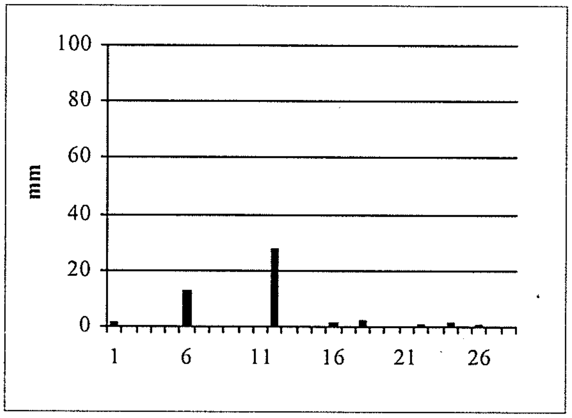

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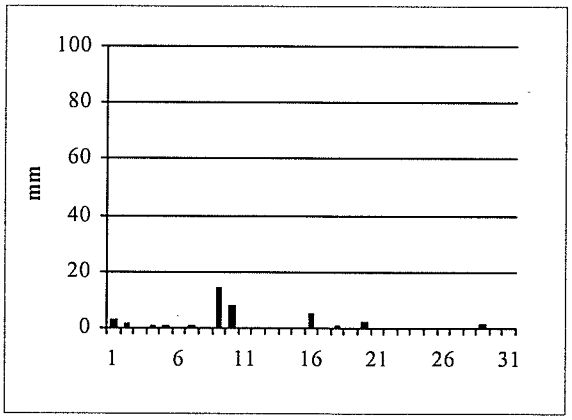
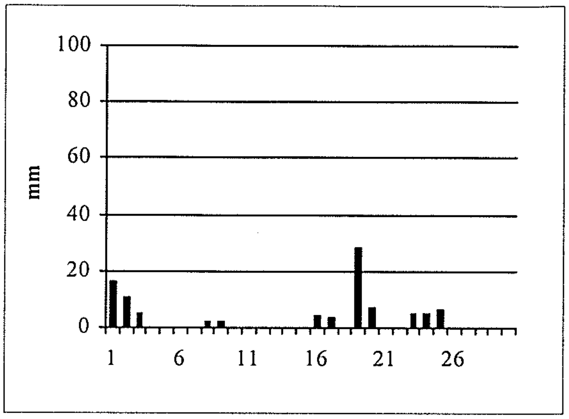


CASTNet: April



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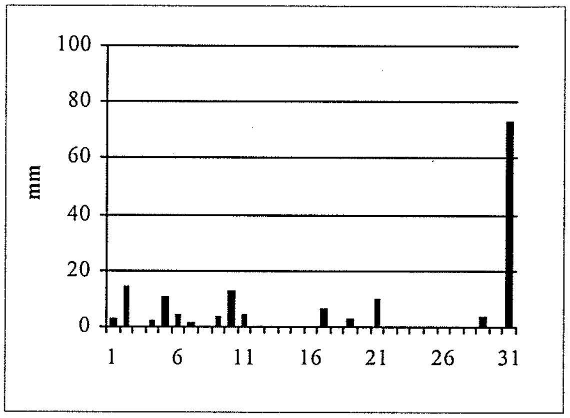
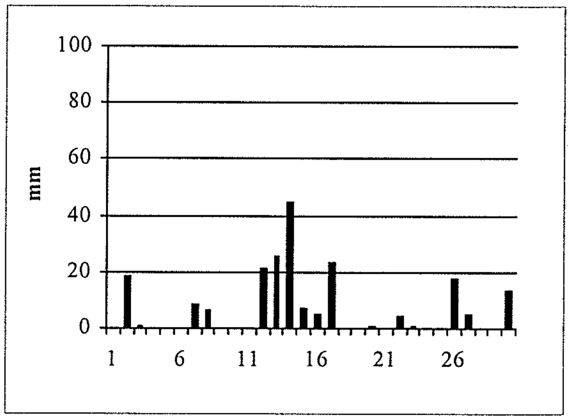
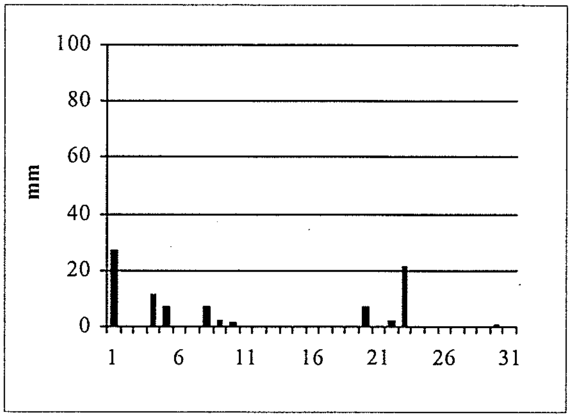


CASTNet: June



Total Daily Precipitation continued

CASTNet: July



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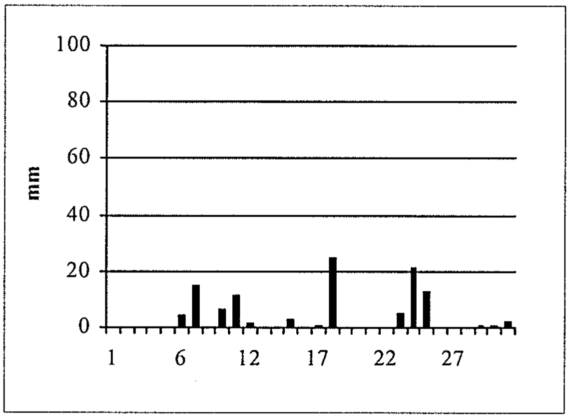
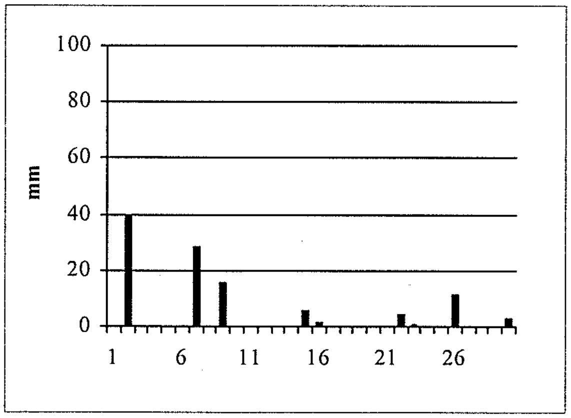


CASTNet: September



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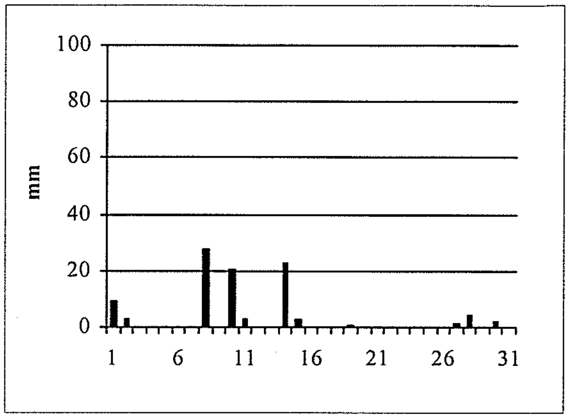

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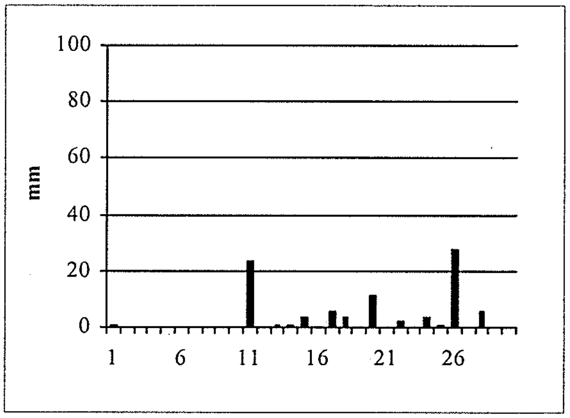

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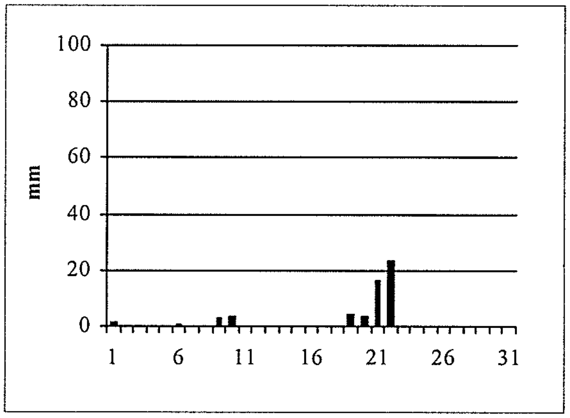
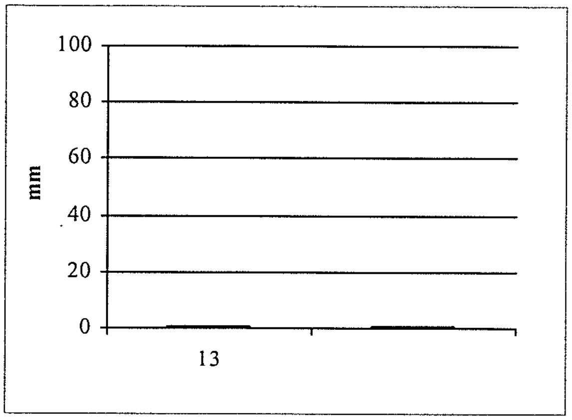
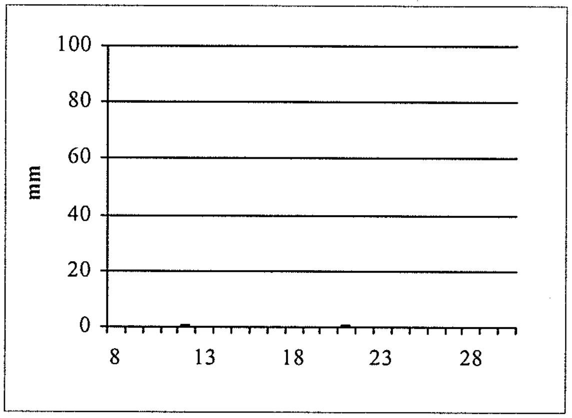


Total Daily Precipitation continued

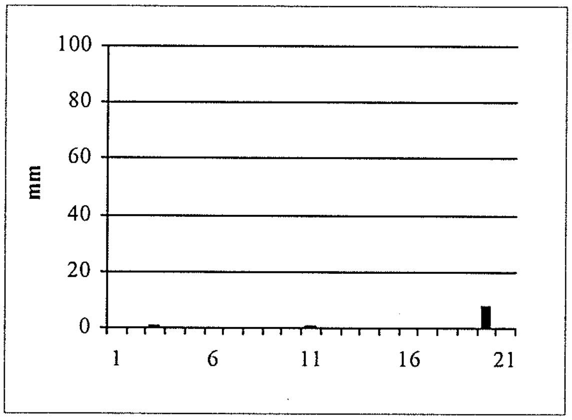
Mount Mansfield (West 2900'): June



Mount Mansfield (West 2900'): September

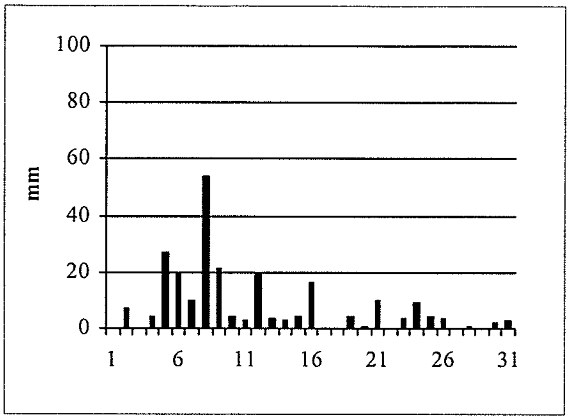


Mount Mansfield (West 2900'): October

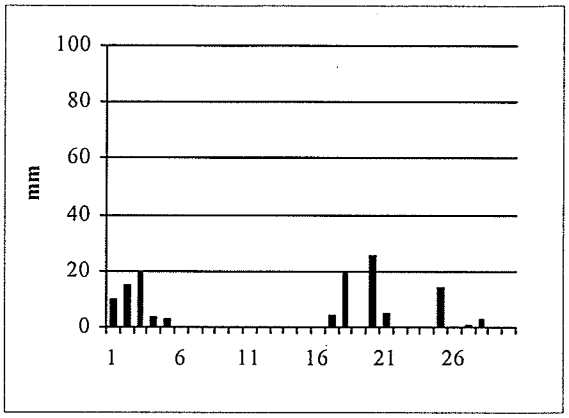


Total Daily Precipitation continued

Mount Mansfield Summit: January



Mount Mansfield Summit: April



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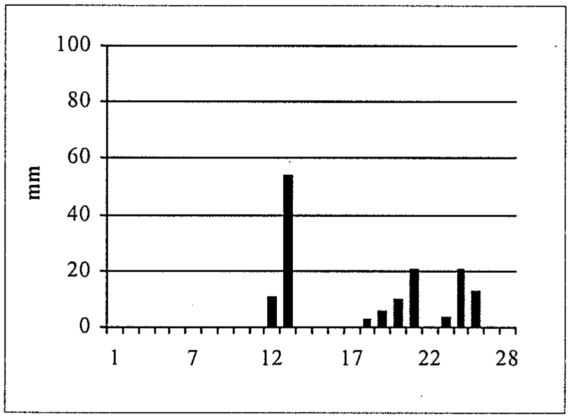

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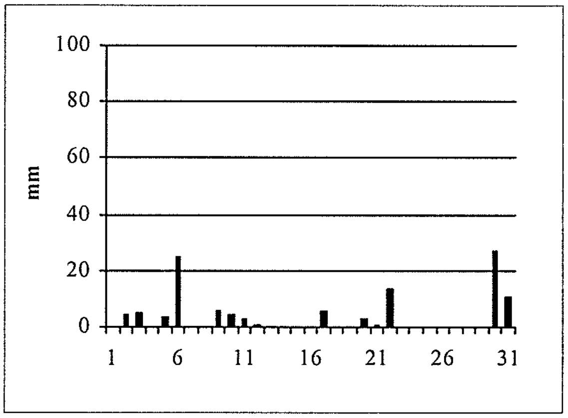

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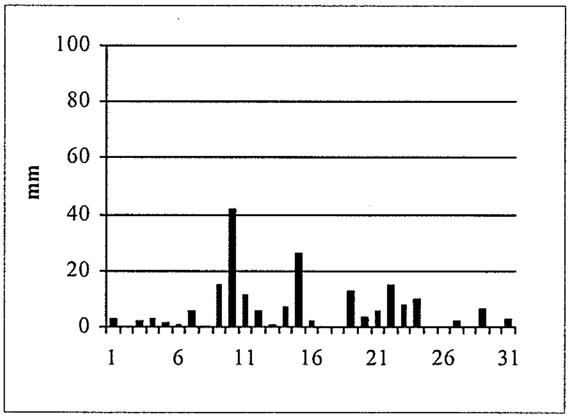

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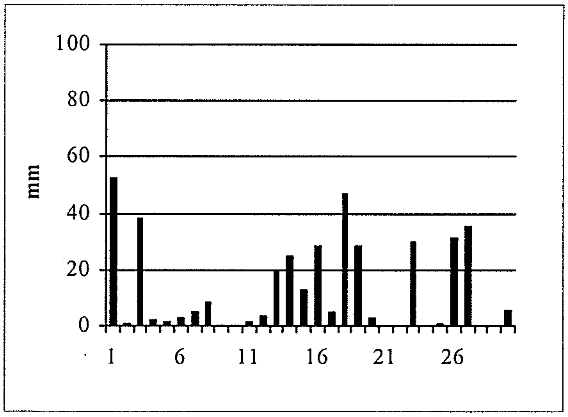
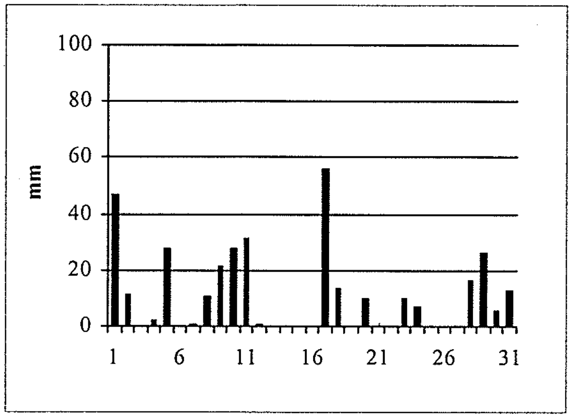


Total Daily Precipitation continued

Mount Mansfield Summit: July



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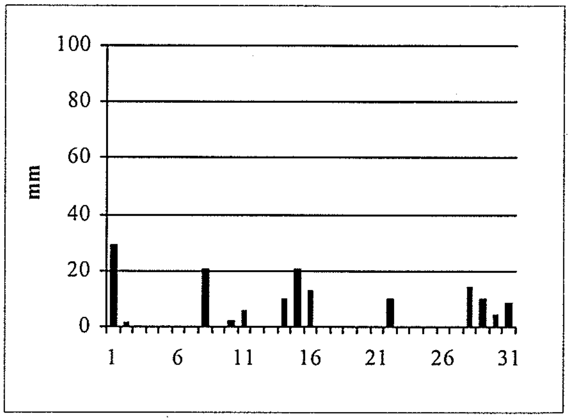

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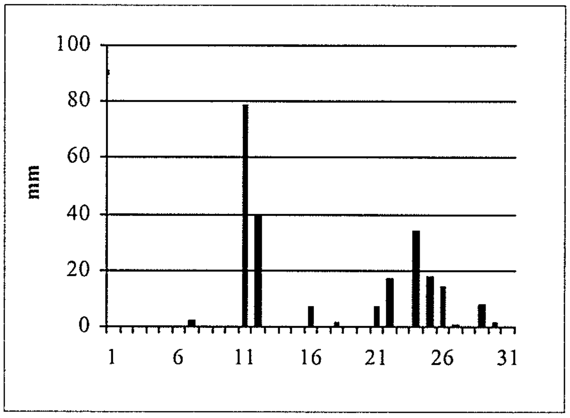

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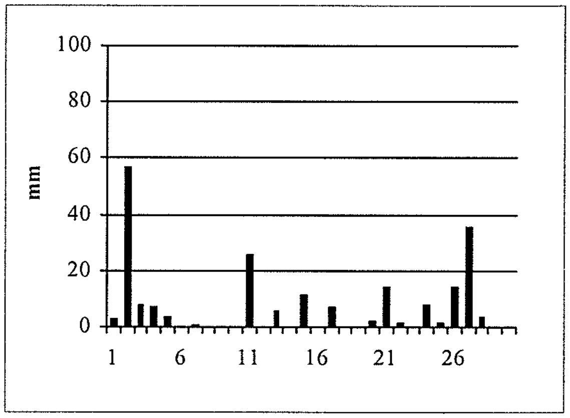

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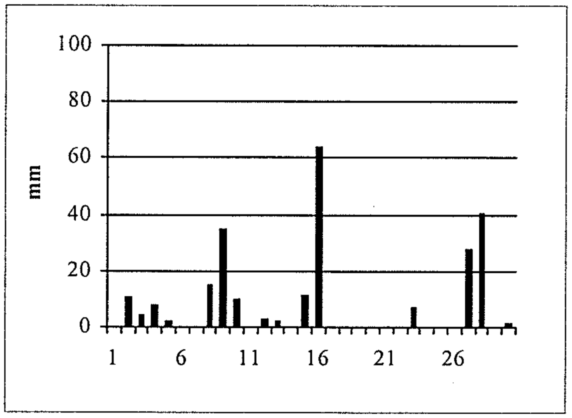
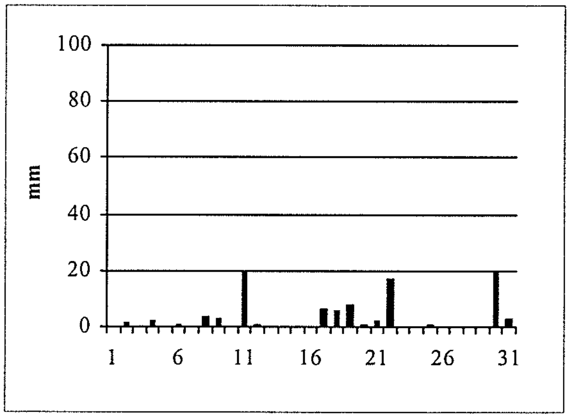
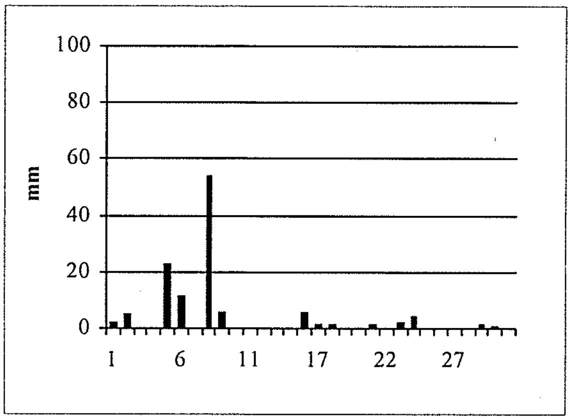


Mount Mansfield Summit: December



Total Daily Precipitation continued

PMRC Air Quality Site: January



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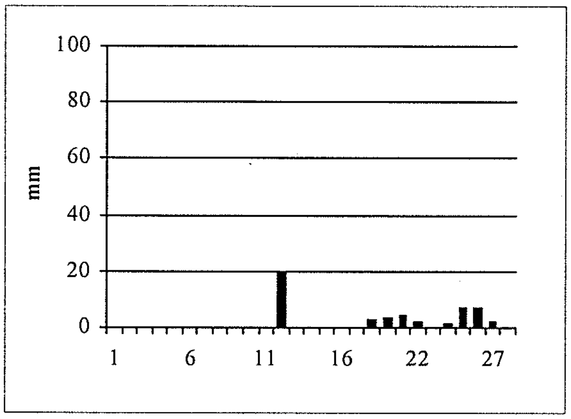

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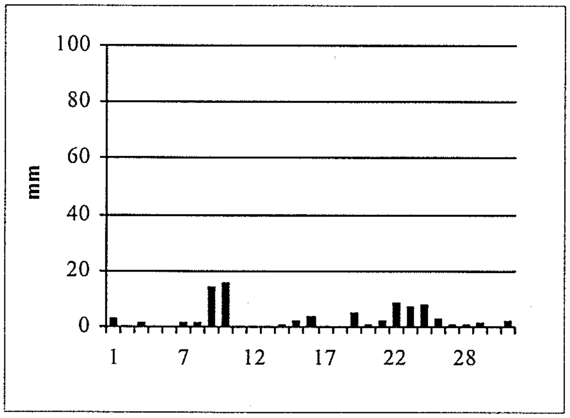

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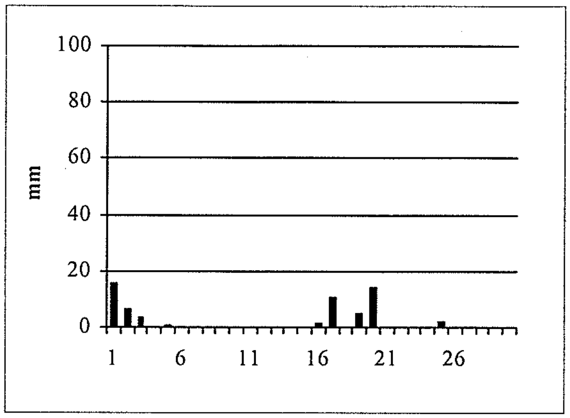

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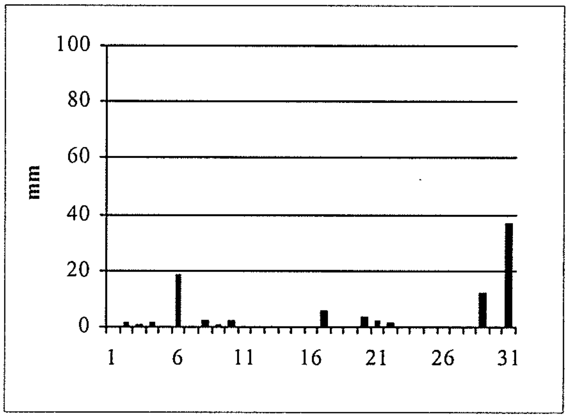

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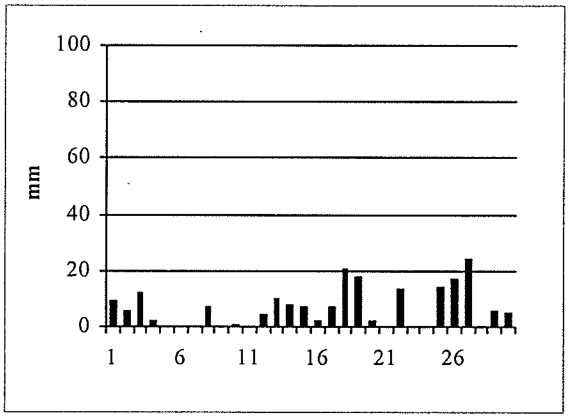
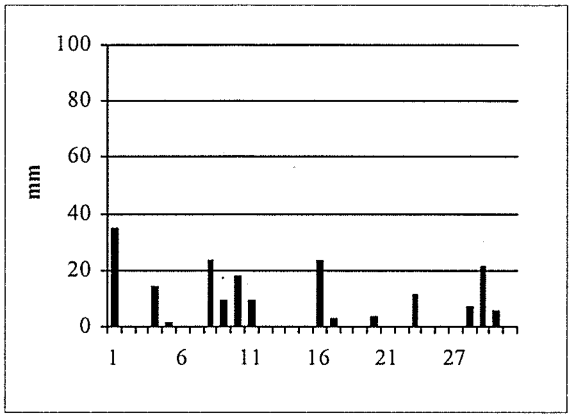


Total Daily Precipitation continued

PMRC Air Quality Site: July



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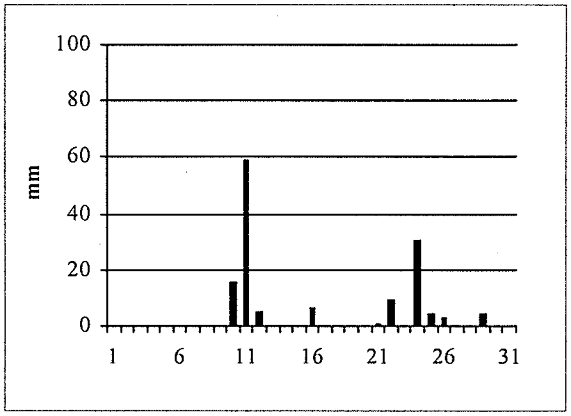

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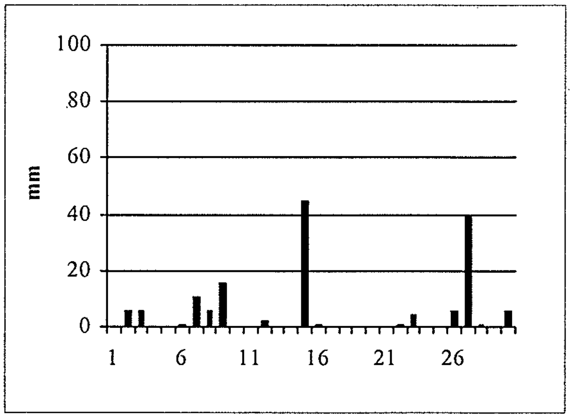

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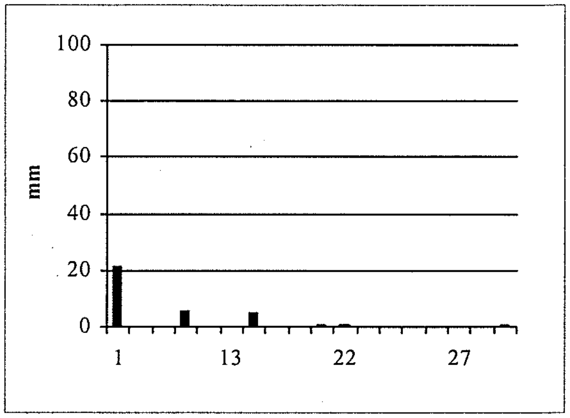

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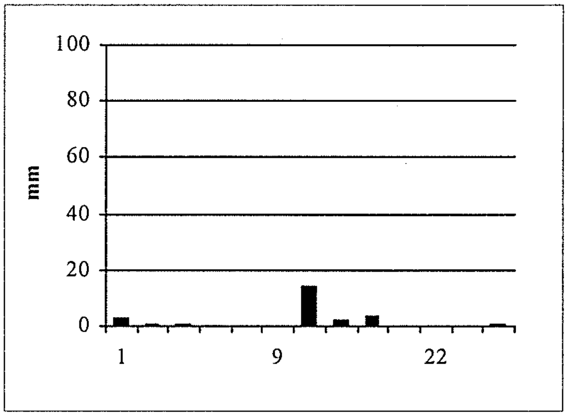
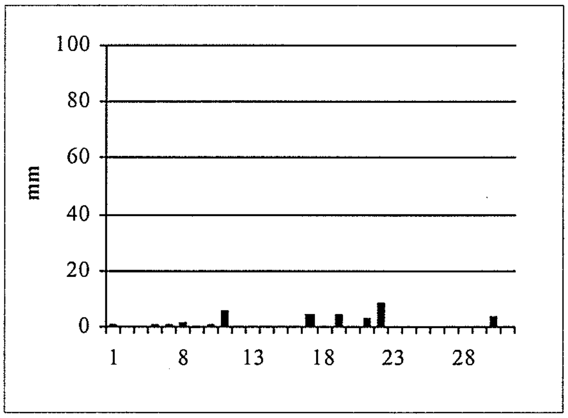
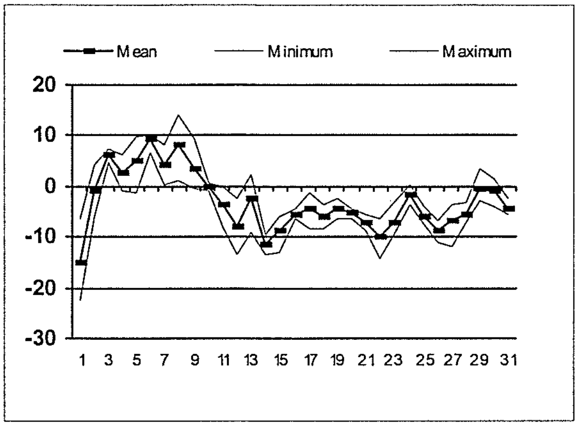


PMRC Air Quality Site: December

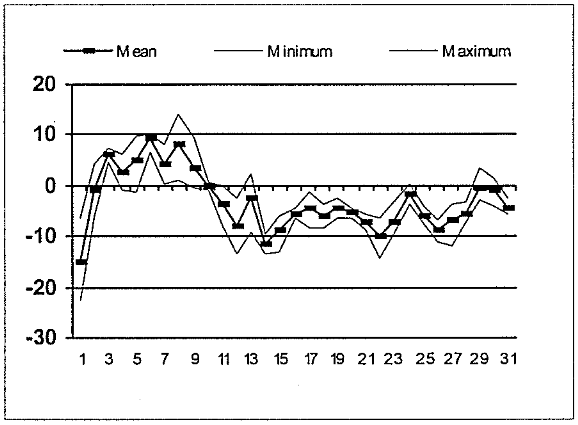


Daily Variables

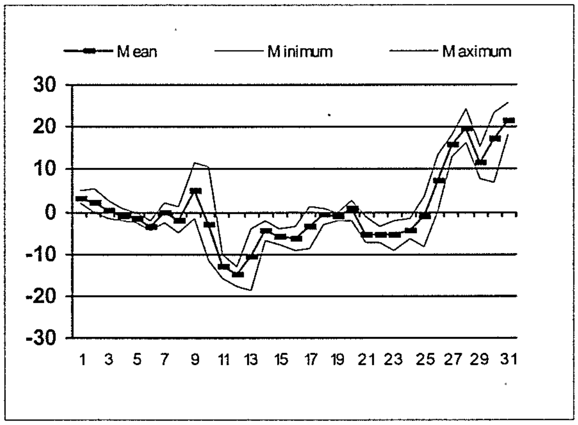
CASTNet: January - Air Temperature (degrees C)



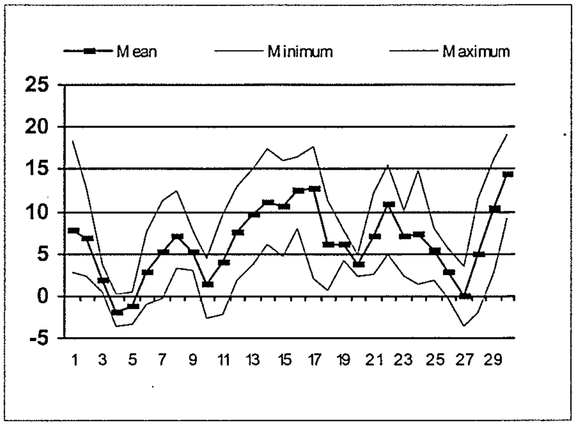
CASTNet: February - Air Temperature (degrees C)



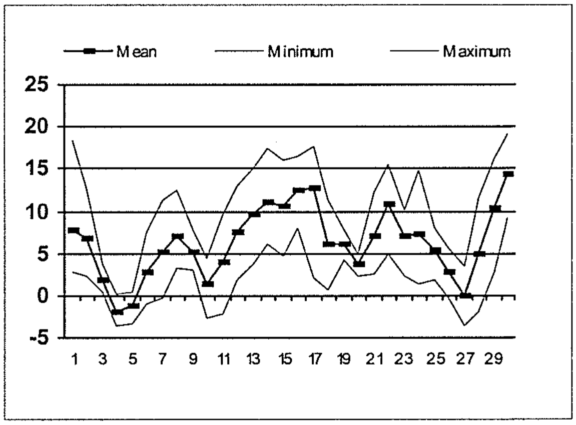
CASTNet: March - Air Temperature (degrees C)



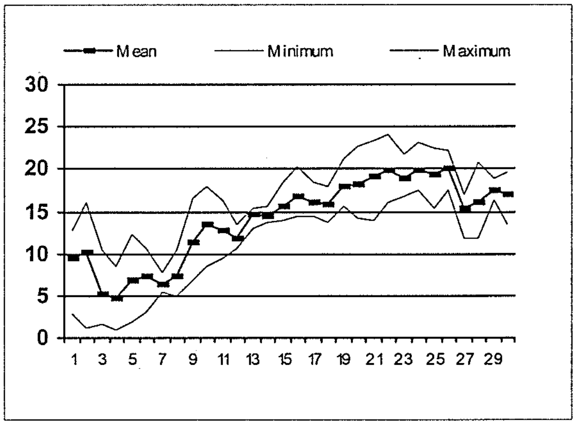
CASTNet: April - Air Temperature (degrees C)



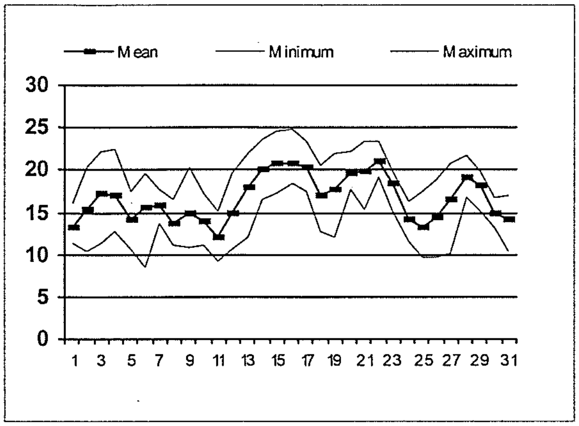
CASTNet: May - Air Temperature (degrees C)



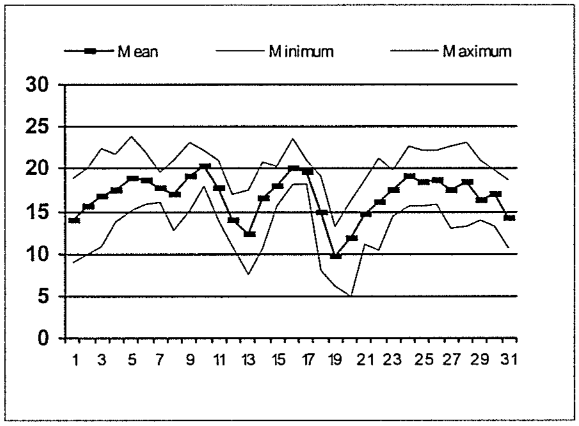
CASTNet: June - Air Temperature (degrees C)



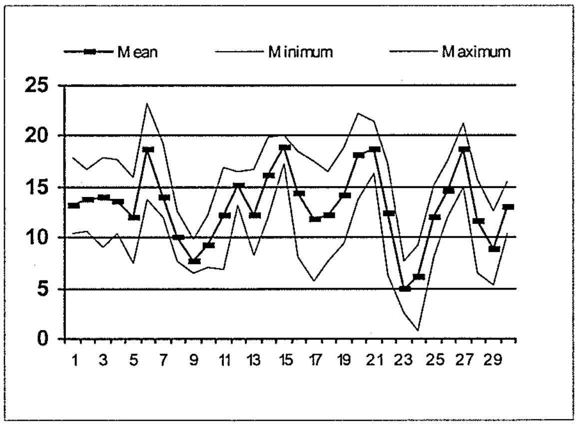
CASTNet: July - Air Temperature (degrees C)



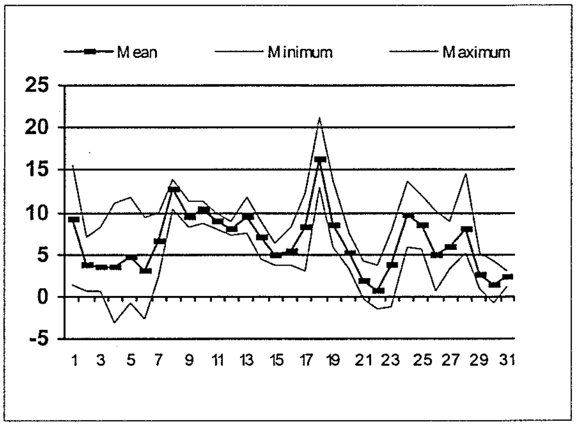
CASTNet: August - Air Temperature (degrees C)



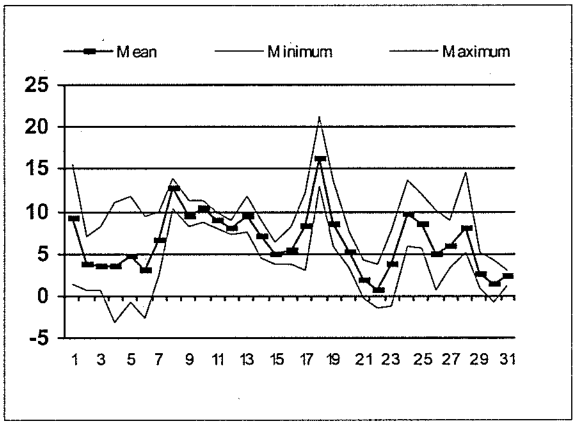
CASTNet: September - Air Temperature (degrees C)



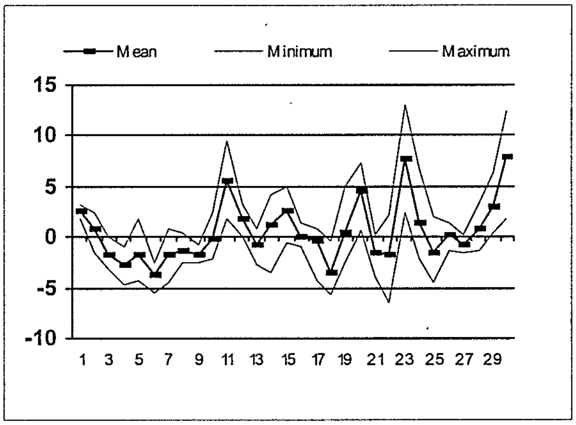
CASTNet: October - Air Temperature (degrees C)



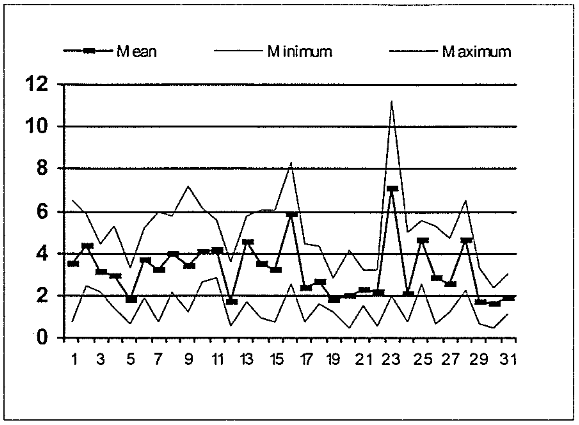
CASTNet: November - Air Temperature (degrees C)



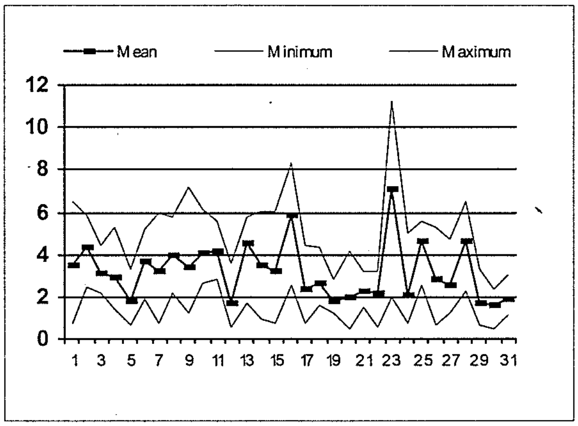
CASTNet: December - Air Temperature (degrees C)



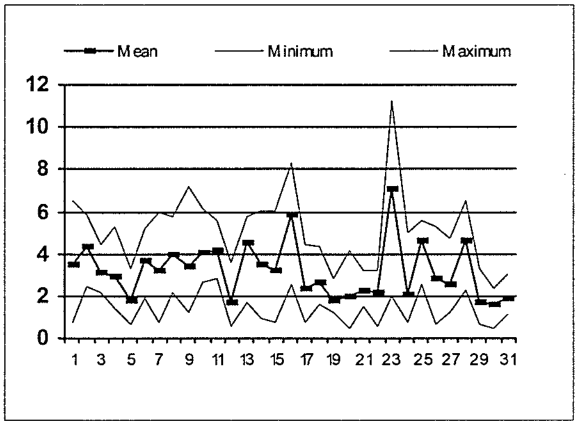
CASTNet: January - Horizontal Wind Speed (ms)



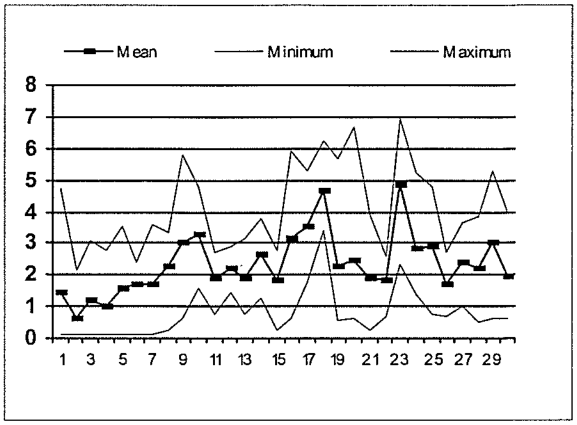
CASTNet: February - Horizontal Wind Speed (ms)



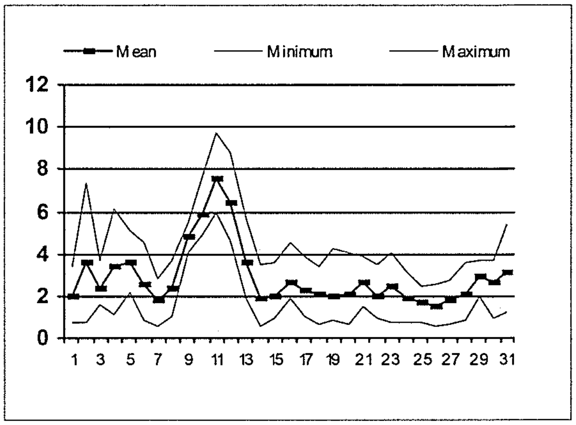
CASTNet: March - Horizontal Wind Speed (ms)



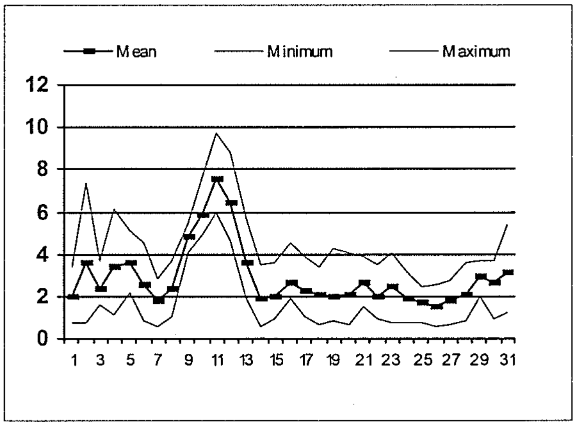
CASTNet: April - Horizontal Wind Speed (ms)



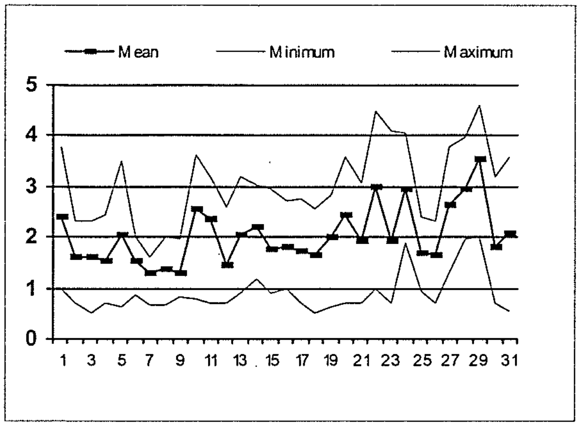
CASTNet: May - Horizontal Wind Speed (ms)



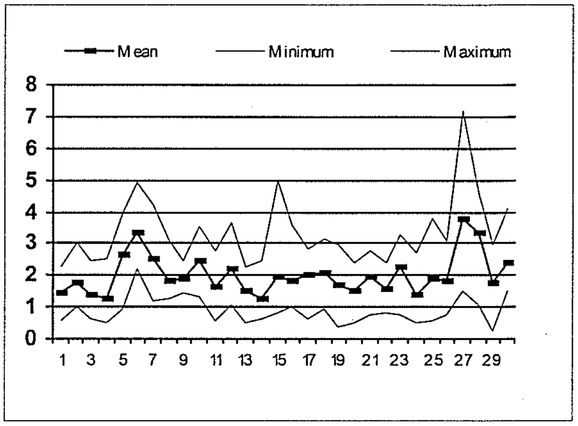
CASTNet: June - Horizontal Wind Speed (ms)



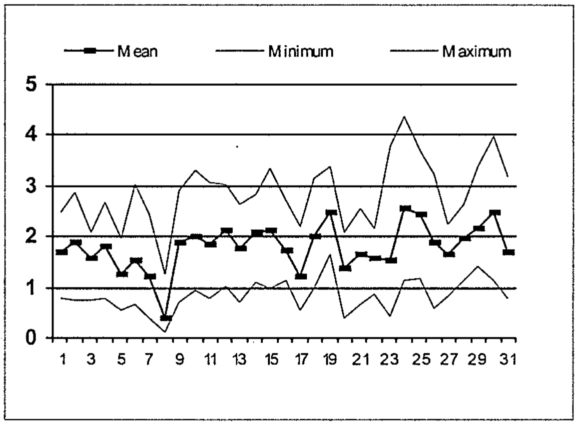
CASTNet: July - Horizontal Wind Speed (ms)



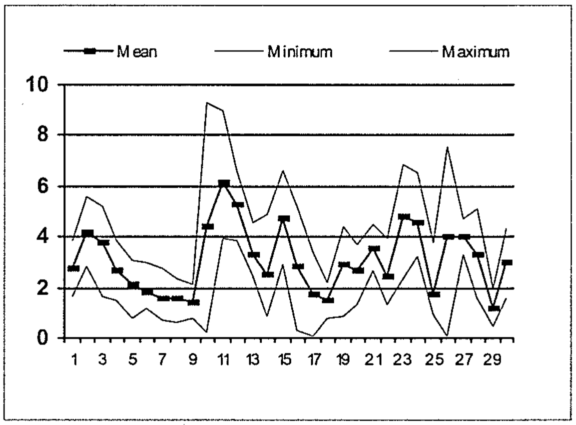
CASTNet: October - Horizontal Wind Speed (ms)



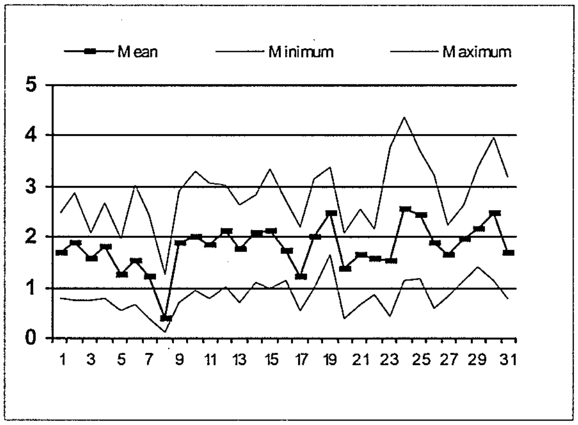
CASTNet: August - Horizontal Wind Speed (ms)



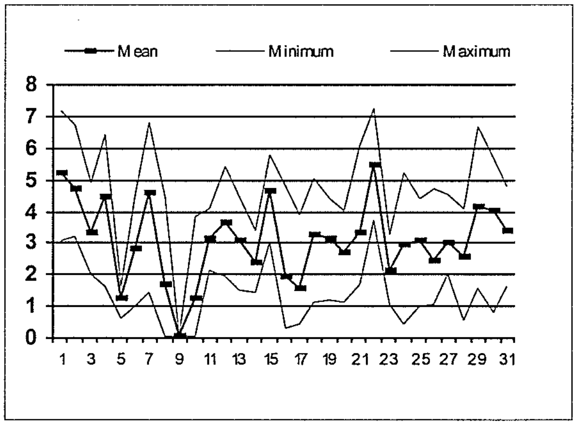
CASTNet: November - Horizontal Wind Speed (ms)



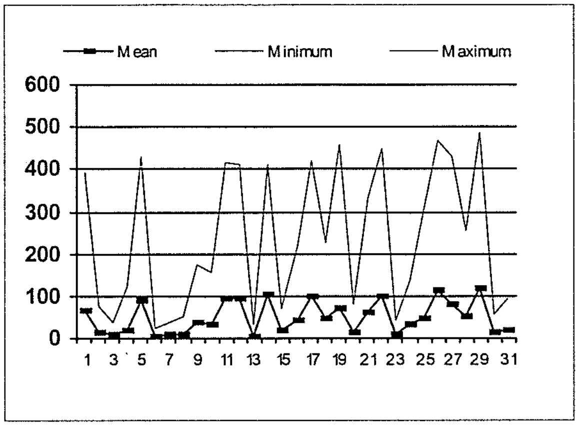
CASTNet: September - Horizontal Wind Speed (ms)



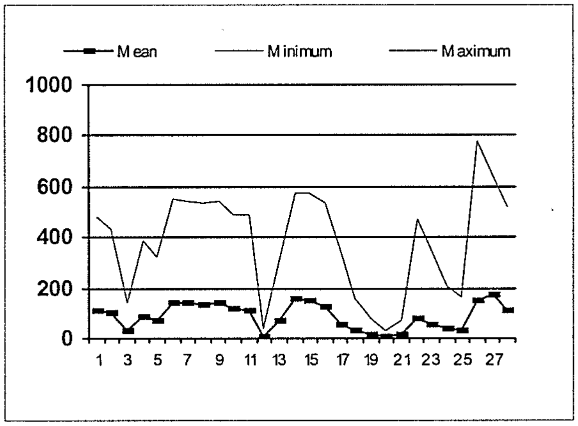
CASTNet: December - Horizontal Wind Speed (ms)



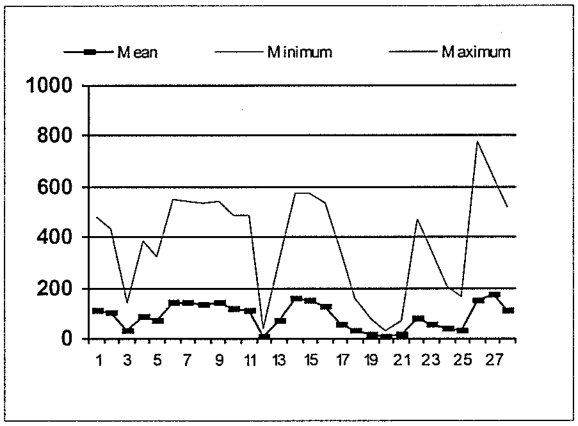
CASTNet: January - Pyranometer (watts/m^2)



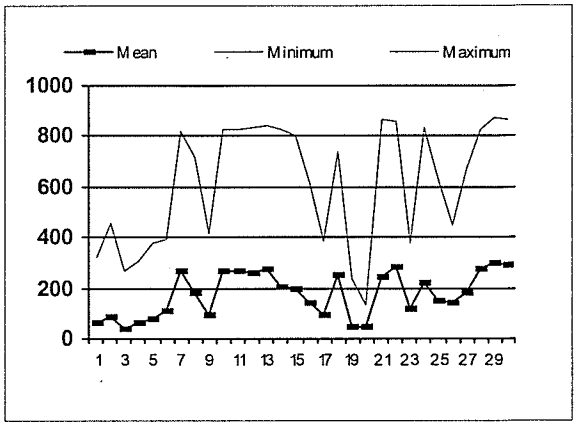
CASTNet: February - Pyranometer (watts/m^2)



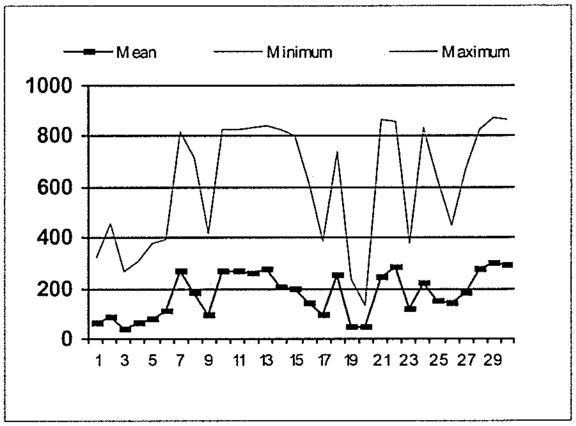
CASTNet: March - Pyranometer (watts/m^2)



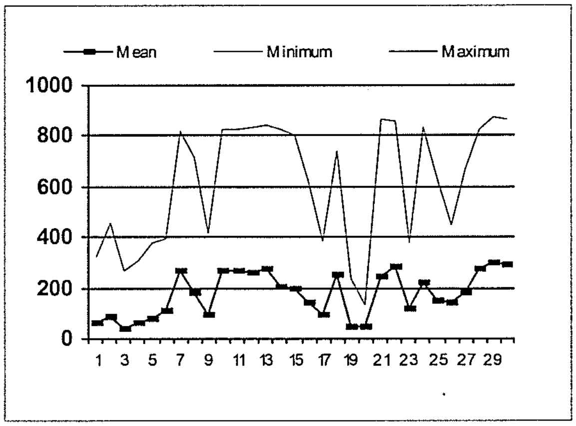
CASTNet: April - Pyranometer (watts/m^2)



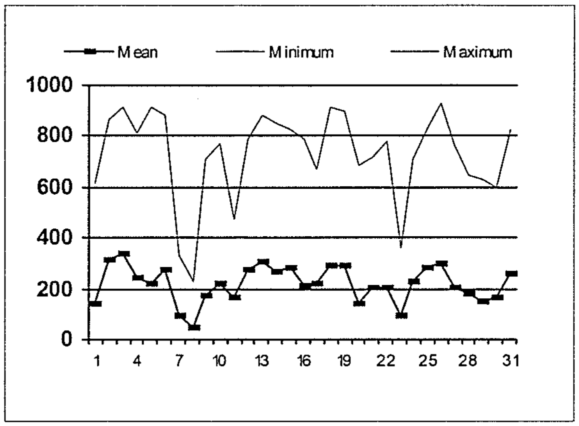
CASTNet: May - Pyranometer (watts/m^2)



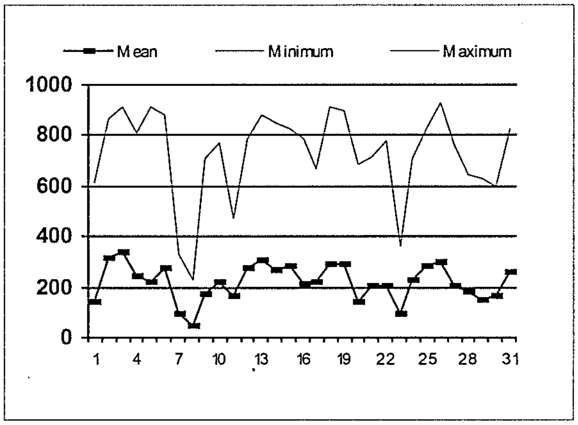
CASTNet: June - Pyranometer (watts/m^2)



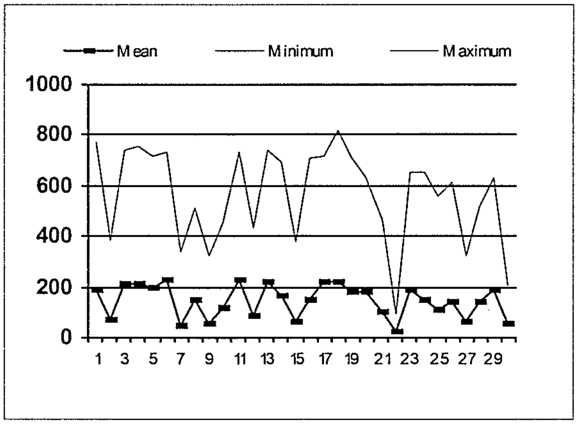
CASTNet: July - Pyranometer (watts/m^2)



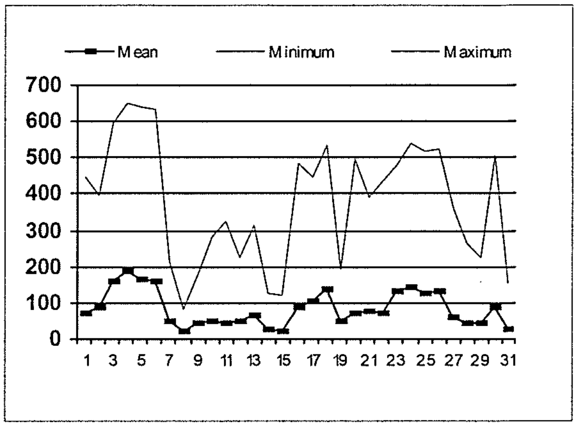
CASTNet: August - Pyranometer (watts/m^2)



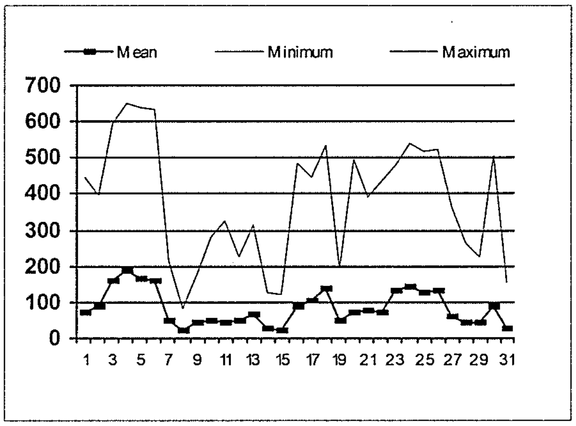
CASTNet: September - Pyranometer (watts/m^2)



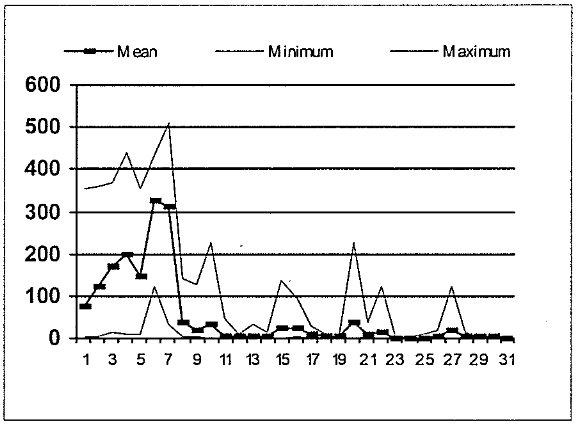
CASTNet: October - Pyranometer (watts/m^2)



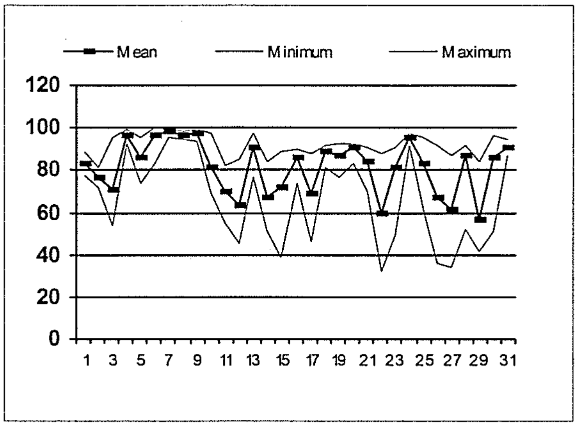
CASTNet: November - Pyranometer (watts/m^2)



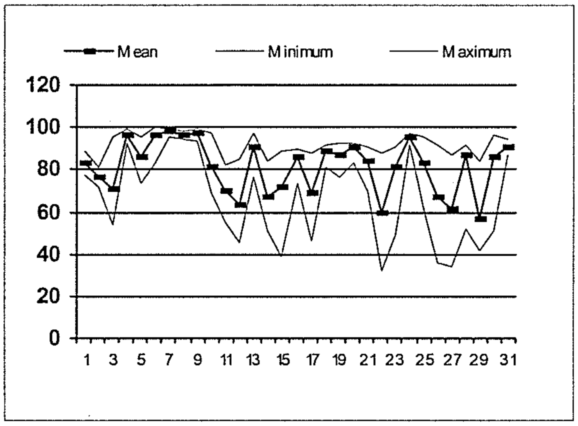
CASTNet: December - Pyranometer (watts/m^2)



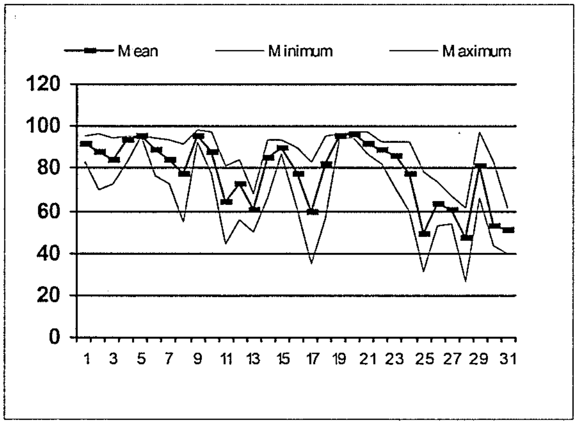
CASTNet: January - Relative Humidity (%)



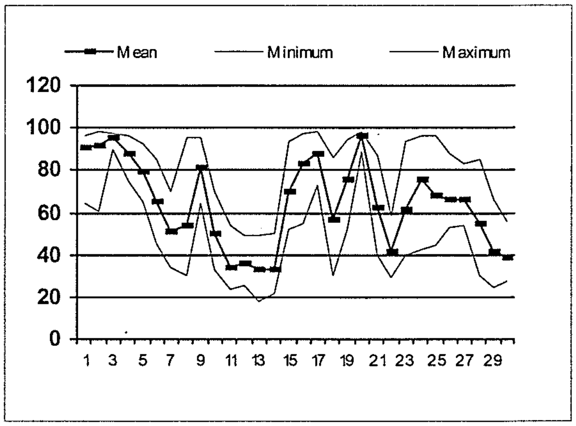
CASTNet: February - Relative Humidity (%)



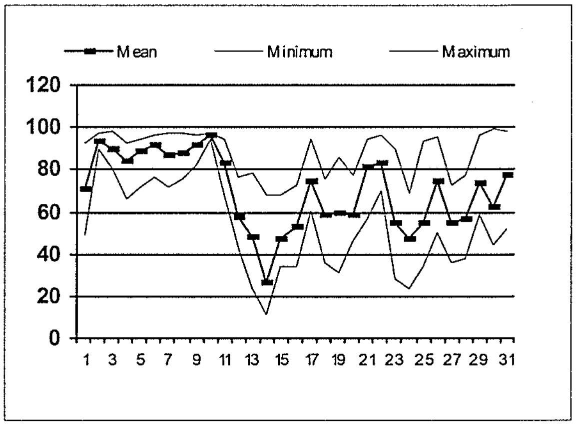
CASTNet: March - Relative Humidity (%)



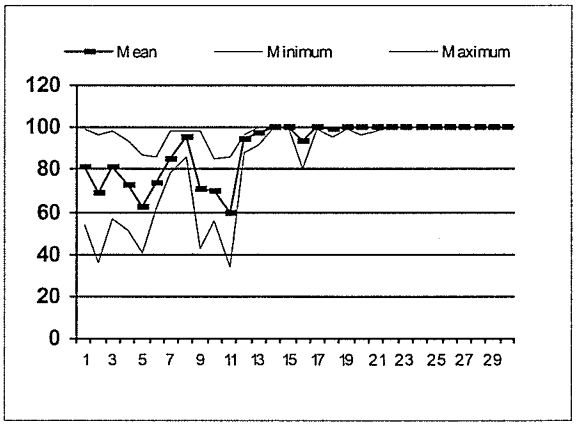
CASTNet: April - Relative Humidity (%)



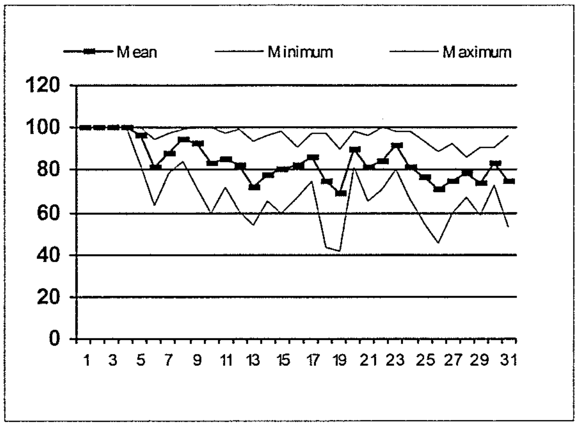
CASTNet: May - Relative Humidity (%)



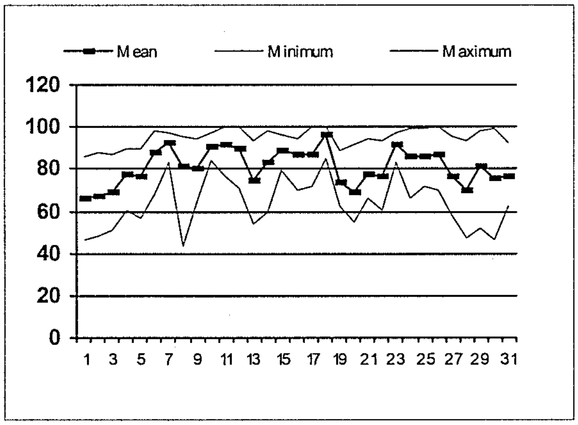
CASTNet: June - Relative Humidity (%)



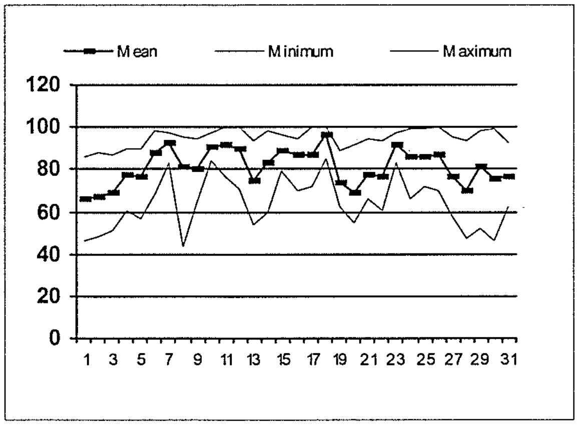
CASTNet: July - Relative Humidity (%)



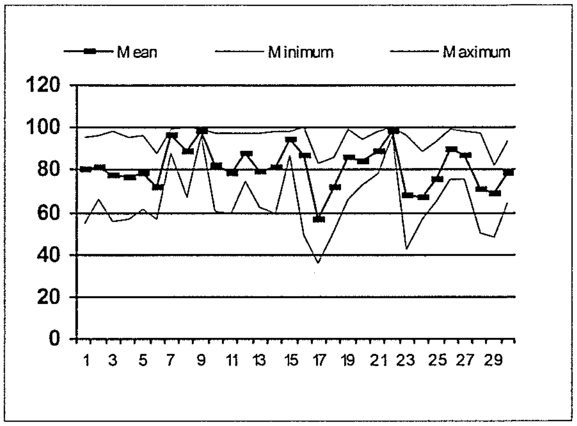
CASTNet: August - Relative Humidity (%)



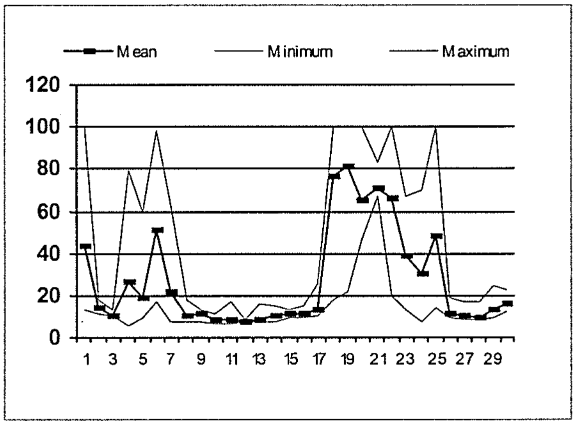
CASTNet: September - Relative Humidity (%)



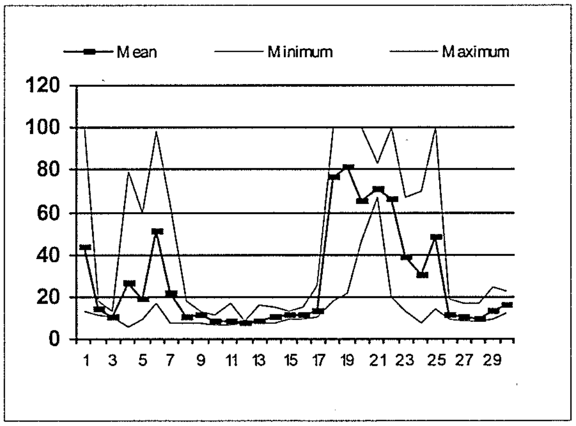
CASTNet: October - Relative Humidity (%)



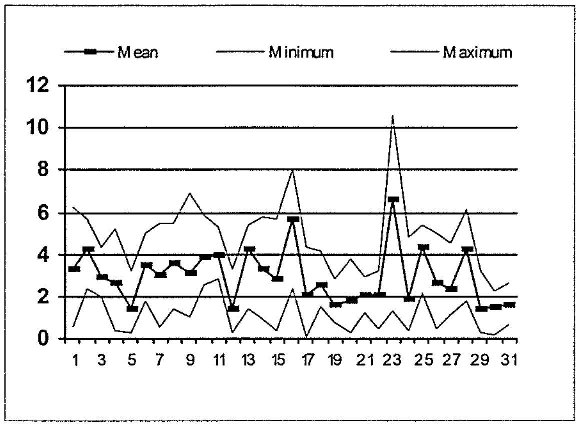
CASTNet: November - Relative Humidity (%)



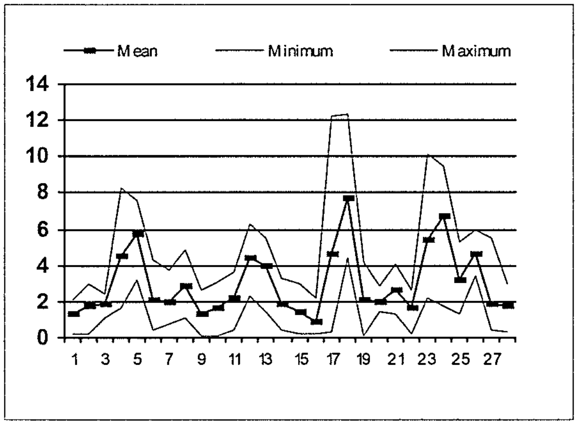
CASTNet: December - Relative Humidity (%)



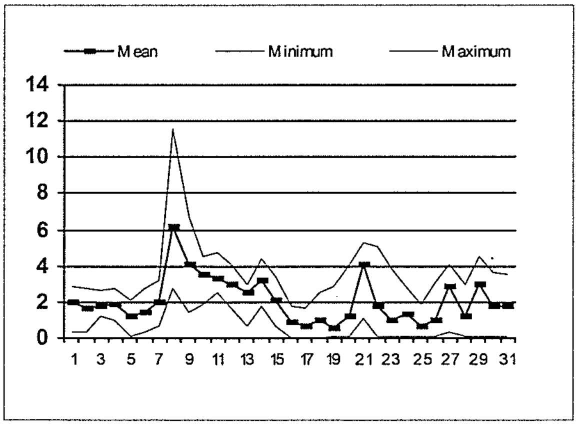
CASTNet: January - Resultant Wind Speed (m/s)



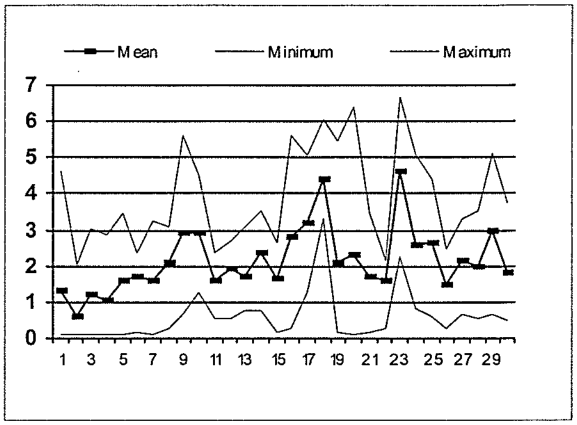
CASTNet: February - Resultant Wind Speed (m/s)



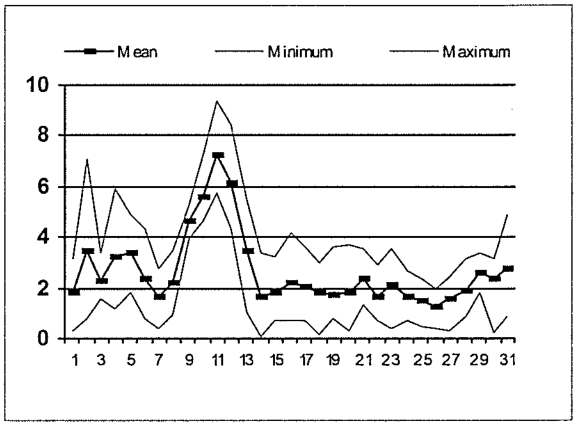
CASTNet: March - Resultant Wind Speed (m/s)



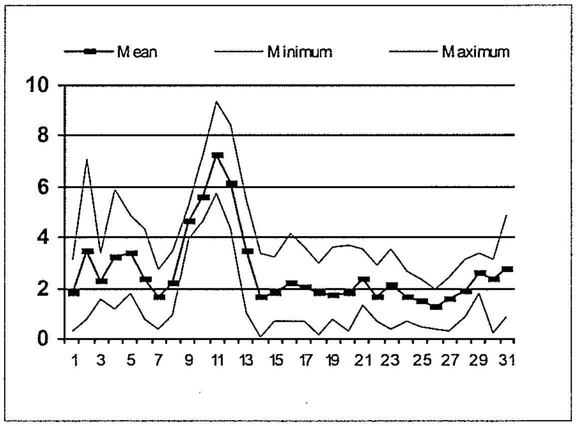
CASTNet: April - Resultant Wind Speed (m/s)



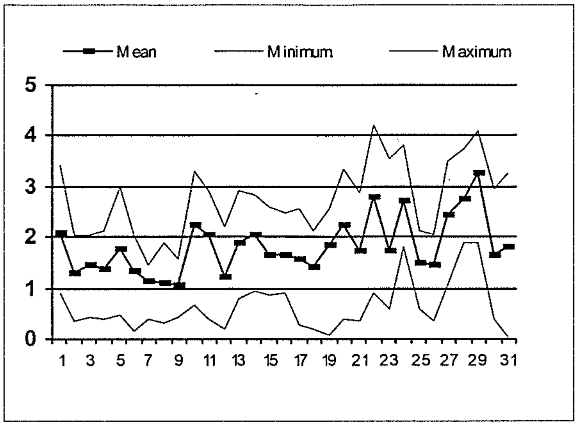
CASTNet: May - Resultant Wind Speed (m/s)



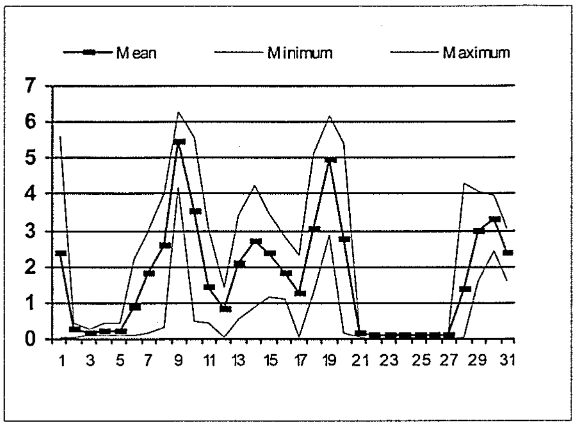
CASTNet: June - Resultant Wind Speed (m/s)



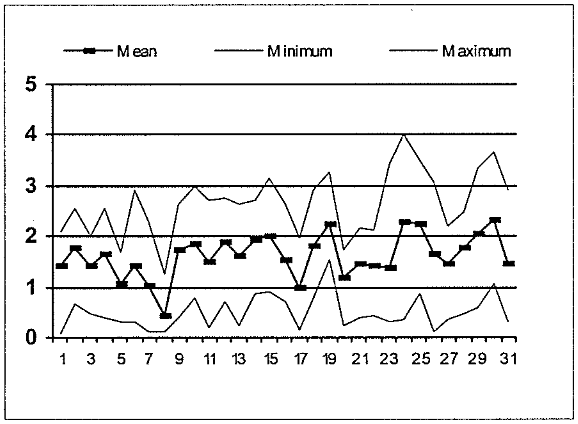
CASTNet: July - Resultant Wind Speed (m/s)



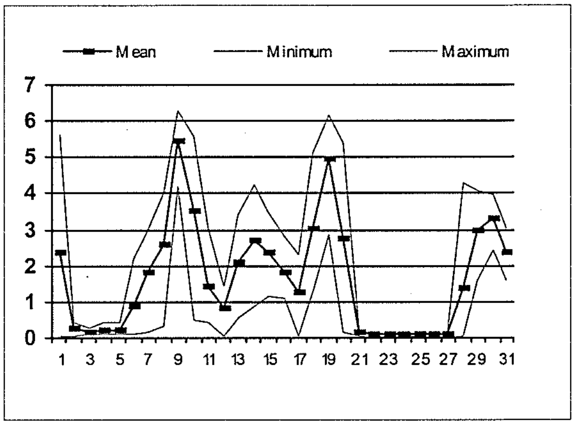
CASTNet: October - Resultant Wind Speed (m/s)



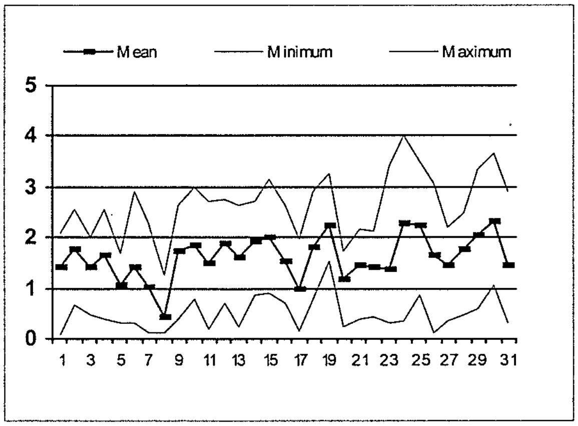
CASTNet: August - Resultant Wind Speed (m/s)



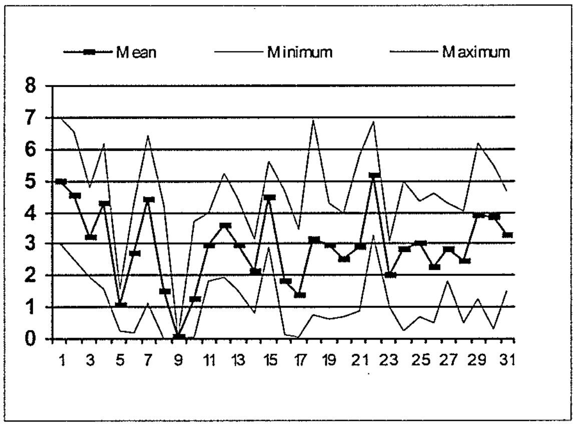
CASTNet: November - Resultant Wind Speed (m/s)



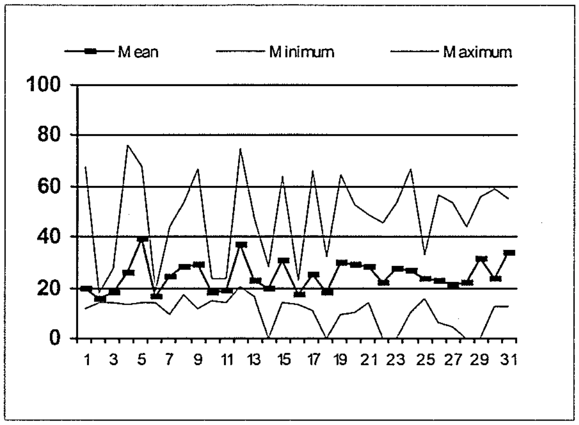
CASTNet: September - Resultant Wind Speed (m/s)



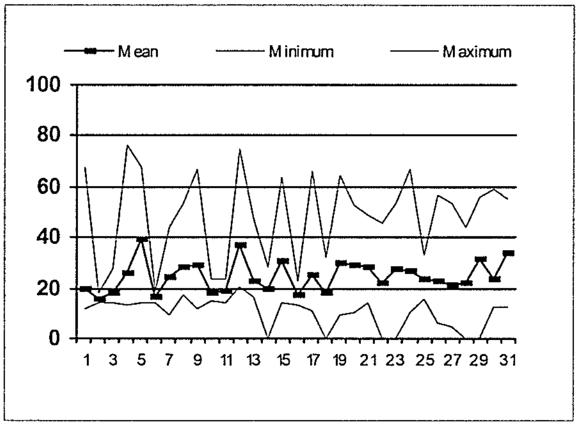
CASTNet: December - Resultant Wind Speed (m/s)



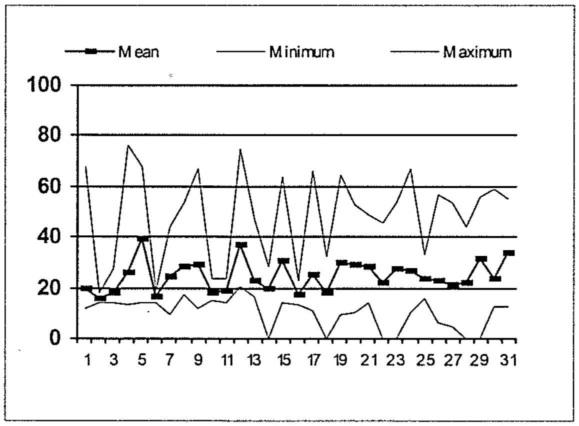
CASTNet: January - Stand Deviation Wind Direction



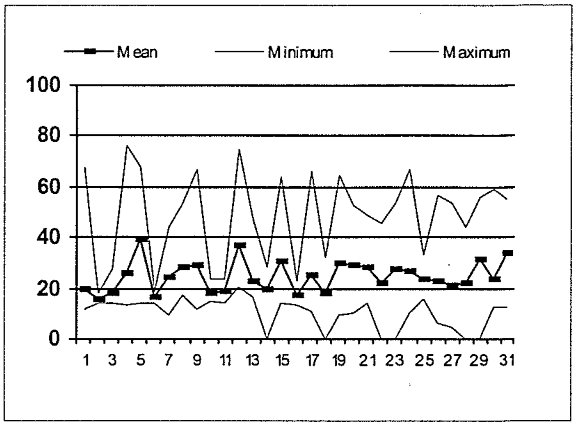
CASTNet: February - Stand Deviation Wind Direction



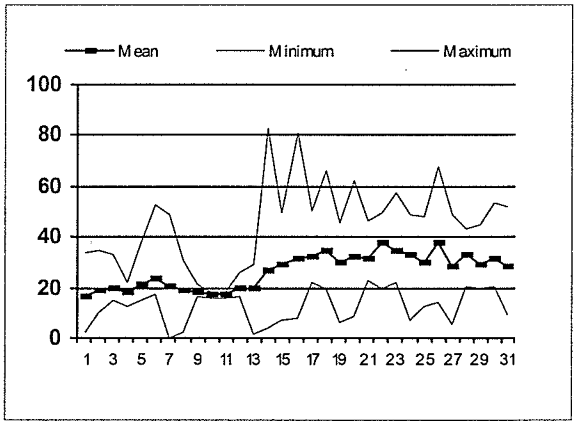
CASTNet: March - Stand Deviation Wind Direction



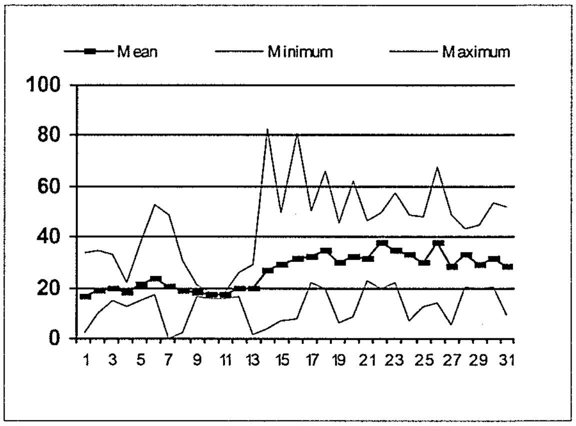
CASTNet: April - Stand Deviation Wind Direction



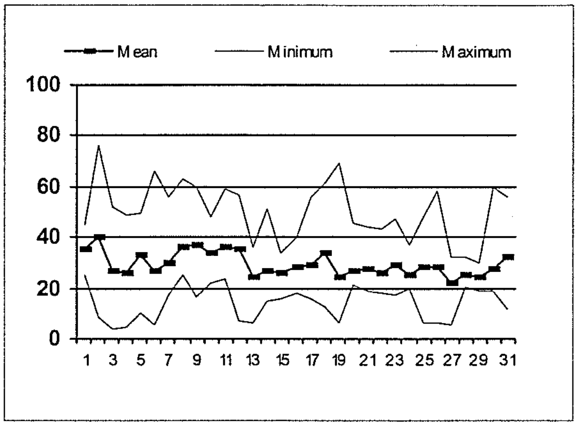
CASTNet: May - Stand Deviation Wind Direction



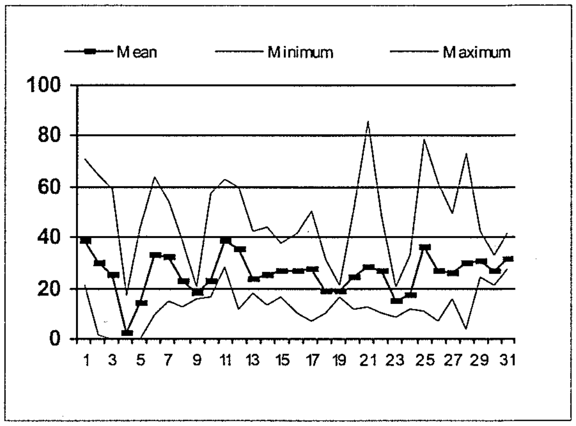
CASTNet: June - Stand Deviation Wind Direction



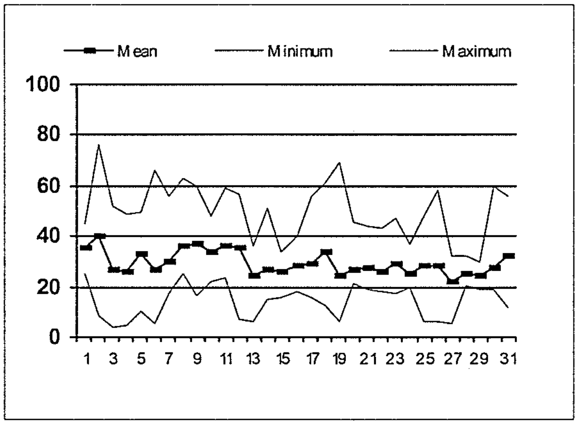
CASTNet: July - Stand Deviation Wind Direction



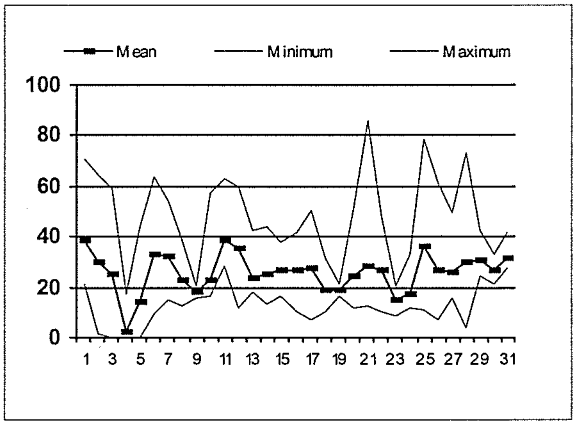
CASTNet: October - Stand Deviation Wind Direction



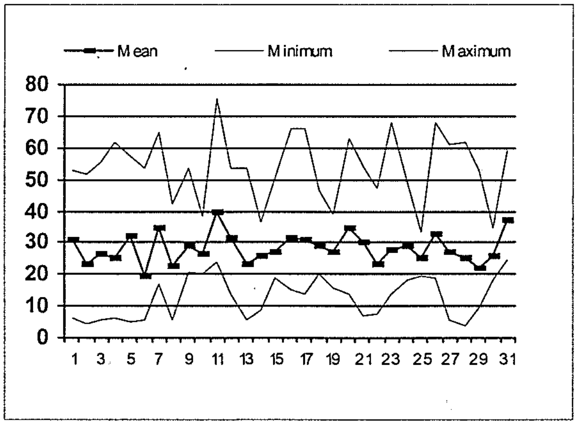
CASTNet: August - Stand Deviation Wind Direction



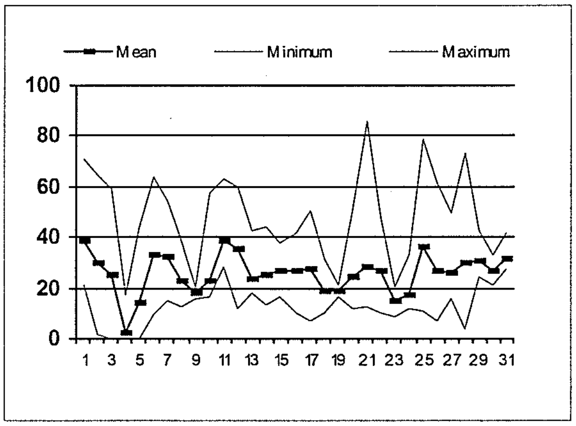
CASTNet: November - Stand Deviation Wind Direction



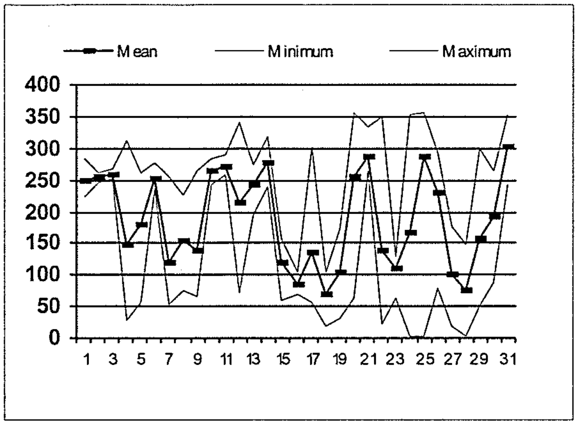
CASTNet: September - Stand Deviation Wind Direction



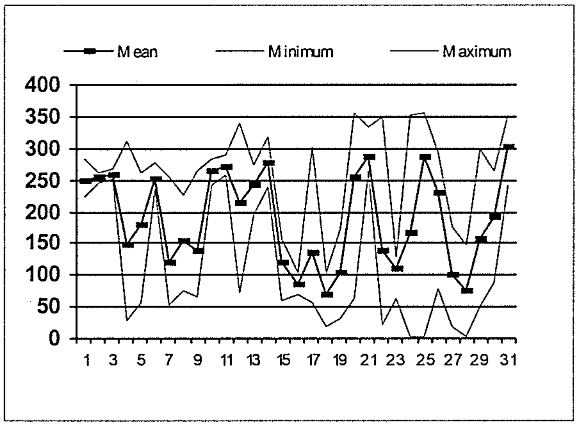
CASTNet: December - Stand Deviation Wind Direction



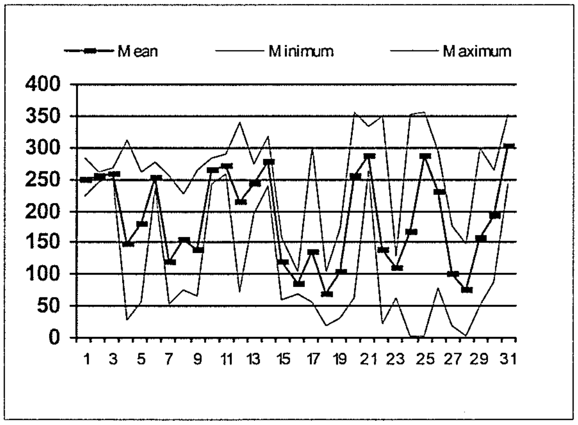
CASTNet: January - Wind Direction (degrees)



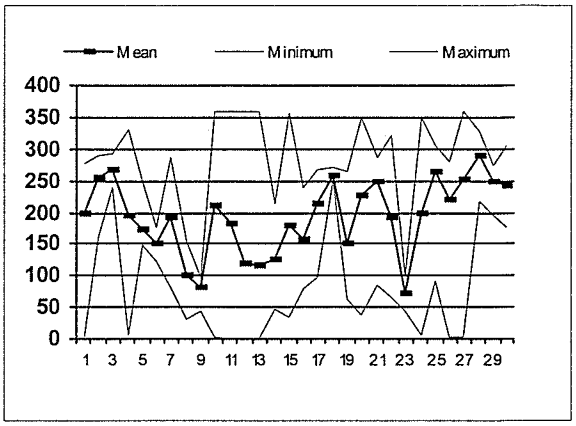
CASTNet: February - Wind Direction (degrees)



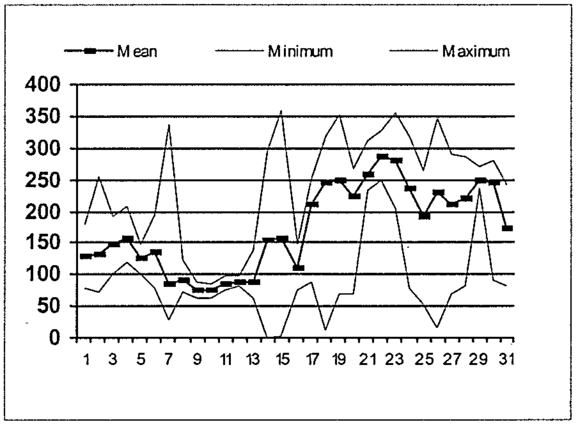
CASTNet: March - Wind Direction (degrees)



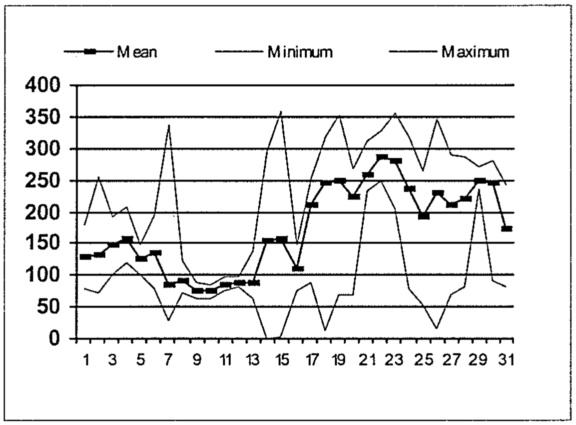
CASTNet: April - Wind Direction (degrees)



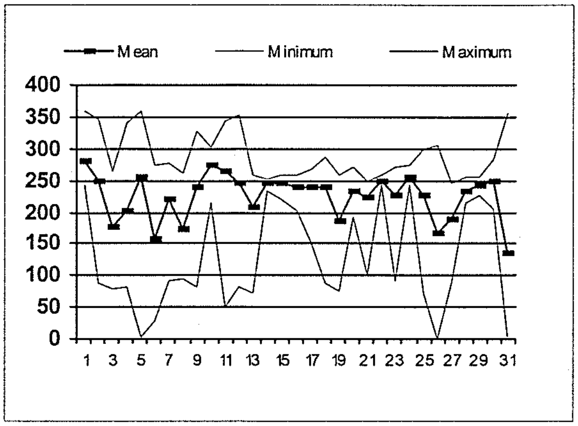
CASTNet: May - Wind Direction (degrees)



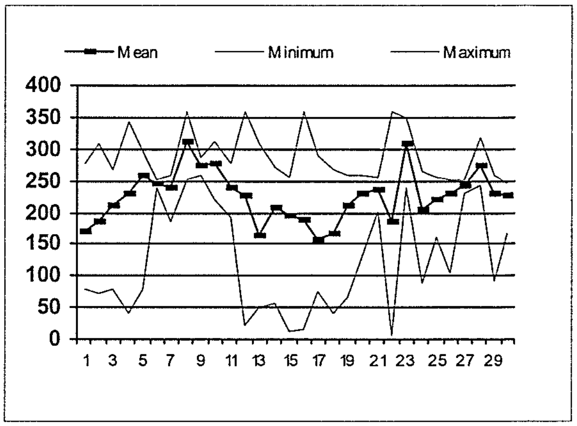
CASTNet: June - Wind Direction (degrees)



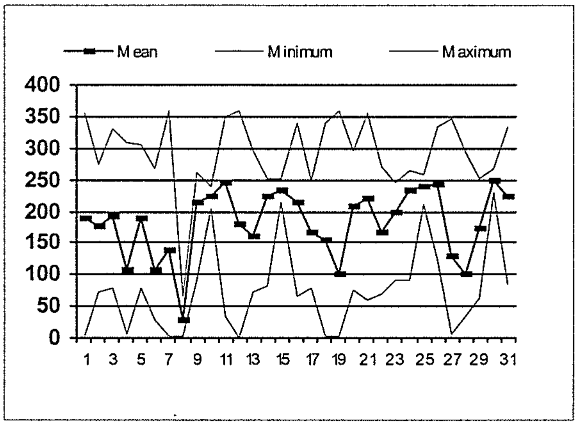
CASTNet: July - Wind Direction (degrees)



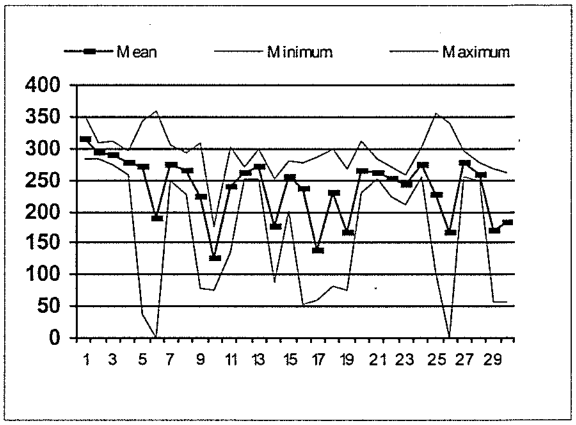
CASTNet: October - Wind Direction (degrees)



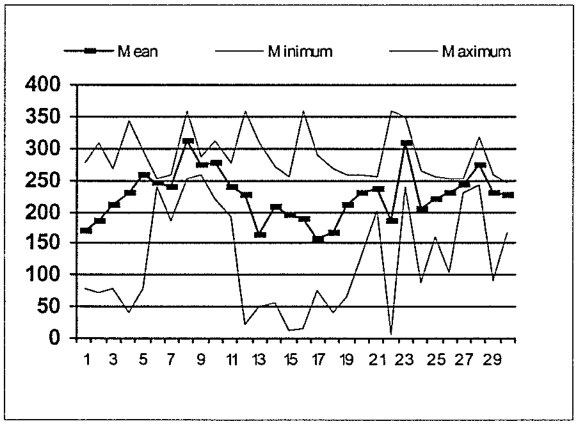
CASTNet: August - Wind Direction (degrees)



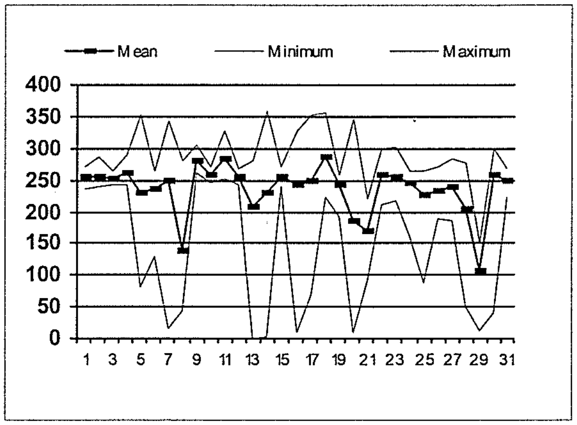
CASTNet: November - Wind Direction (degrees)



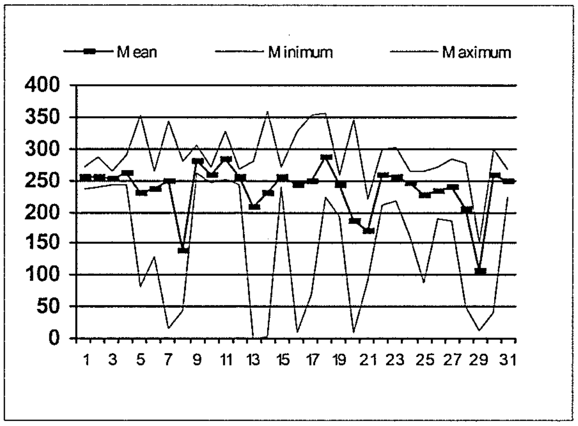
CASTNet: September - Wind Direction (degrees)



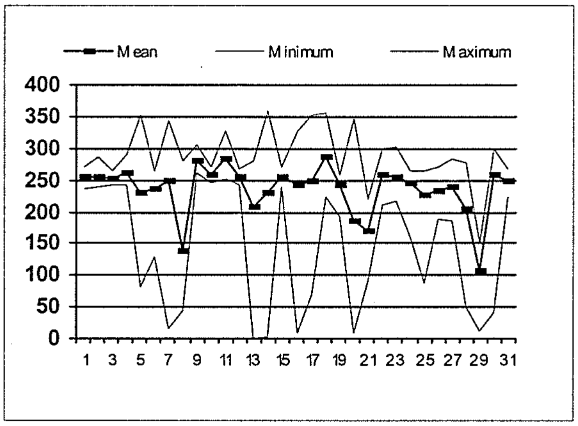
CASTNet: December - Wind Direction (degrees)



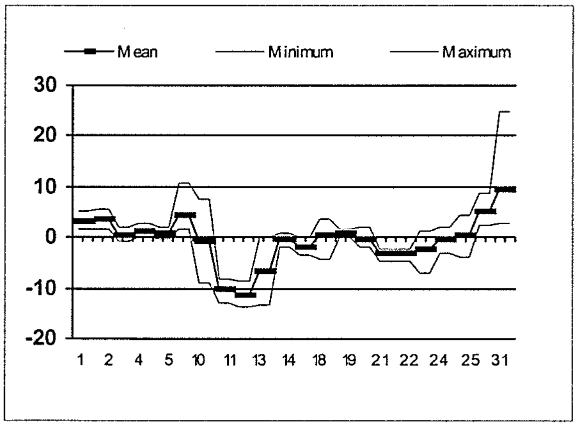
Colchester Reef: January - Air Temperature (degrees C)



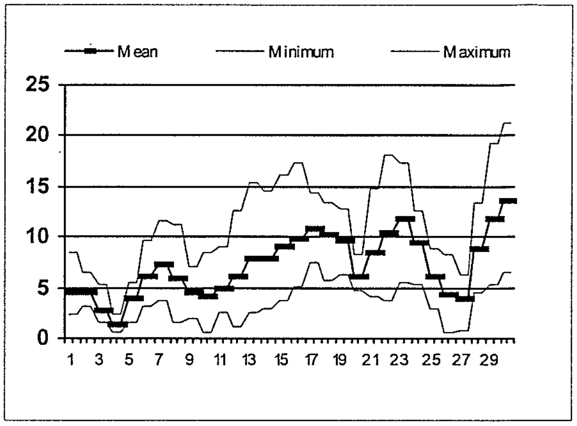
Colchester Reef: February - Air Temperature (degrees C)



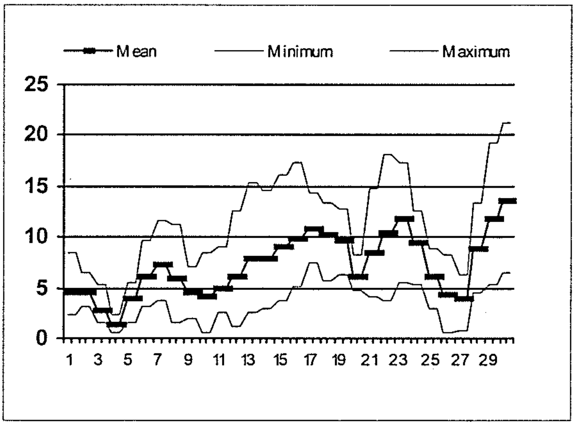
Colchester Reef: March - Air Temperature (degrees C)



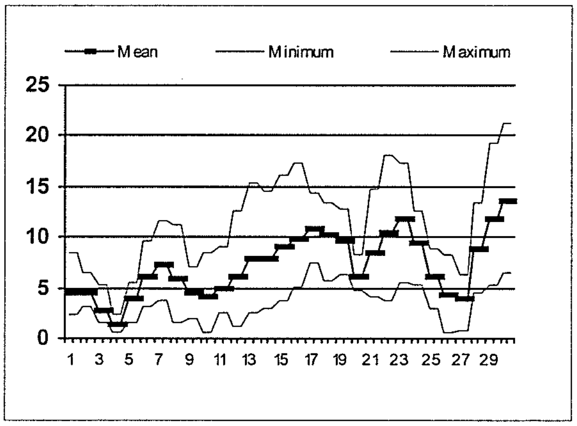
Colchester Reef: April - Air Temperature (degrees C)



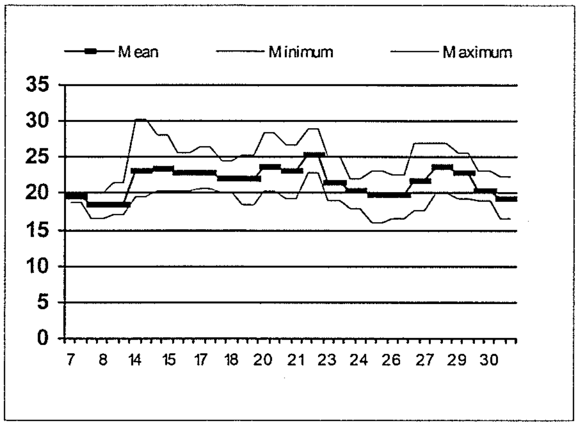
Colchester Reef: May - Air Temperature (degrees C)



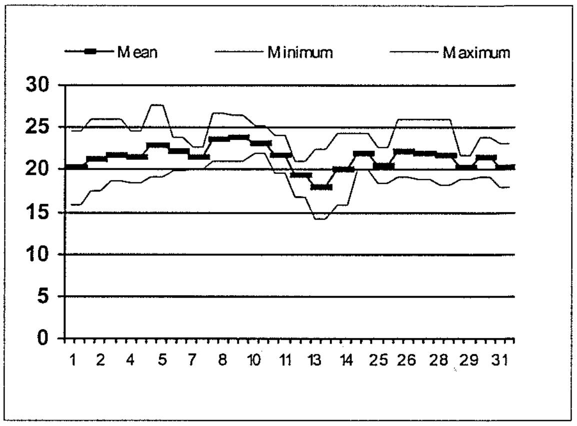
Colchester Reef: June - Air Temperature (degrees C)



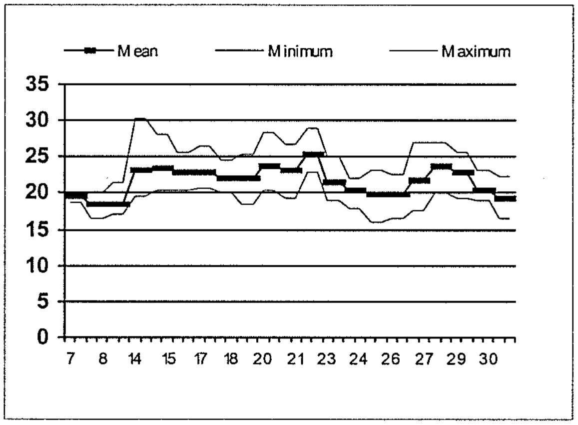
Colchester Reef: July - Air Temperature (degrees C)



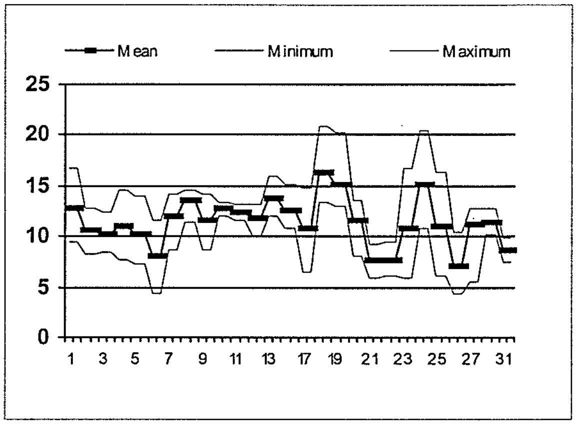
Colchester Reef: October - Air Temperature (degrees C)



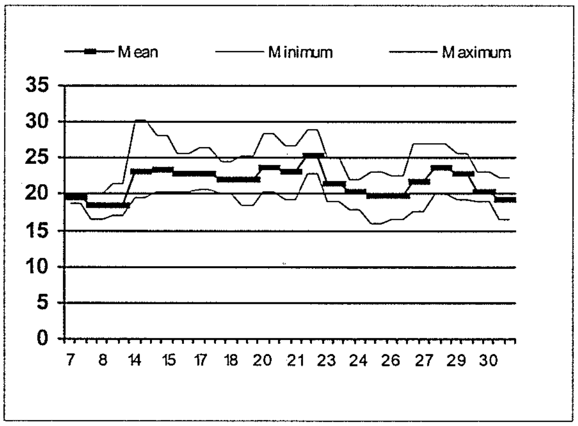
Colchester Reef: August - Air Temperature (degrees C)



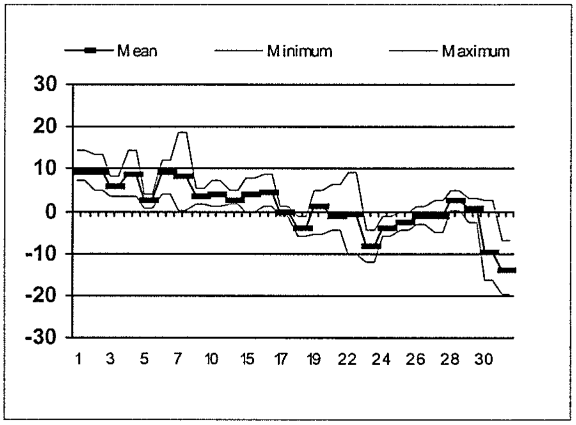
Colchester Reef: November - Air Temperature (degrees C)



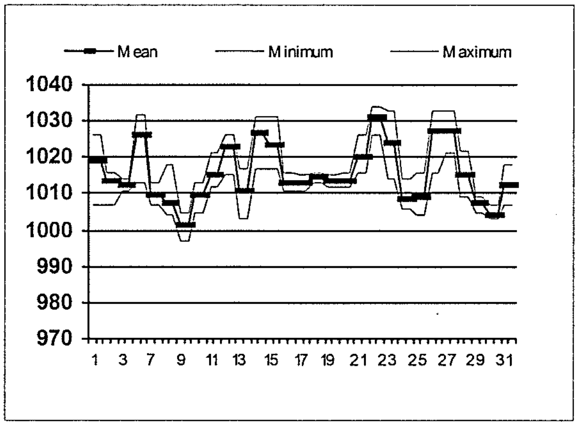
Colchester Reef: September - Air Temperature (degrees C)



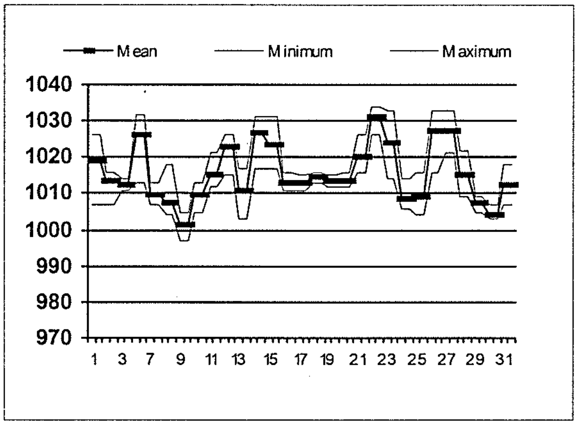
Colchester Reef: December - Air Temperature (degrees C)



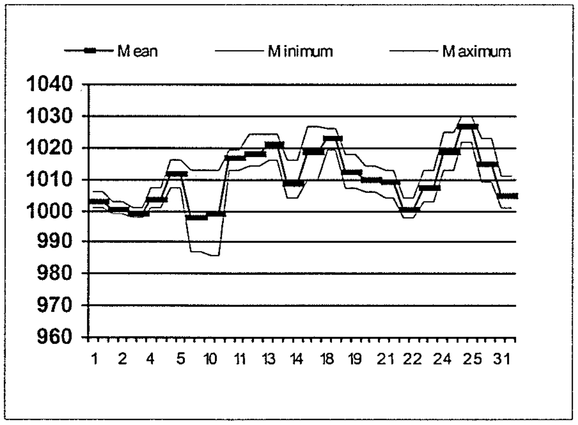
Colchester Reef: January - Barometric Pressure (mb)



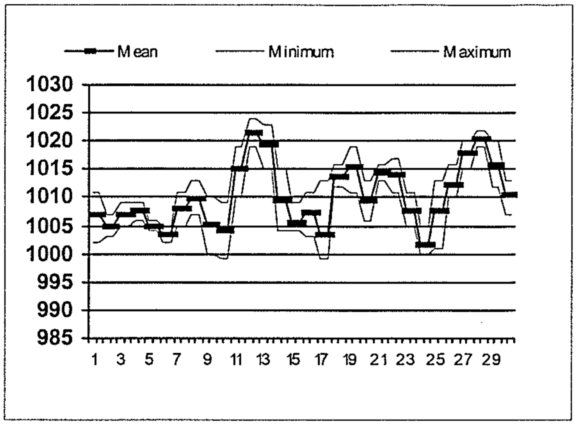
Colchester Reef: February - Barometric Pressure (mb)



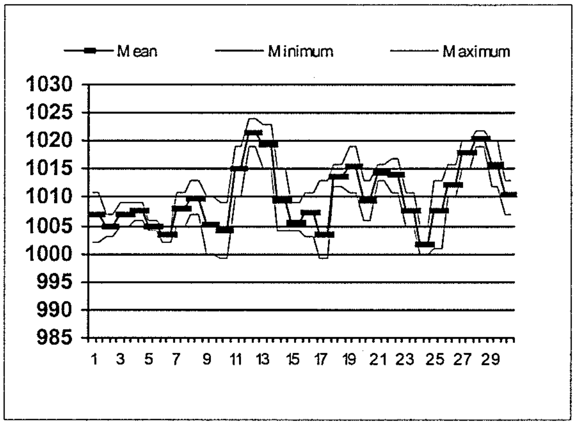
Colchester Reef: March - Barometric Pressure (mb)



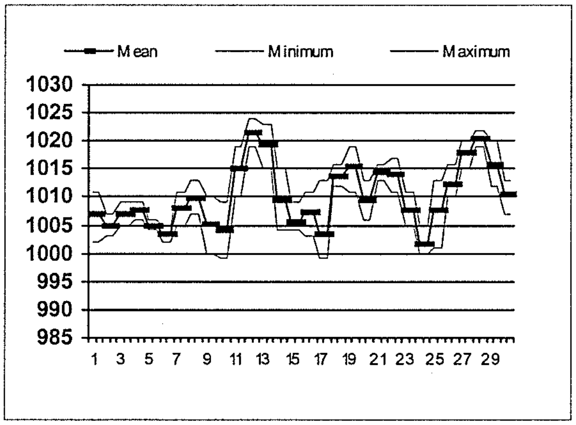
Colchester Reef: April - Barometric Pressure (mb)



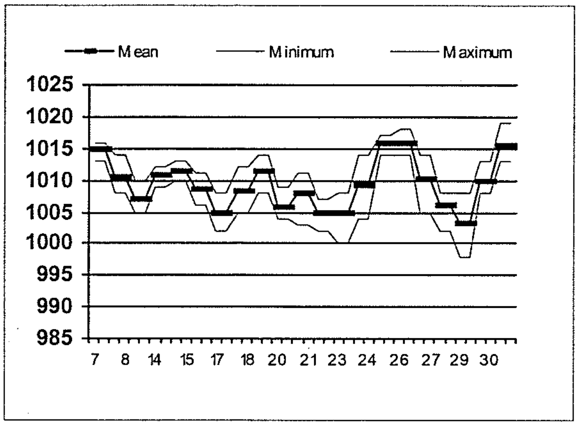
Colchester Reef: May - Barometric Pressure (mb)



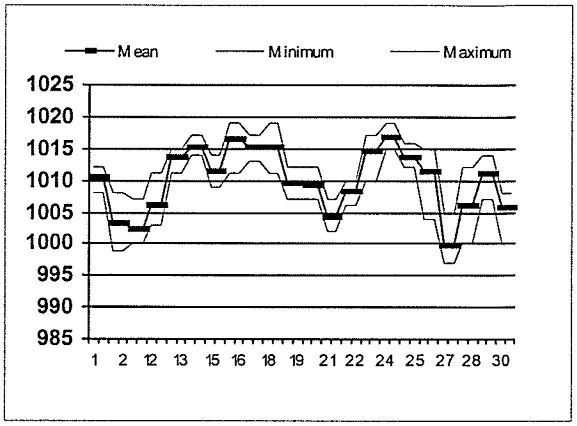
Colchester Reef: June - Barometric Pressure (mb)



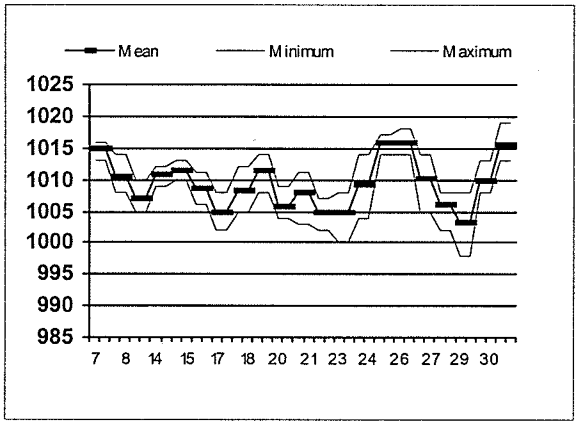
Colchester Reef: July - Barometric Pressure (mb)



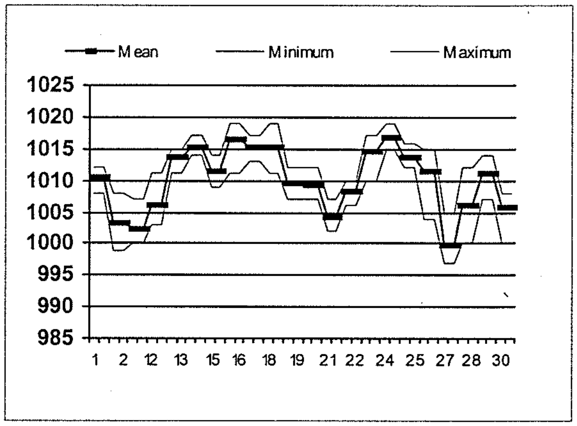
Colchester Reef: October - Barometric Pressure (mb)



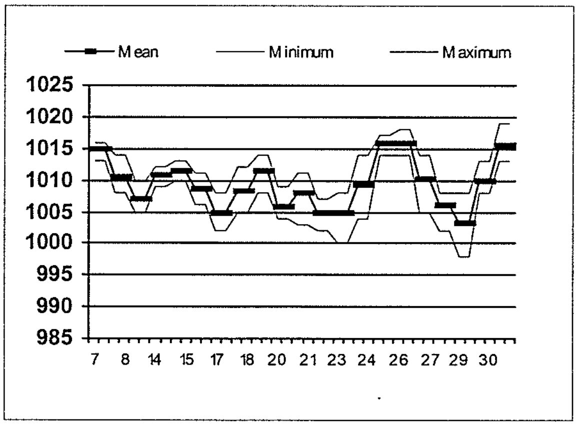
Colchester Reef: August - Barometric Pressure (mb)



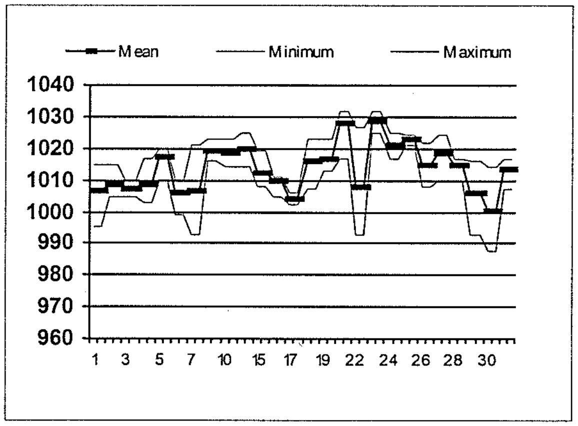
Colchester Reef: November - Barometric Pressure (mb)



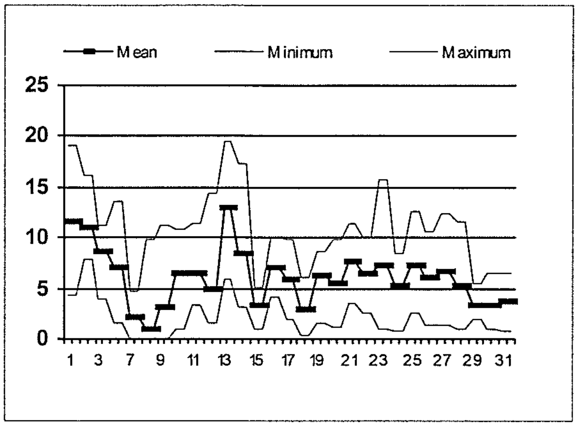
Colchester Reef: September - Barometric Pressure (mb)



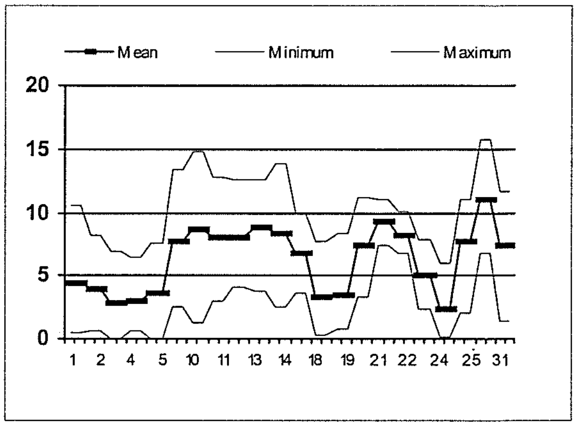
Colchester Reef: December - Barometric Pressure (mb)



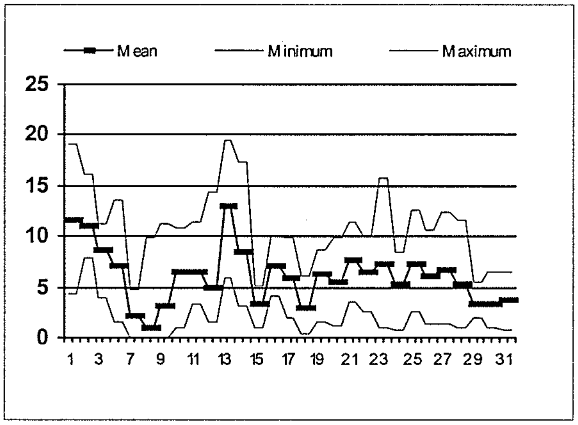
Colchester Reef: January - Horizontal Wind Speed (ms)



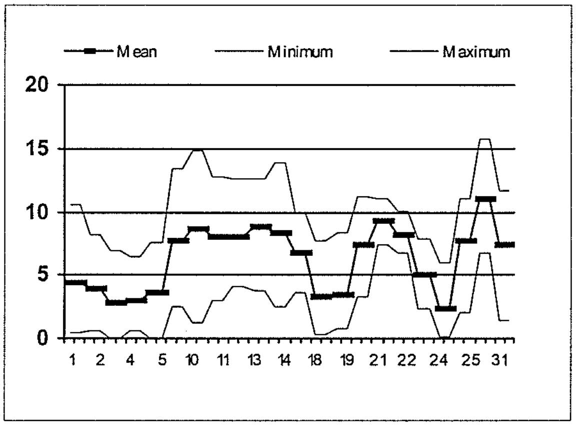
Colchester Reef: April - Horizontal Wind Speed (ms)



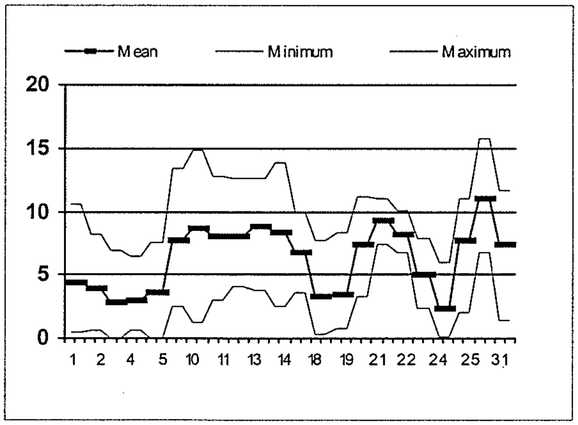
Colchester Reef: February - Horizontal Wind Speed (ms)



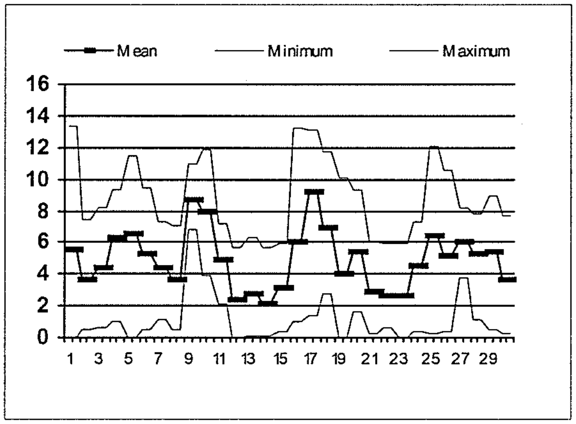
Colchester Reef: May - Horizontal Wind Speed (ms)



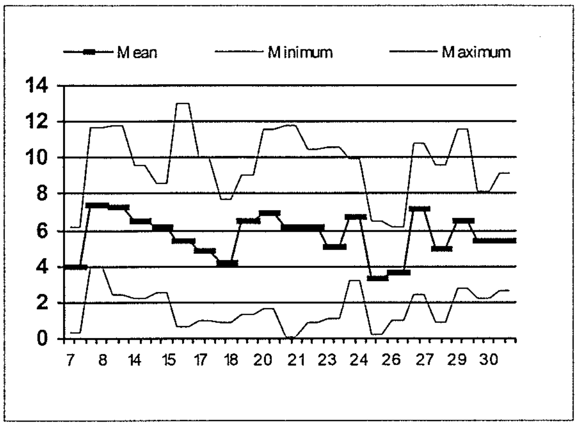
Colchester Reef: March - Horizontal Wind Speed (ms)



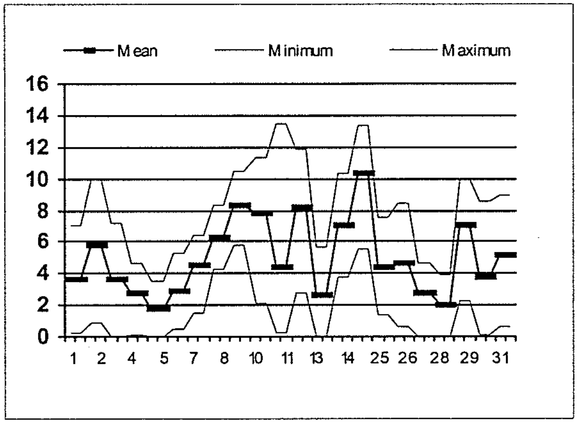
Colchester Reef: June - Horizontal Wind Speed (ms)



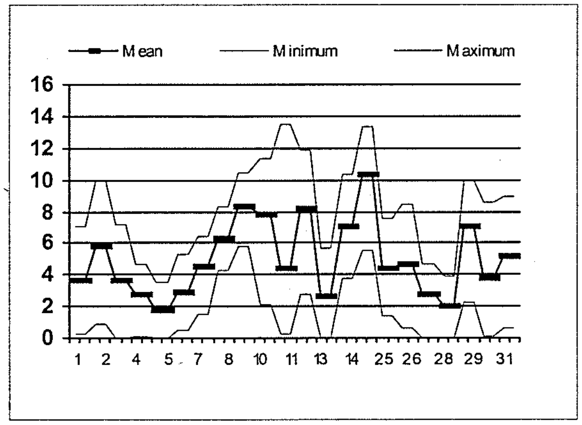
Colchester Reef: July - Horizontal Wind Speed (ms)



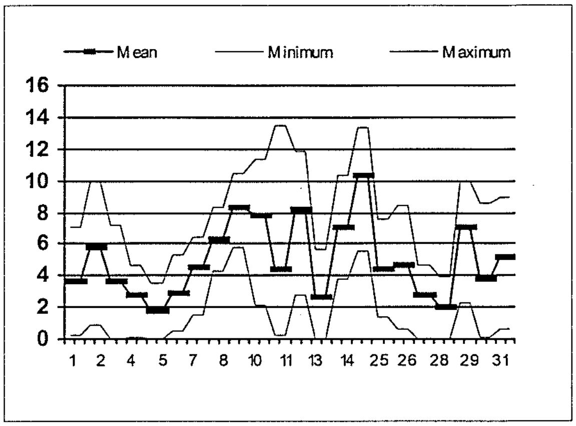
Colchester Reef: August - Horizontal Wind Speed (ms)



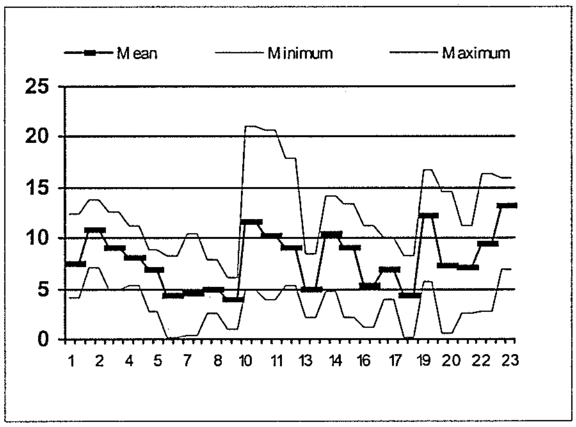
Colchester Reef: September - Horizontal Wind Speed (ms)



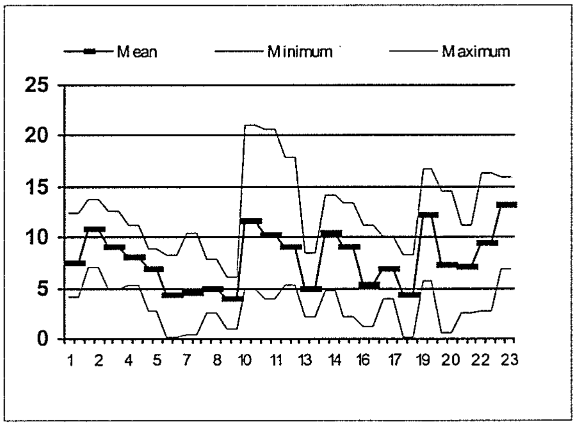
Colchester Reef: October - Horizontal Wind Speed (ms)



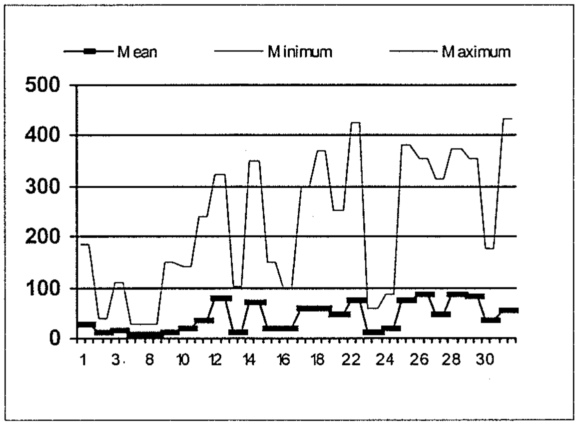
Colchester Reef: November - Horizontal Wind Speed (ms)



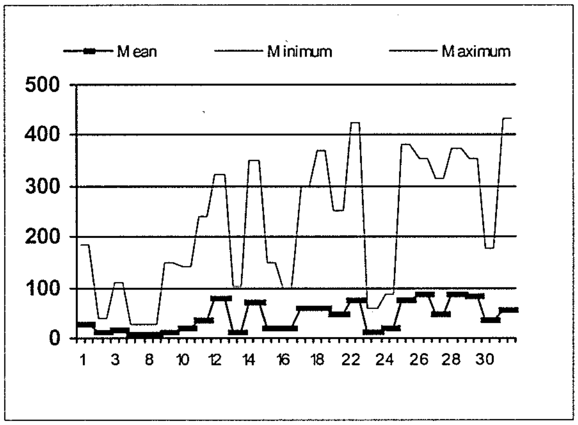
Colchester Reef: December - Horizontal Wind Speed (ms)



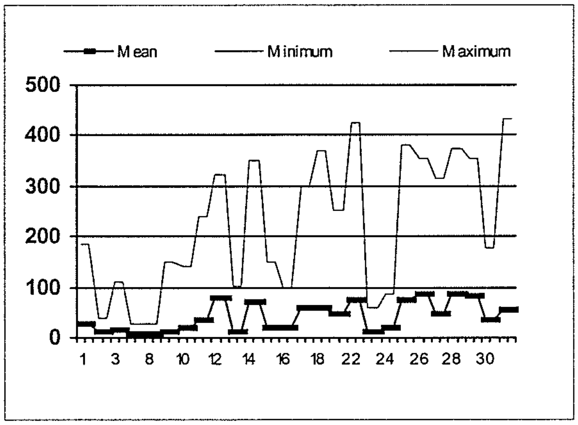
Colchester Reef: January - Pyranometer (watts/m^2)



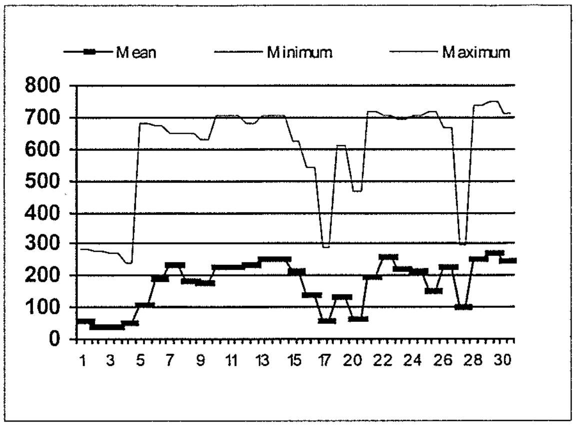
Colchester Reef: February - Pyranometer (watts/m^2)



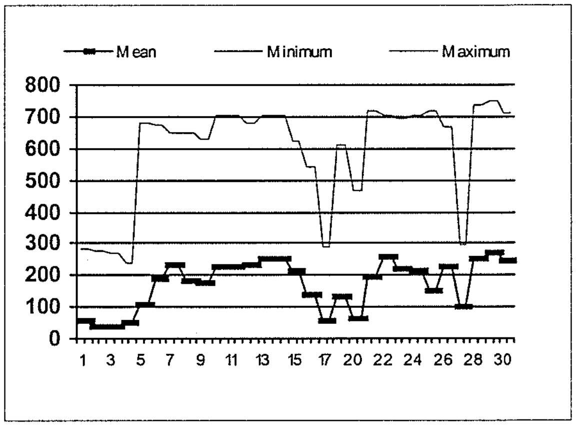
Colchester Reef: March - Pyranometer (watts/m^2)



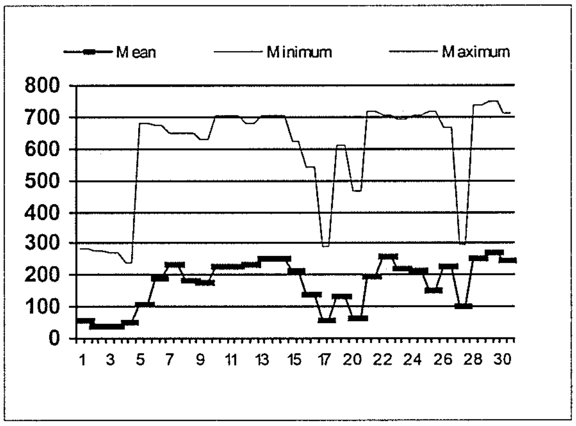
Colchester Reef: April - Pyranometer (watts/m^2)



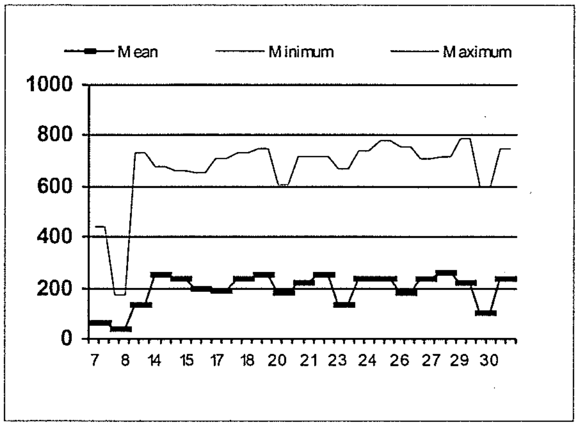
Colchester Reef: May - Pyranometer (watts/m^2)



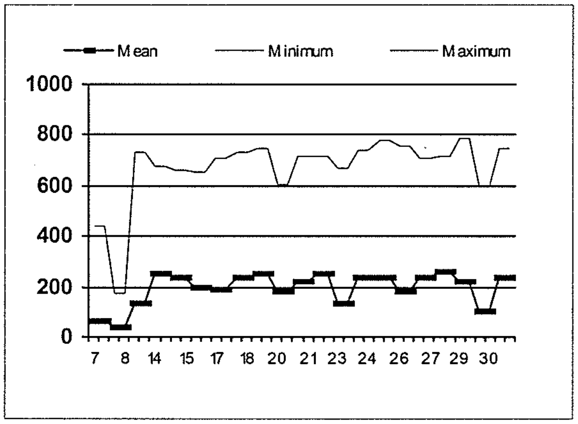
Colchester Reef: June - Pyranometer (watts/m^2)



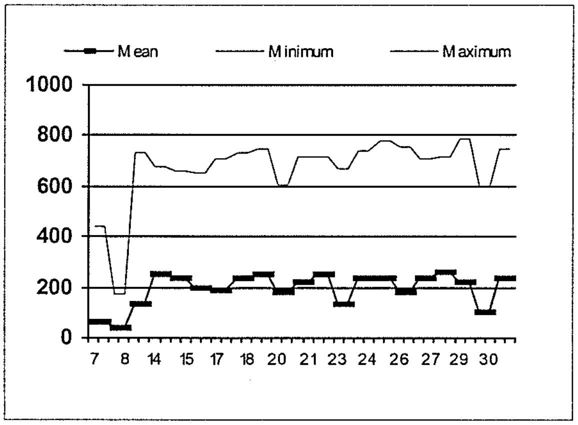
Colchester Reef: July - Pyranometer (watts/m^2)



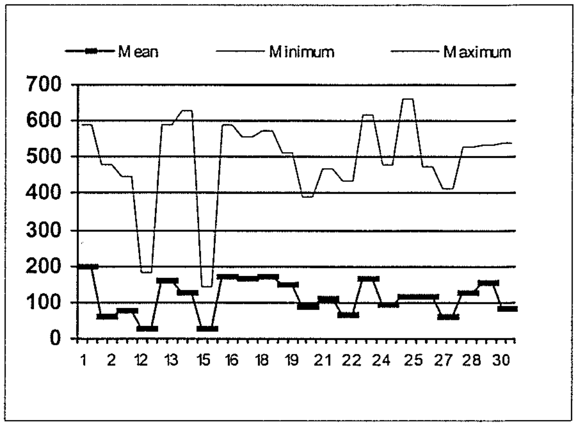
Colchester Reef: August - Pyranometer (watts/m^2)



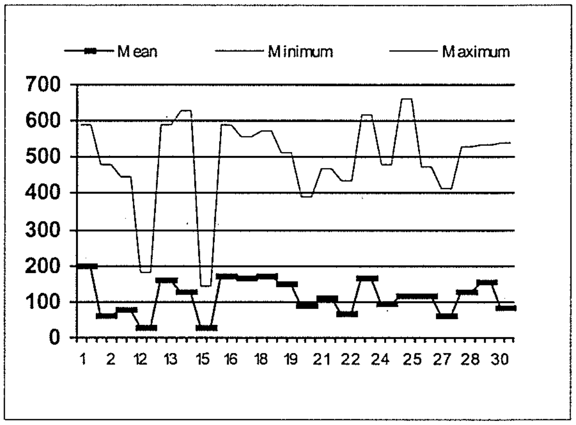
Colchester Reef: September - Pyranometer (watts/m^2)



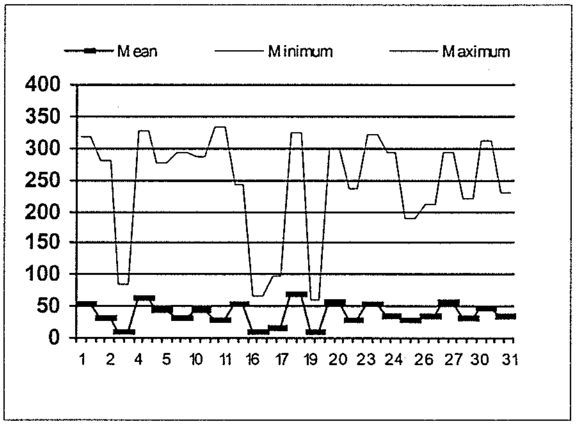
Colchester Reef: October - Pyranometer (watts/m^2)



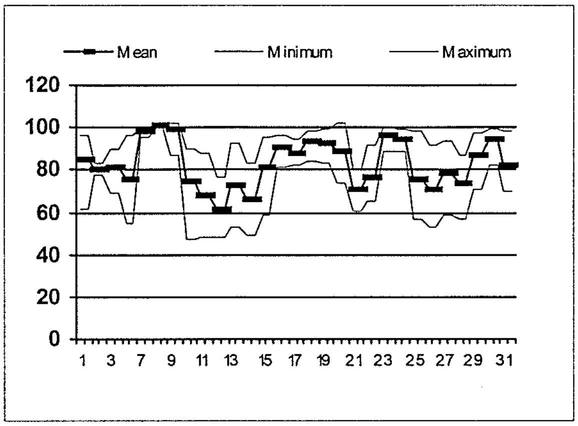
Colchester Reef: November - Pyranometer (watts/m^2)



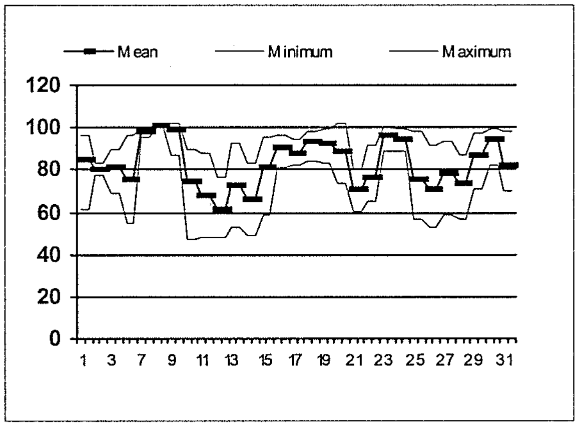
Colchester Reef: December - Pyranometer (watts/m^2)



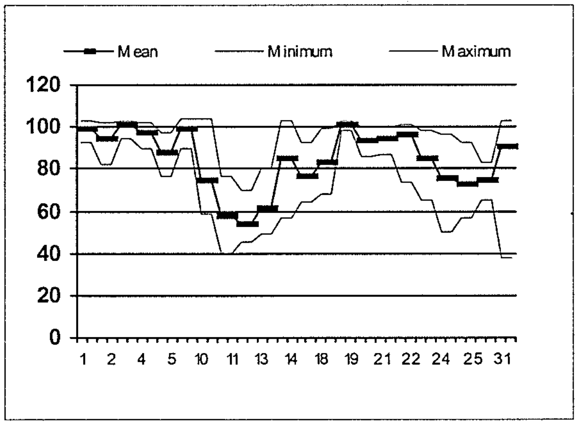
Colchester Reef: January - Relative Humidity (%)



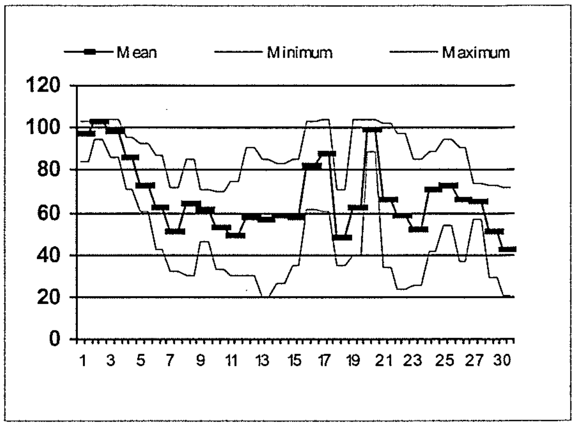
Colchester Reef: February - Relative Humidity (%)



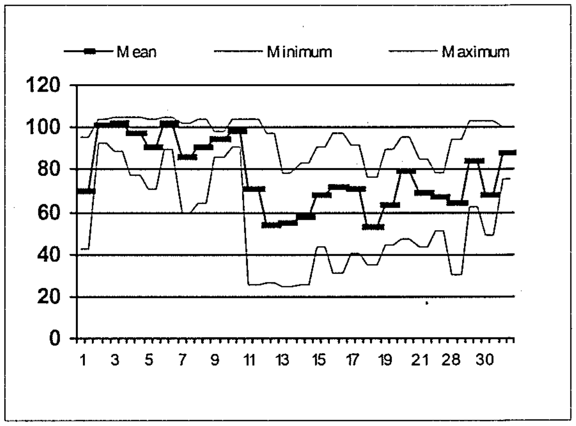
Colchester Reef: March - Relative Humidity (%)



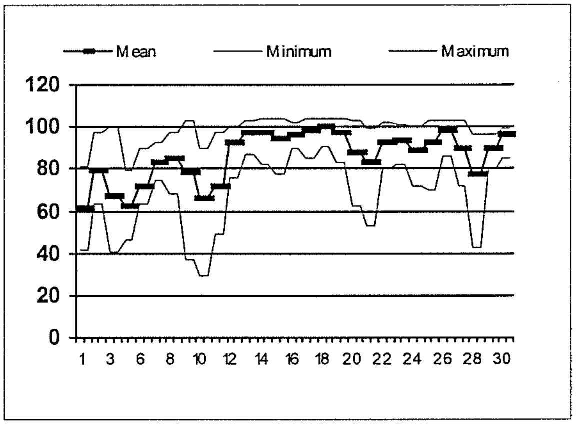
Colchester Reef: April - Relative Humidity (%)



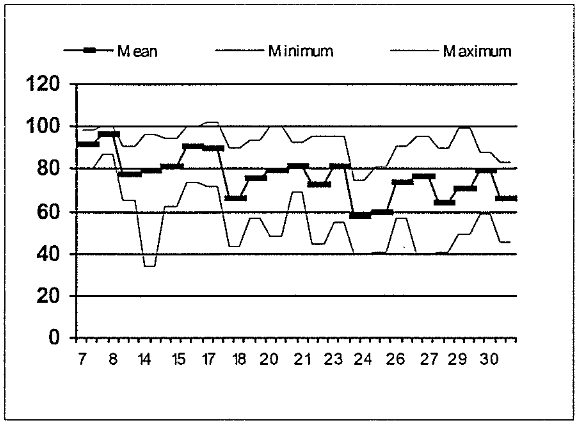
Colchester Reef: May - Relative Humidity (%)



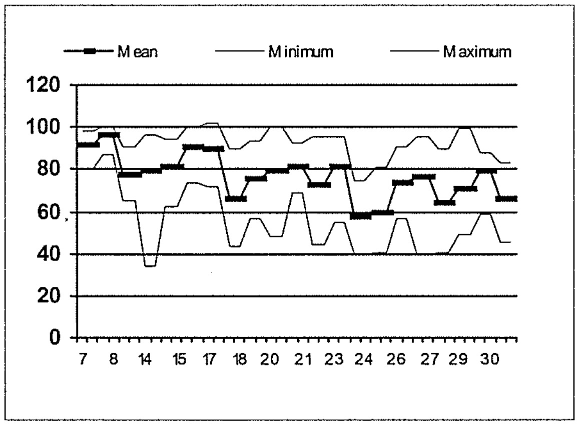
Colchester Reef: June - Relative Humidity (%)



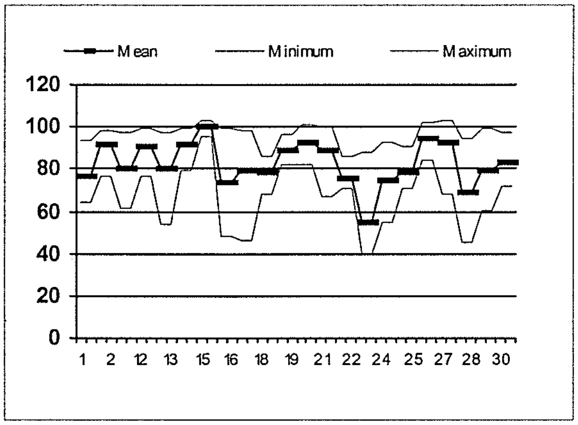
Colchester Reef: July - Relative Humidity (%)



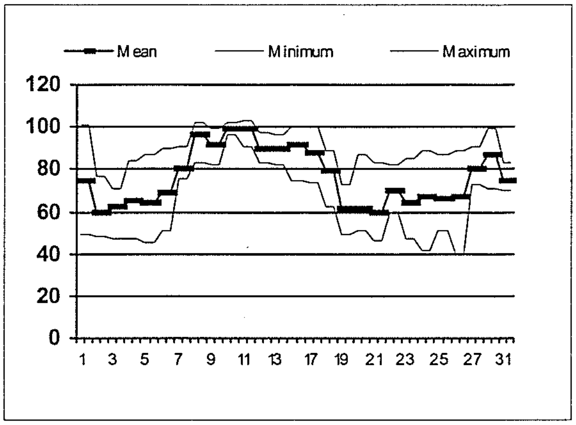
Colchester Reef: August - Relative Humidity (%)



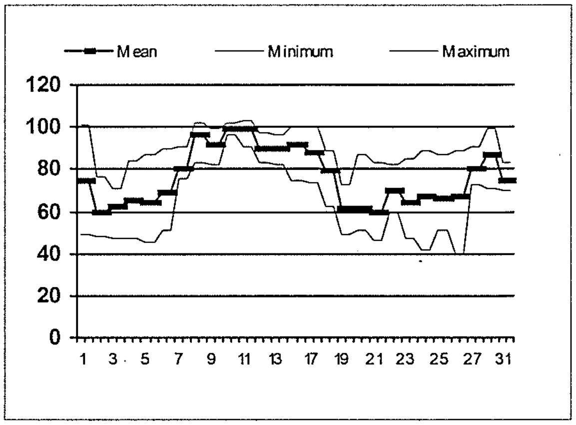
Colchester Reef: September - Relative Humidity (%)



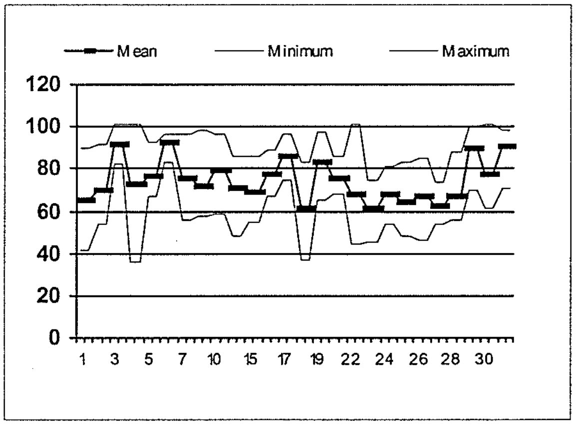
Colchester Reef: October - Relative Humidity (%)



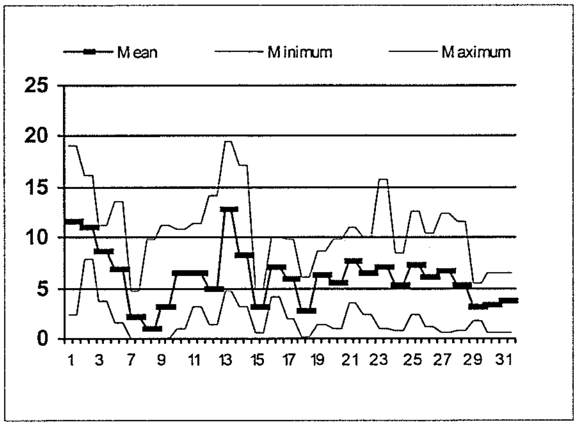
Colchester Reef: November - Relative Humidity (%)



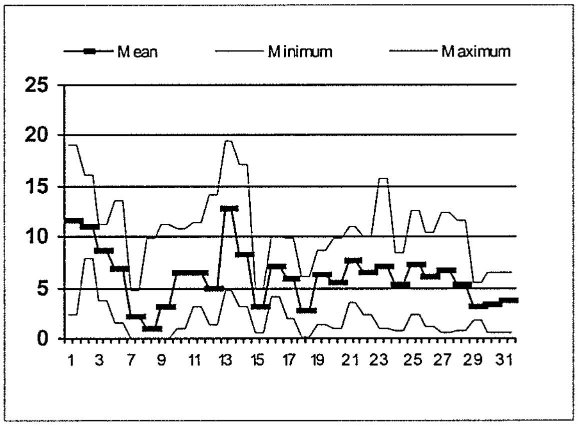
Colchester Reef: December - Relative Humidity (%)



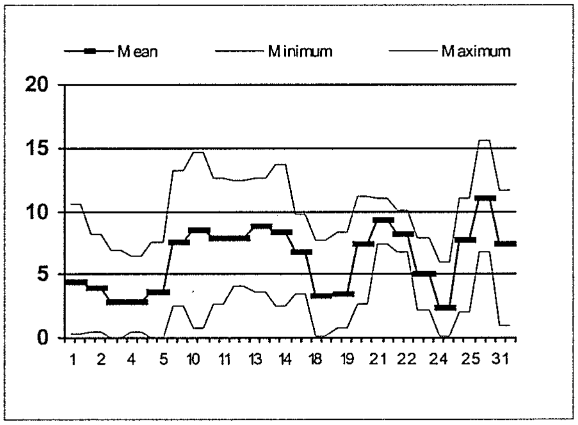
Colchester Reef: January - Resultant Wind Speed (m/s)



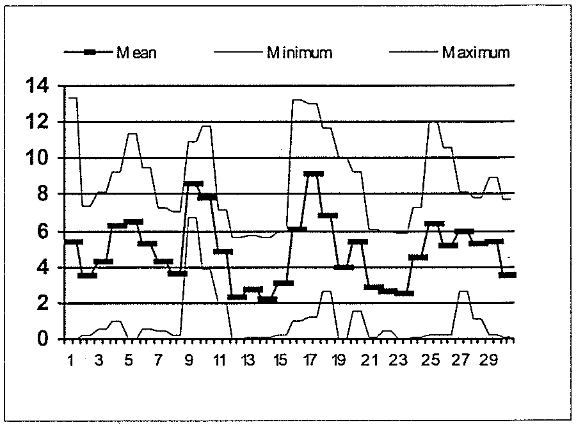
Colchester Reef: February - Resultant Wind Speed (m/s)



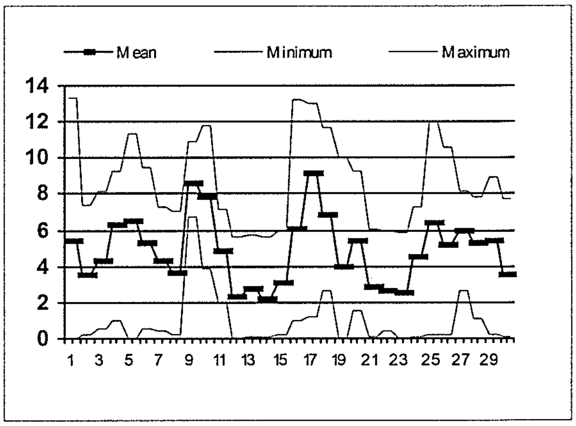
Colchester Reef: March - Resultant Wind Speed (m/s)



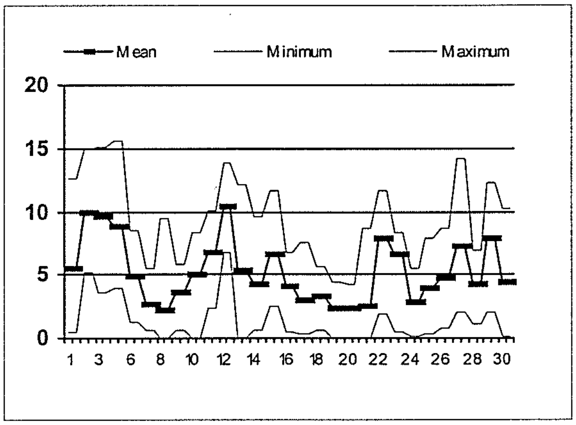
Colchester Reef: April - Resultant Wind Speed (m/s)



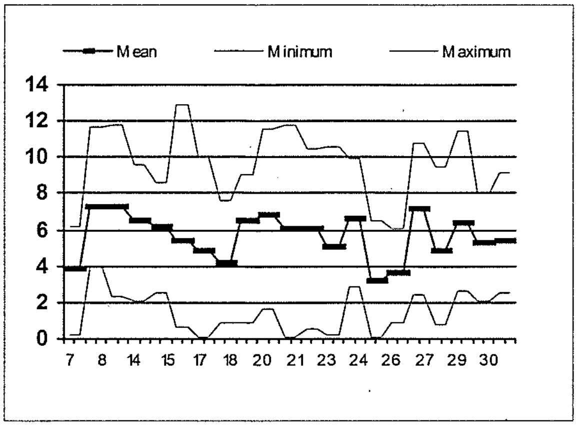
Colchester Reef: May - Resultant Wind Speed (m/s)



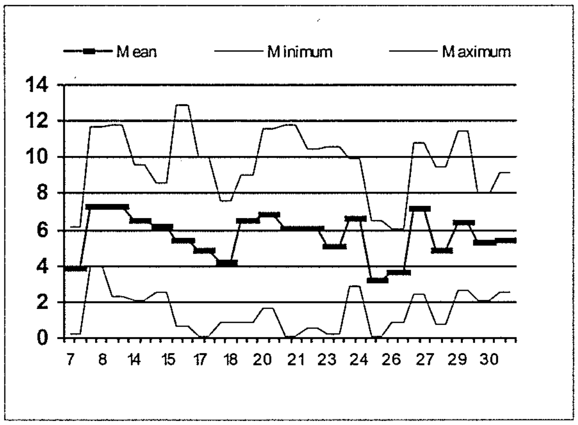
Colchester Reef: June - Resultant Wind Speed (m/s)



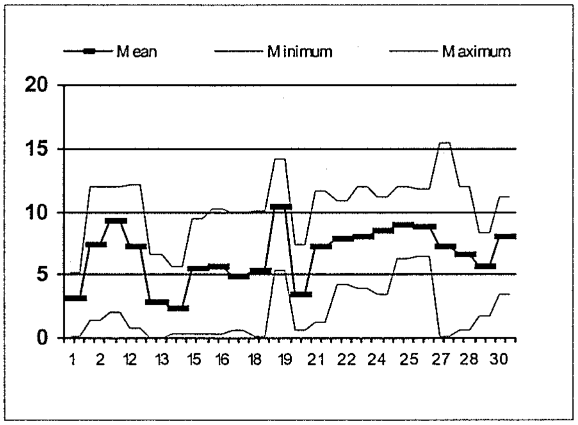
Colchester Reef: July - Resultant Wind Speed (m/s)



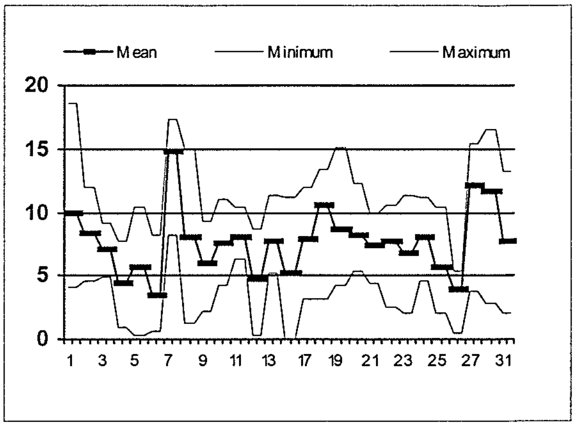
Colchester Reef: August - Resultant Wind Speed (m/s)



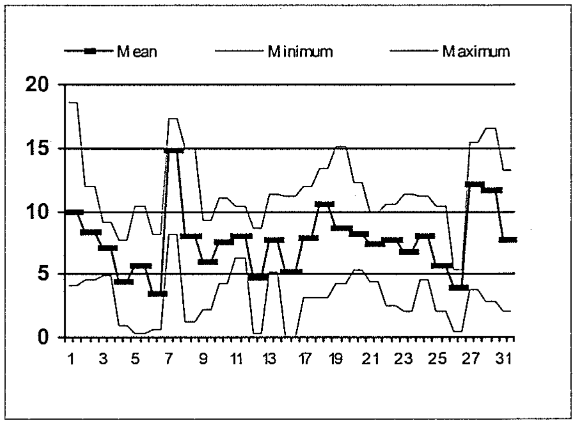
Colchester Reef: September - Resultant Wind Speed (m/s)



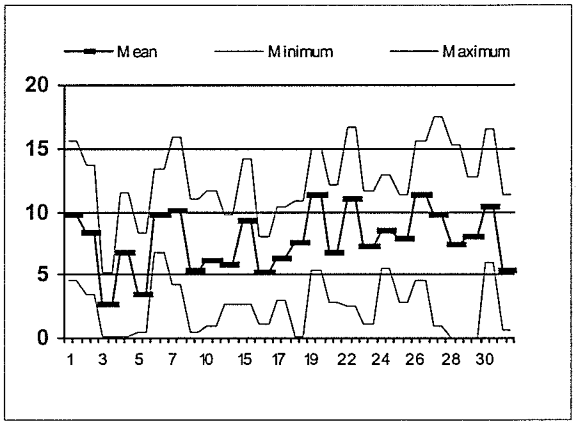
Colchester Reef: October - Resultant Wind Speed (m/s)



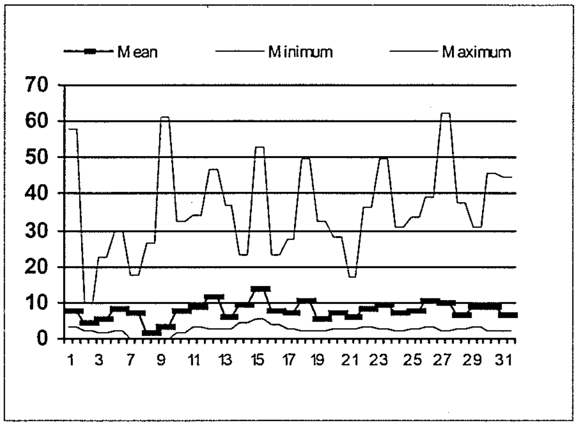
Colchester Reef: November - Resultant Wind Speed (m/s)



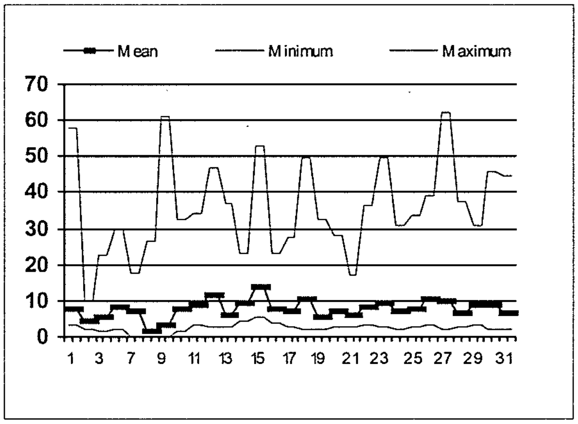
Colchester Reef: December - Resultant Wind Speed (m/s)



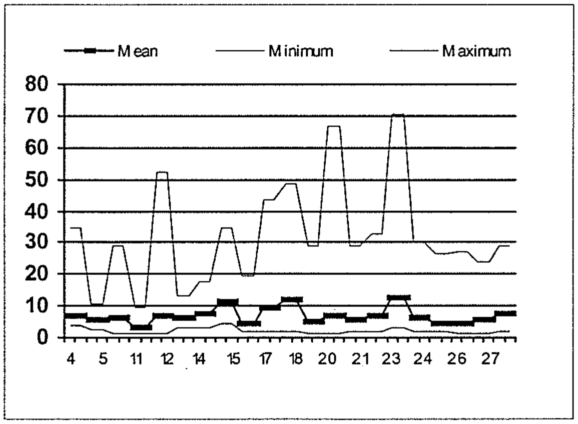
Colchester Reef: January - Stand Deviation Wind Direction



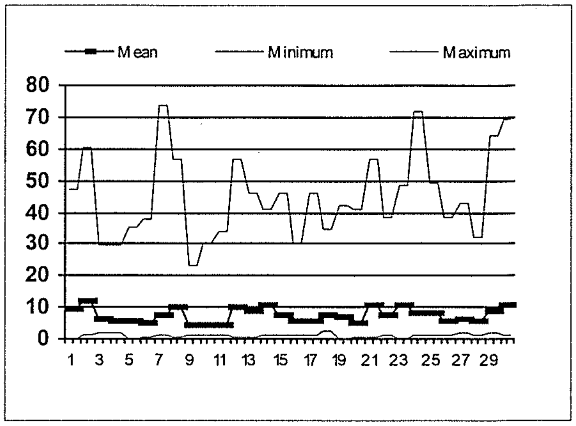
Colchester Reef: February - Stand Deviation Wind Direction



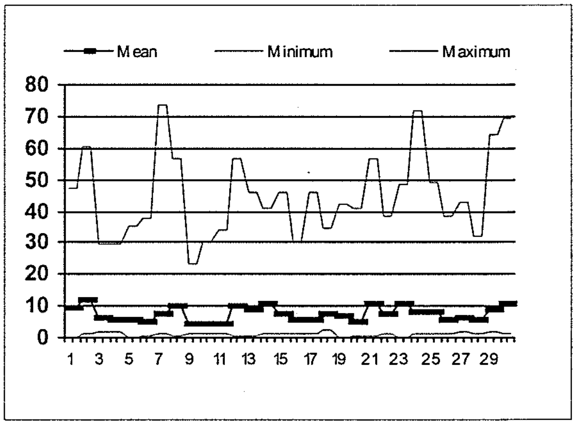
Colchester Reef: March - Stand Deviation Wind Direction



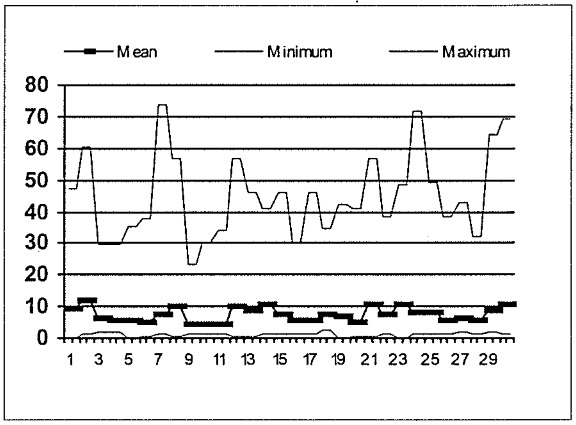
Colchester Reef: April - Stand Deviation Wind Direction



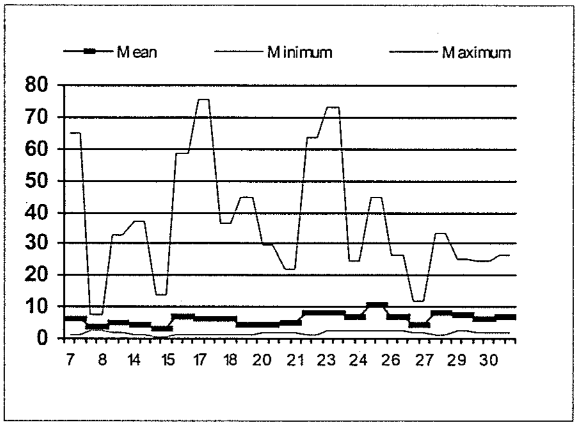
Colchester Reef: May - Stand Deviation Wind Direction



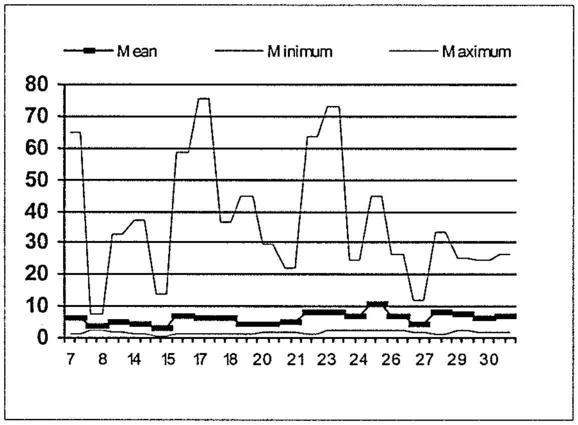
Colchester Reef: June - Stand Deviation Wind Direction



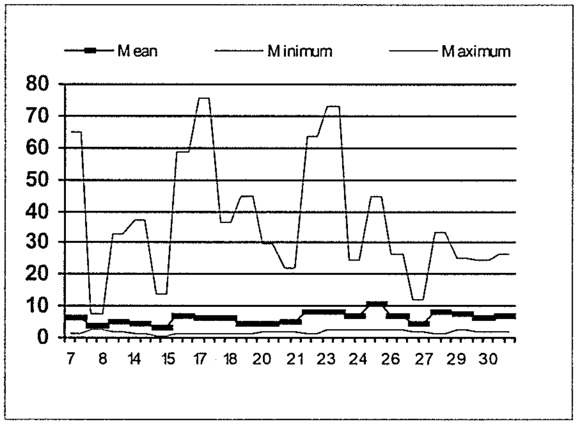
Colchester Reef: July - Stand Deviation Wind Direction



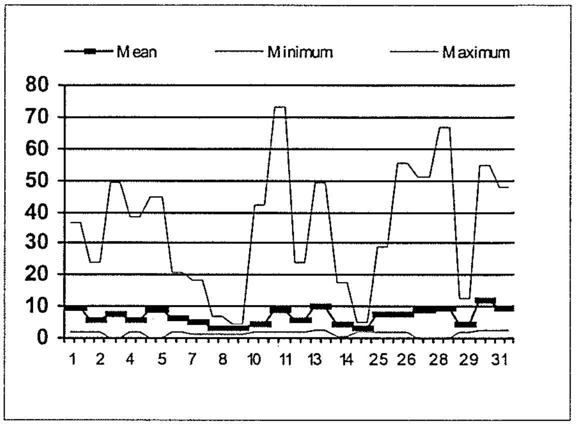
Colchester Reef: August - Stand Deviation Wind Direction



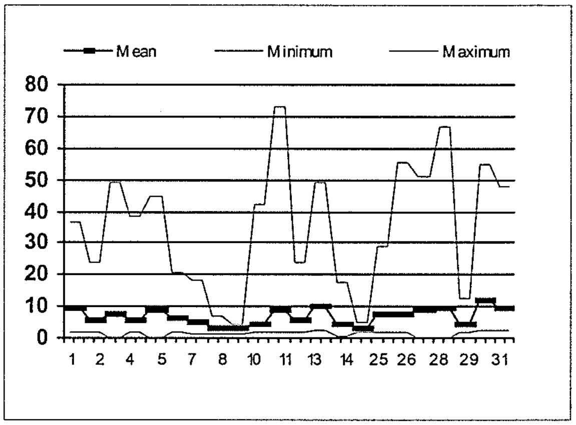
Colchester Reef: September - Stand Deviation Wind Direction



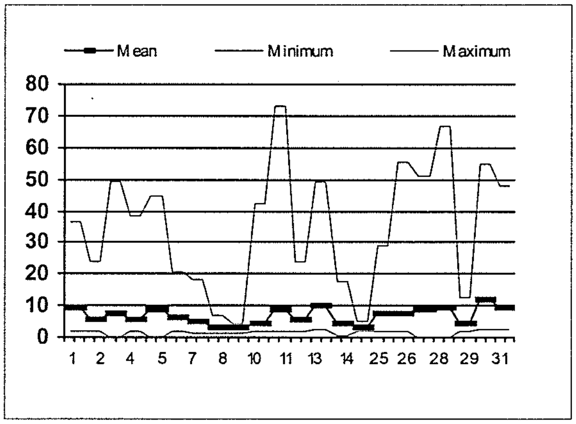
Colchester Reef: October - Stand Deviation Wind Direction



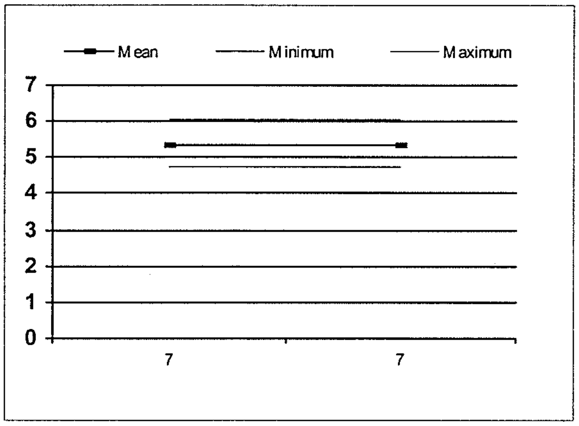
Colchester Reef: November - Stand Deviation Wind Direction



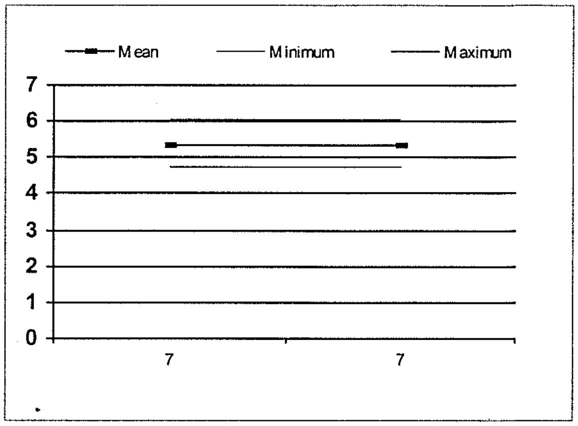
Colchester Reef: December - Stand Deviation Wind Direction



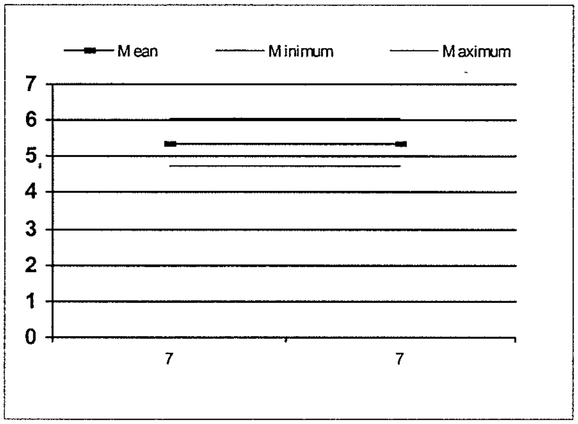
Colchester Reef: January - Water Temperature (degrees C)



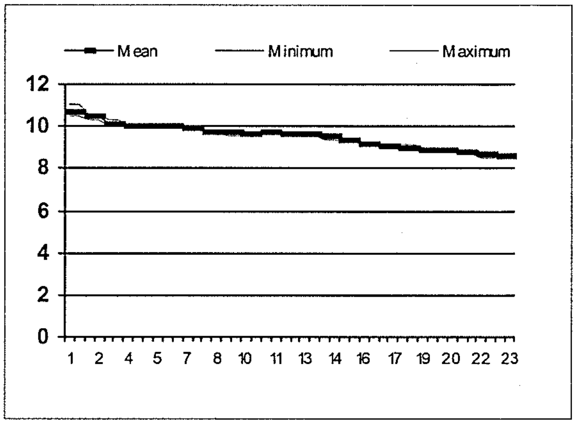
Colchester Reef: December - Water Temperature (degrees C)



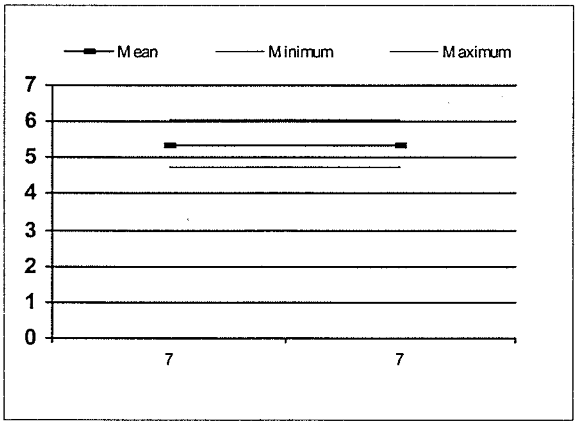
Colchester Reef: October - Water Temperature (degrees C)



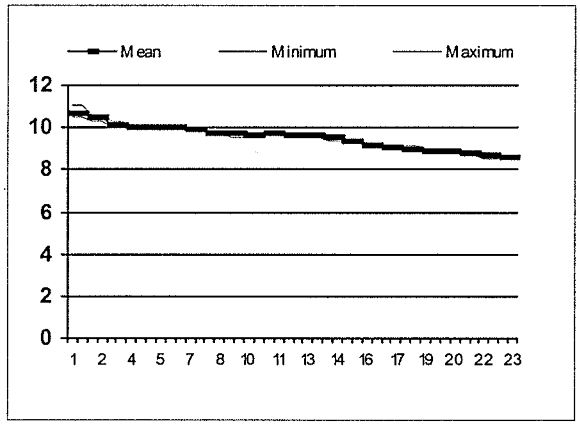
Colchester Reef: January - Wind Direction (degrees)



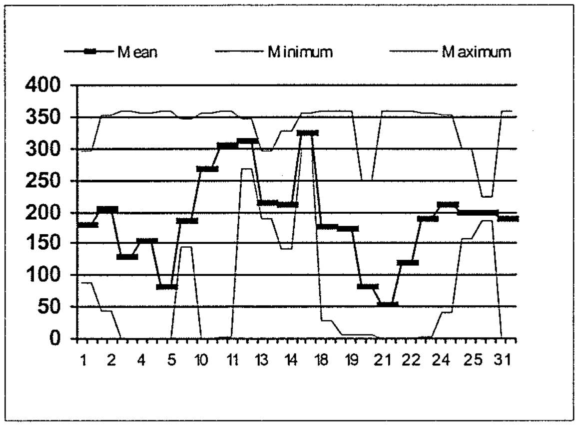
Colchester Reef: November - Water Temperature (degrees C)



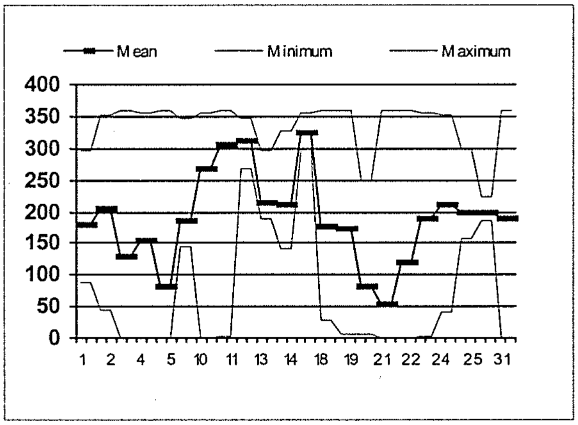
Colchester Reef: February - Wind Direction (degrees)



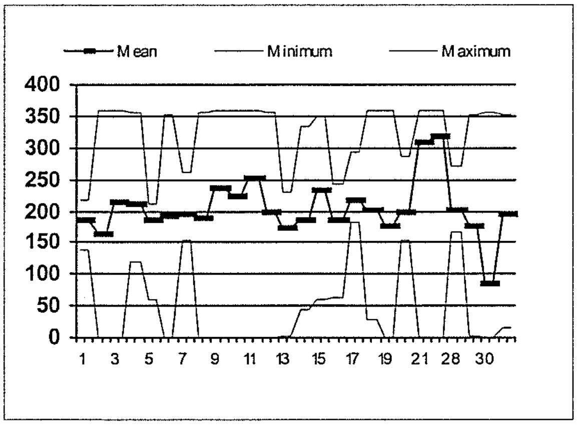
Colchester Reef: March - Wind Direction (degrees)



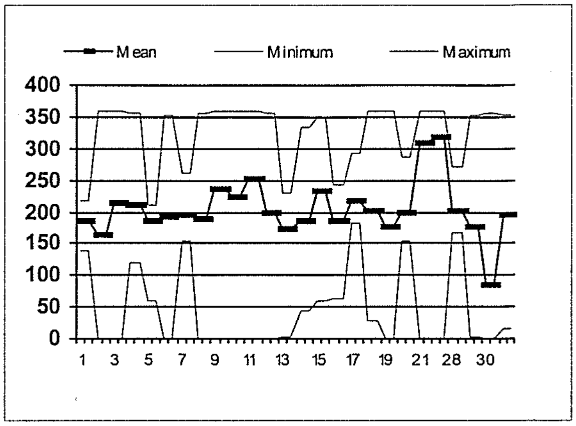
Colchester Reef: April - Wind Direction (degrees)



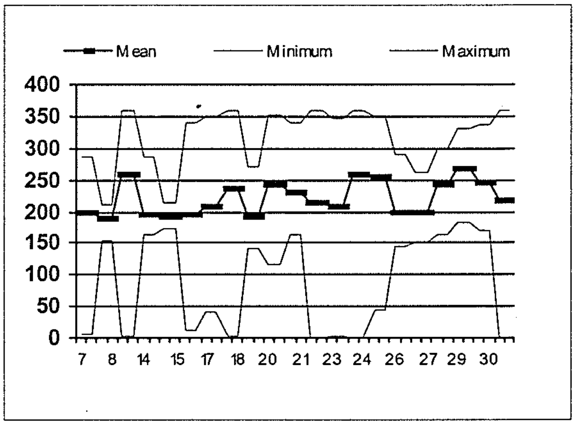
Colchester Reef: May - Wind Direction (degrees)



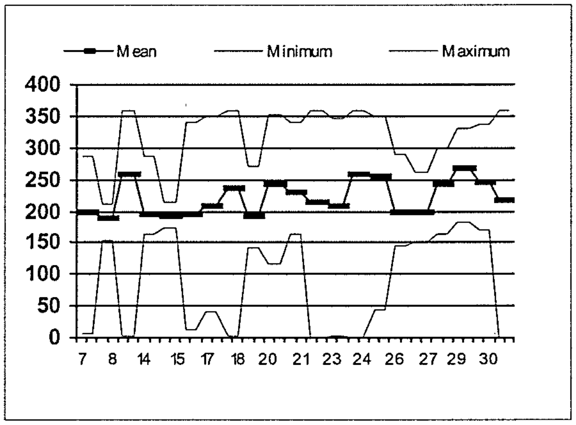
Colchester Reef: June - Wind Direction (degrees)



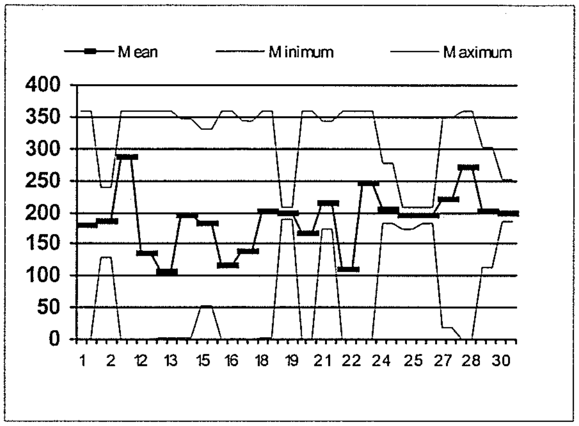
Colchester Reef: July - Wind Direction (degrees)



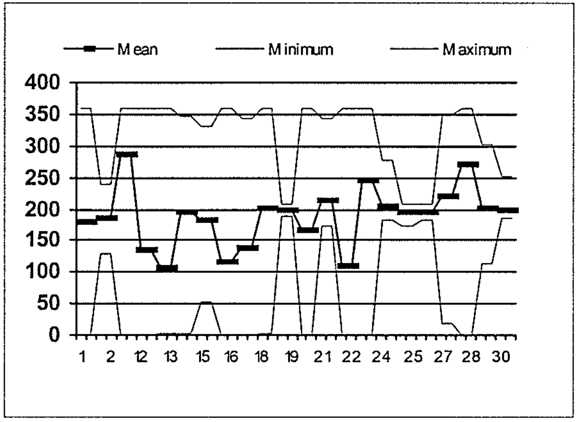
Colchester Reef: August - Wind Direction (degrees)



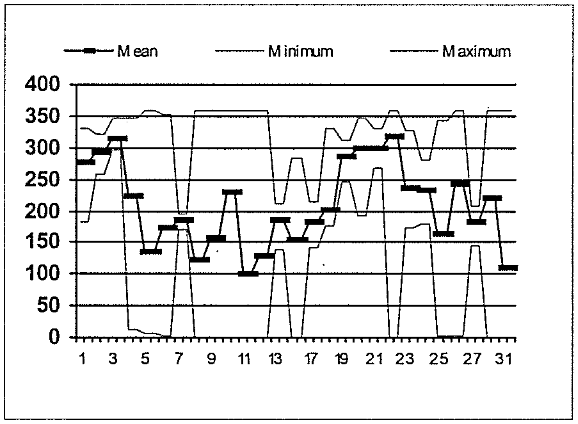
Colchester Reef: September - Wind Direction (degrees)



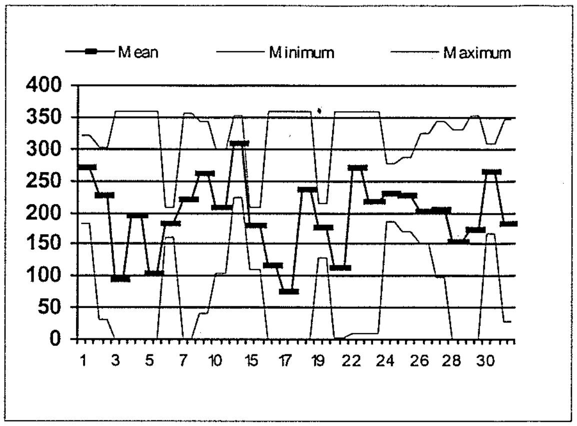
Colchester Reef: October - Wind Direction (degrees)



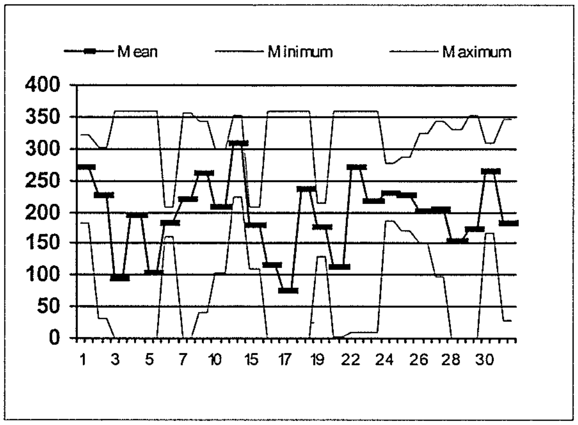
Colchester Reef: November - Wind Direction (degrees)



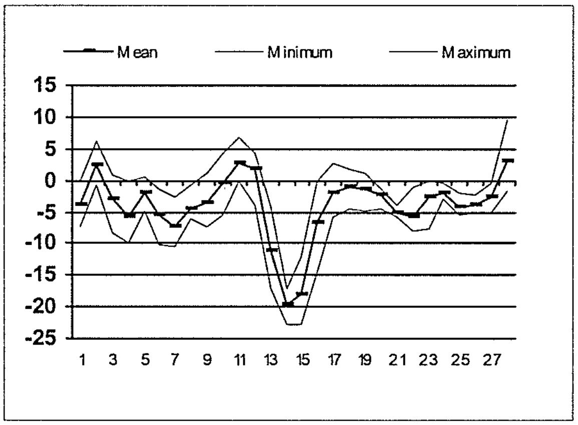
Colchester Reef: December - Wind Direction (degrees)



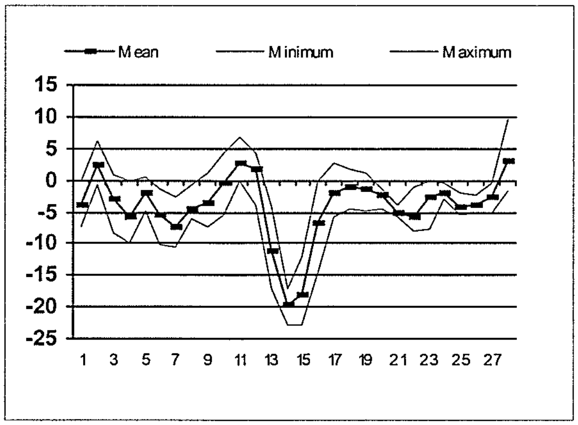
Mount Mansfield (West 2900'): January - Air Temperature
(degrees C)



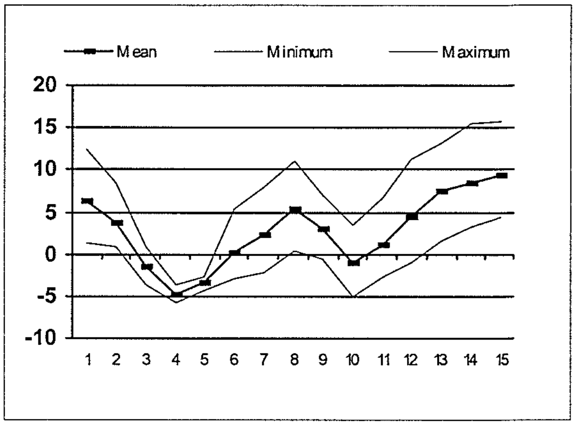
Mount Mansfield (West 2900'): February - Air Temperature
(degrees C)



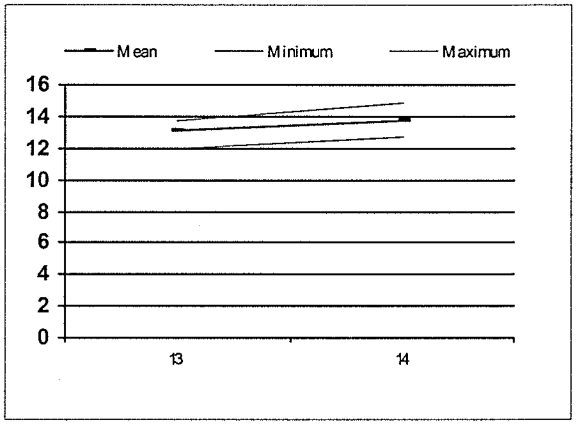
Mount Mansfield (West 2900'): March - Air Temperature
(degrees C)



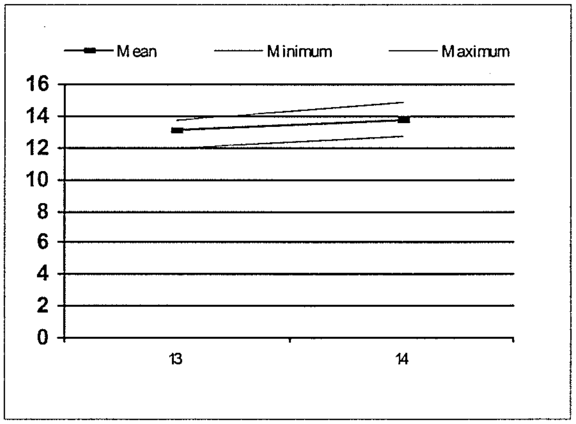
Mount Mansfield (West 2900'): April - Air Temperature
(degrees C)



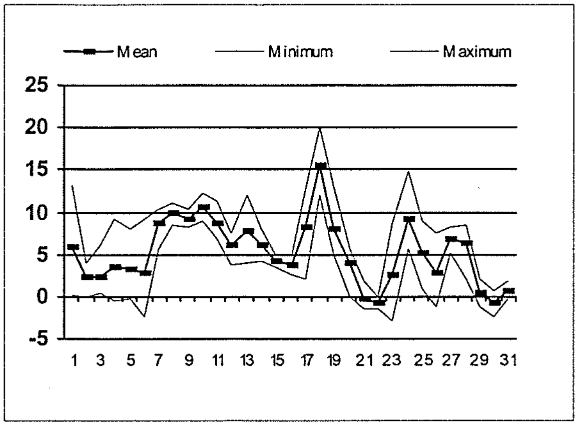
Mount Mansfield (West 2900'): June - Air Temperature
(degrees C)



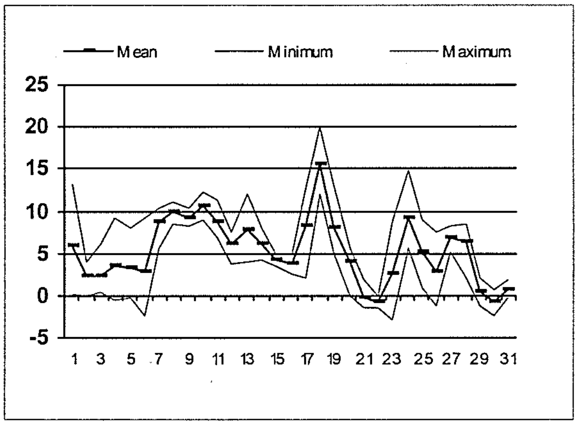
Mount Mansfield (West 2900'): September - Air Temperature
(degrees C)



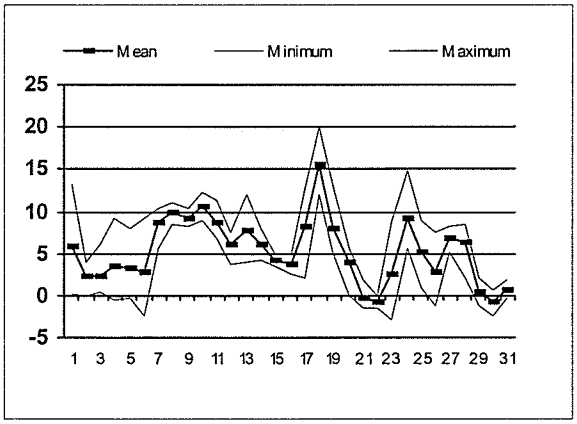
Mount Mansfield (West 2900'): October - Air Temperature (degrees C)



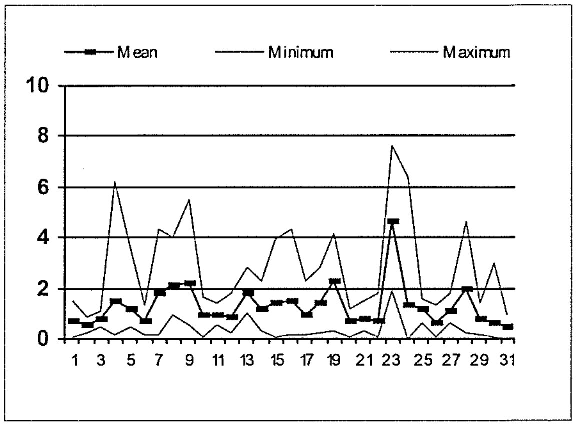
Mount Mansfield (West 2900'): November - Air Temperature (degrees C)



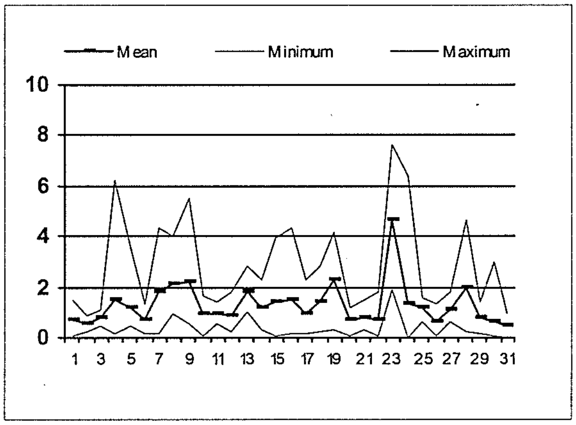
Mount Mansfield (West 2900'): December - Air Temperature (degrees C)



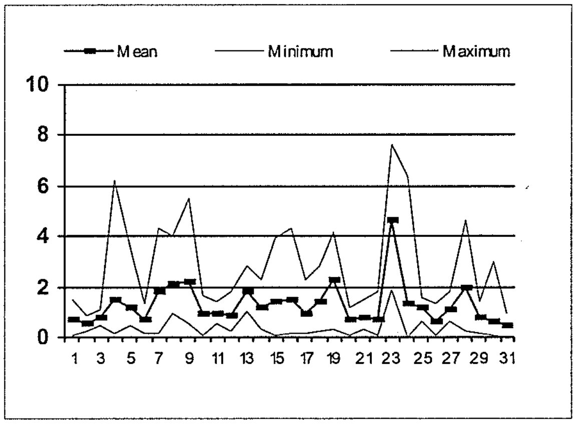
Mount Mansfield (West 2900'): January - Horizontal Wind Speed (ms)



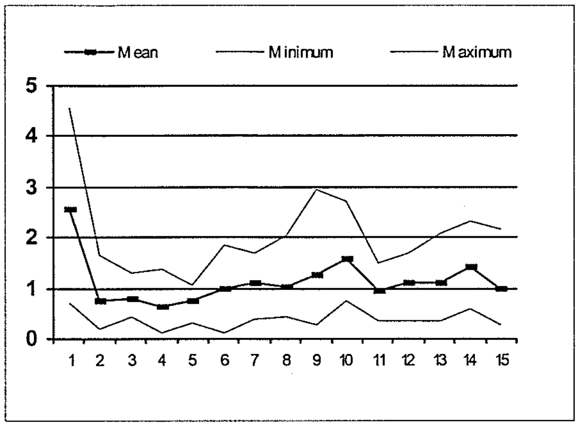
Mount Mansfield (West 2900'): February - Horizontal Wind Speed (ms)



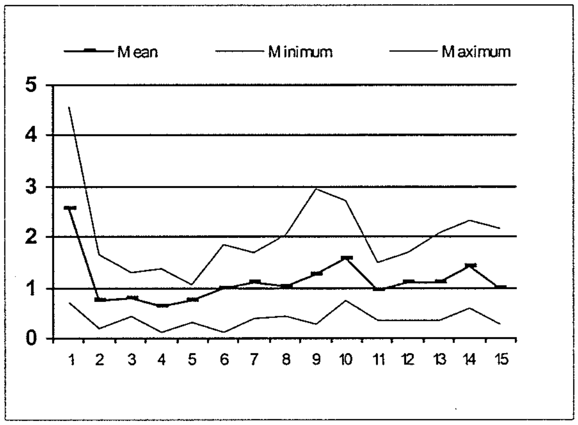
Mount Mansfield (West 2900'): March - Horizontal Wind Speed (ms)



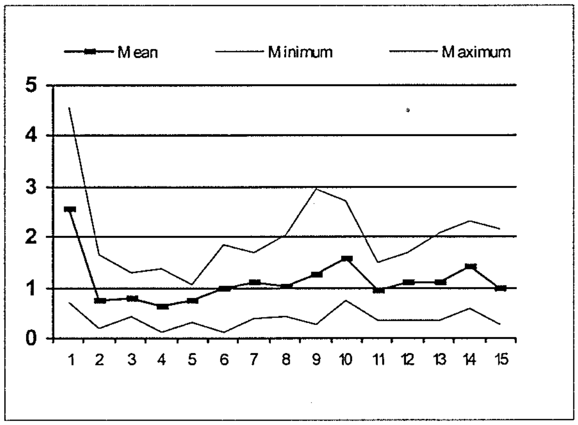
Mount Mansfield (West 2900'): April - Horizontal Wind Speed (ms)



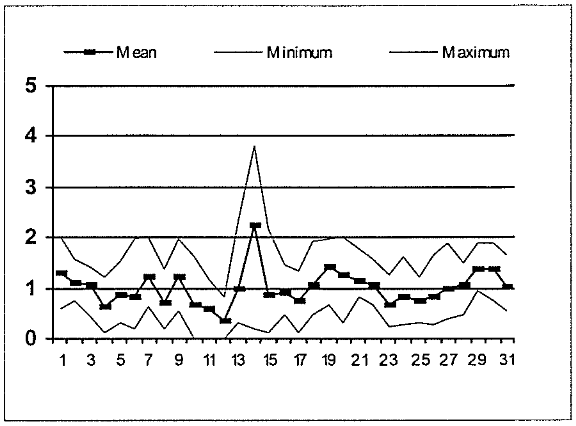
Mount Mansfield (West 2900'): June - Horizontal Wind Speed (ms)



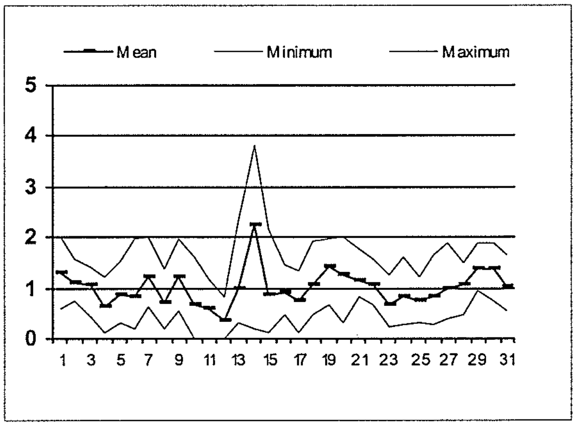
Mount Mansfield (West 2900'): September - Horizontal Wind Speed (ms)



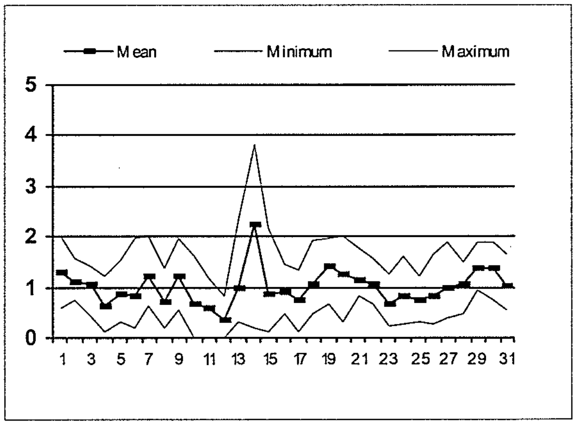
Mount Mansfield (West 2900'): October - Horizontal Wind Speed (ms)



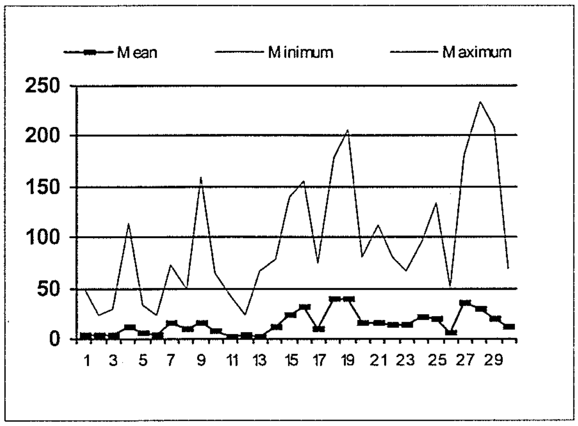
Mount Mansfield (West 2900'): November - Horizontal Wind Speed (ms)



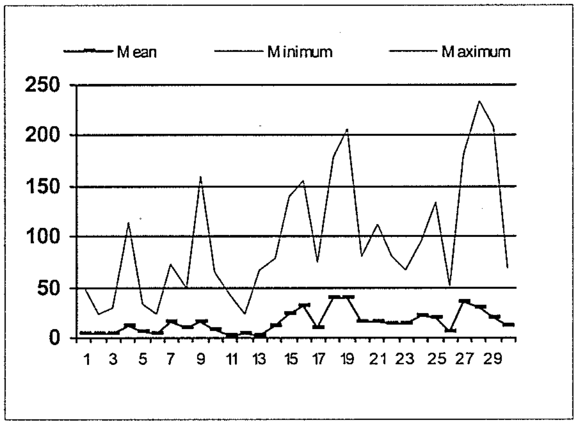
Mount Mansfield (West 2900'): December - Horizontal Wind Speed (ms)



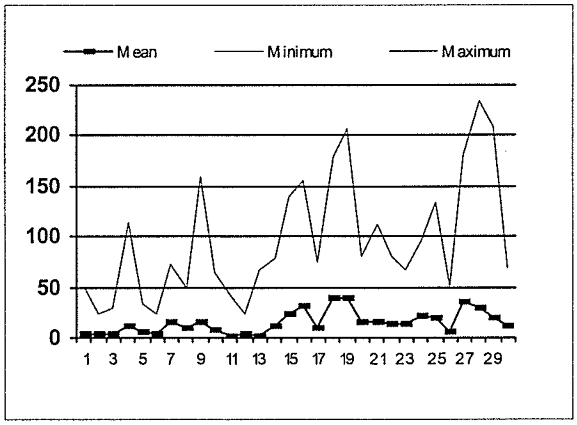
Mount Mansfield (West 2900'): January - Pyranometer (watts/m^2)



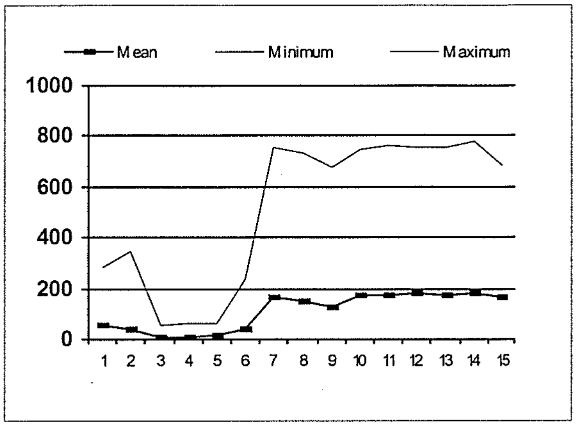
Mount Mansfield (West 2900'): February - Pyranometer (watts/m^2)



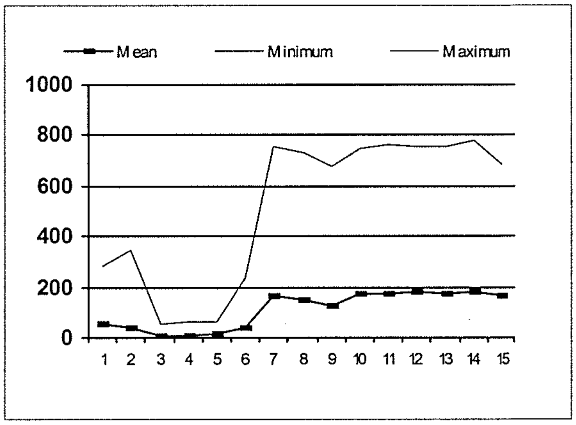
Mount Mansfield (West 2900'): March - Pyranometer (watts/m^2)



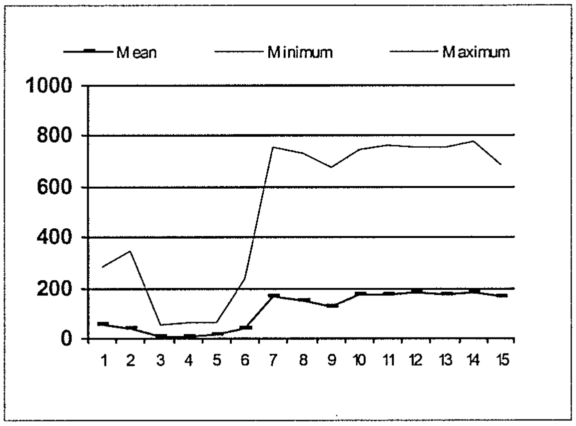
Mount Mansfield (West 2900'): April - Pyranometer (watts/m^2)



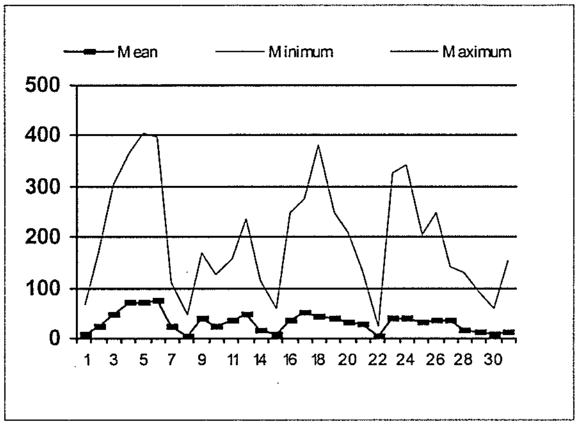
Mount Mansfield (West 2900'): June - Pyranometer (watts/m^2)



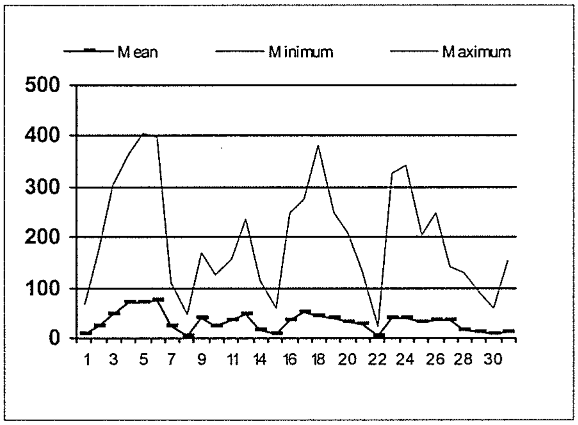
Mount Mansfield (West 2900'): September - Pyranometer (watts/m^2)



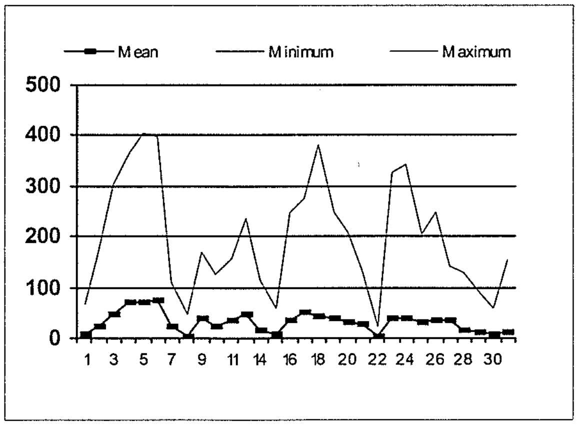
Mount Mansfield (West 2900'): October - Pyranometer (watts/m^2)



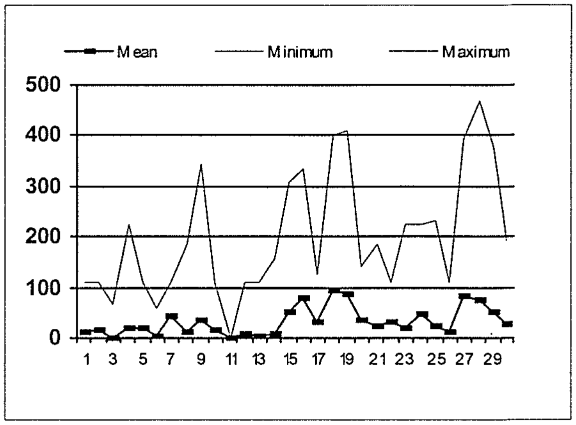
Mount Mansfield (West 2900'): November - Pyranometer (watts/m^2)



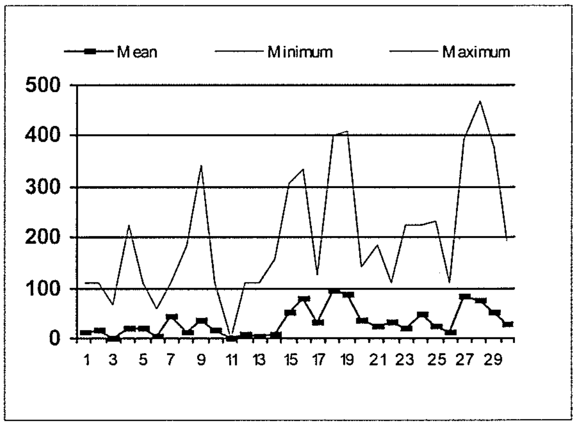
Mount Mansfield (West 2900'): December - Pyranometer (watts/m^2)



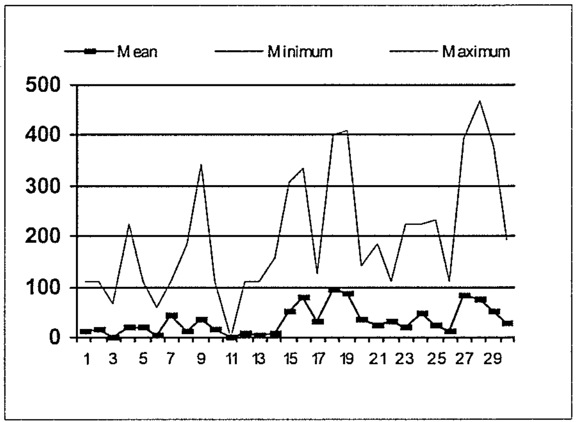
Mount Mansfield (West 2900'): January - Quantum



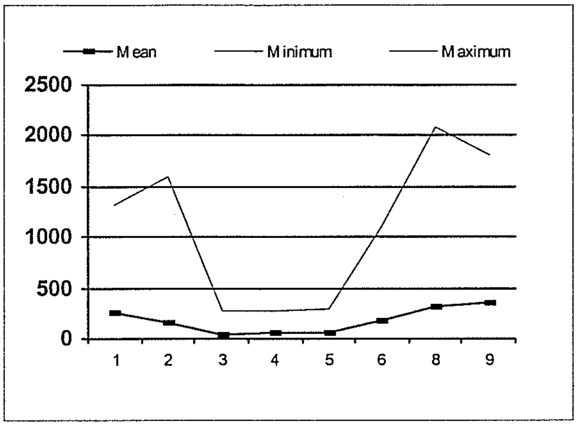
Mount Mansfield (West 2900'): February - Quantum



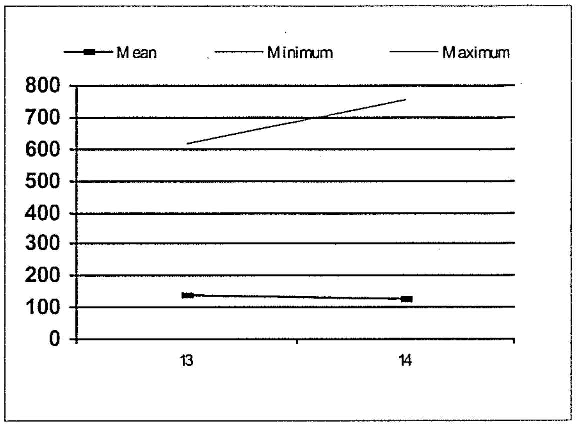
Mount Mansfield (West 2900'): March - Quantum



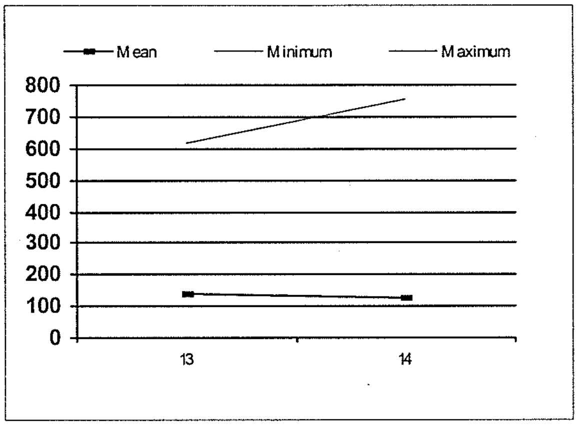
Mount Mansfield (West 2900'): April - Quantum



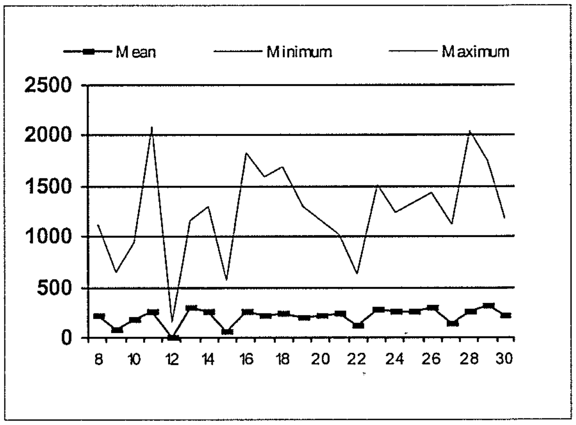
Mount Mansfield (West 2900'): October - Quantum



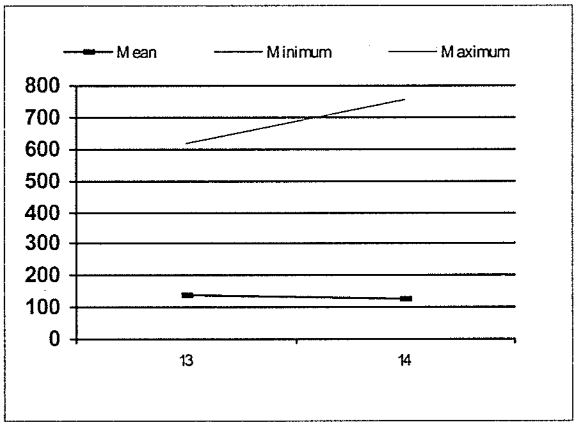
Mount Mansfield (West 2900'): June - Quantum



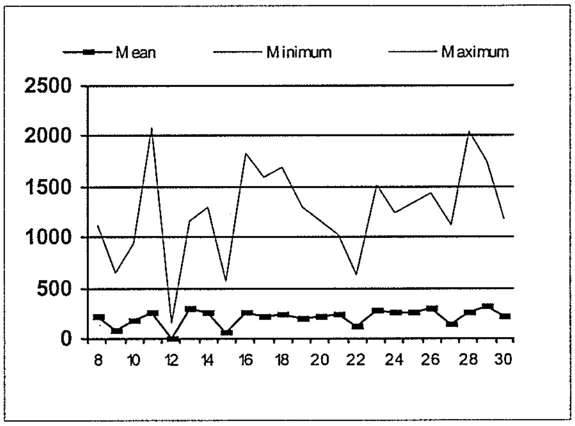
Mount Mansfield (West 2900'): November - Quantum



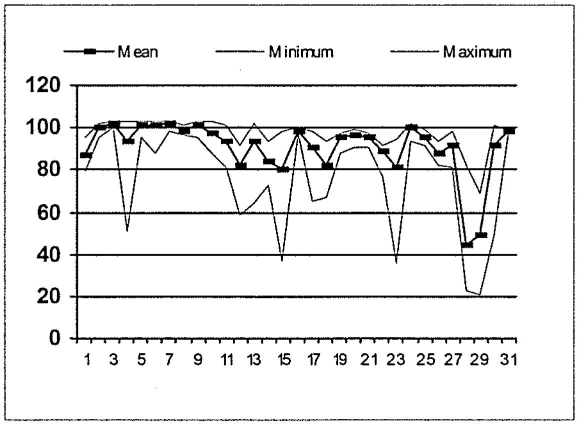
Mount Mansfield (West 2900'): September - Quantum



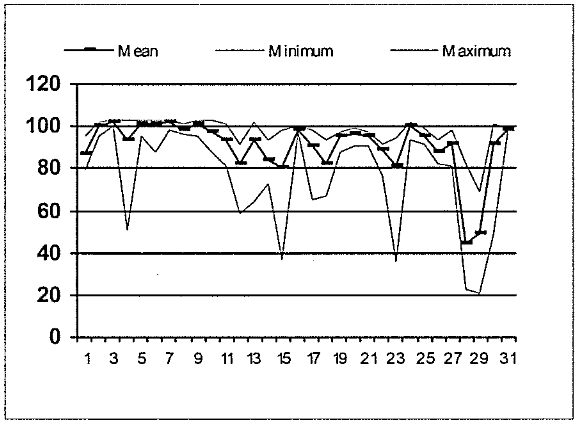
Mount Mansfield (West 2900'): December - Quantum



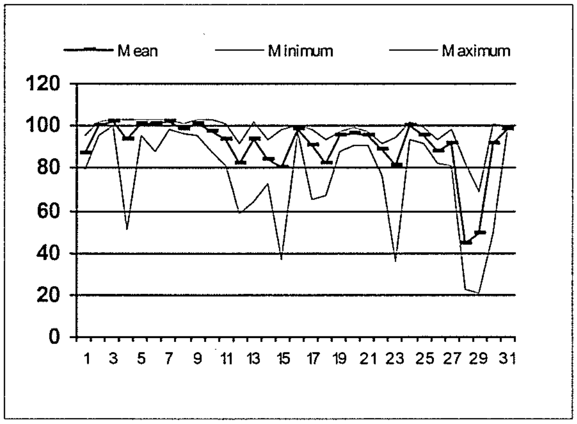
Mount Mansfield (West 2900'): January - Relative Humidity (%)



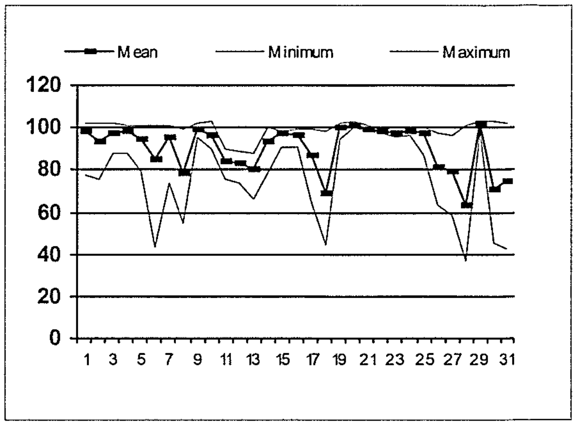
Mount Mansfield (West 2900'): February - Relative Humidity (%)



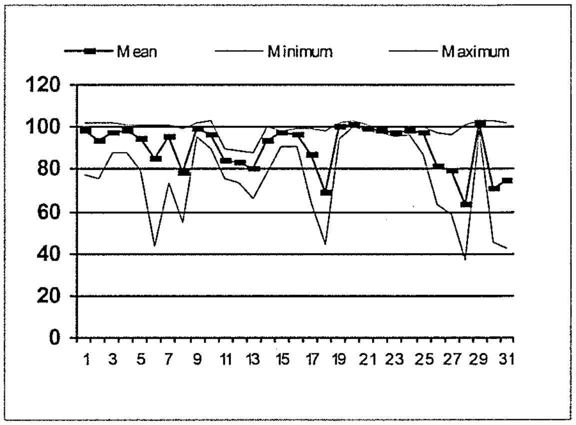
Mount Mansfield (West 2900'): March - Relative Humidity (%)



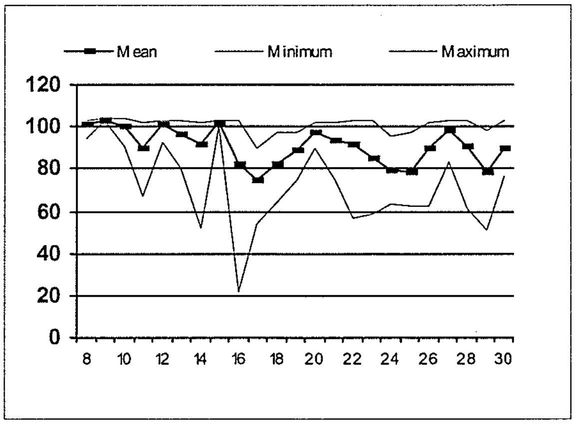
Mount Mansfield (West 2900'): April - Relative Humidity (%)



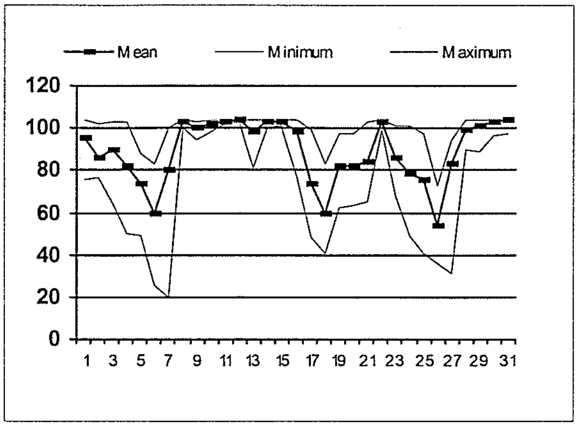
Mount Mansfield (West 2900'): June - Relative Humidity (%)



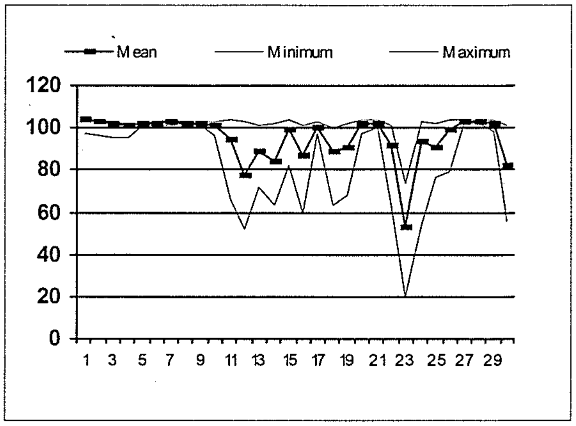
Mount Mansfield (West 2900'): September - Relative Humidity (%)



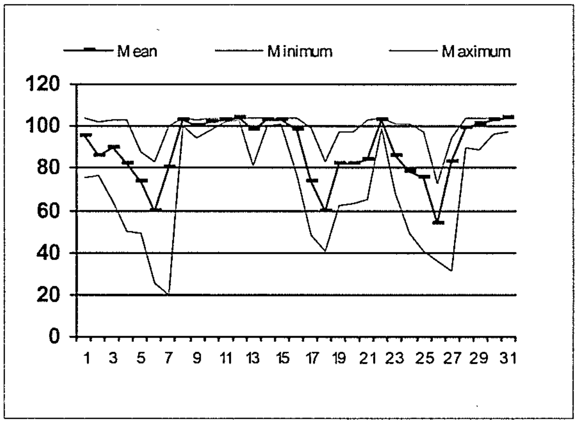
Mount Mansfield (West 2900'): October - Relative Humidity (%)



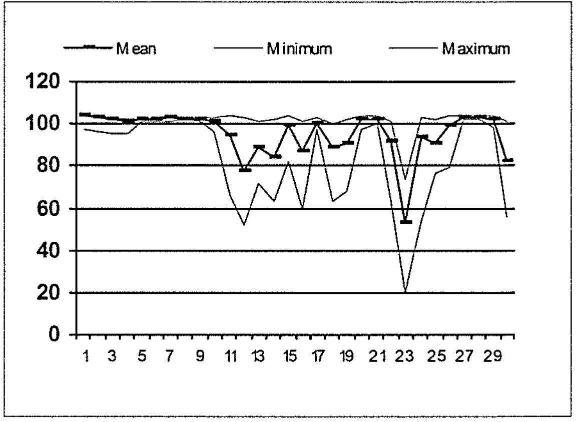
Mount Mansfield (West 2900'): January - Resultant Wind Speed (m/s)



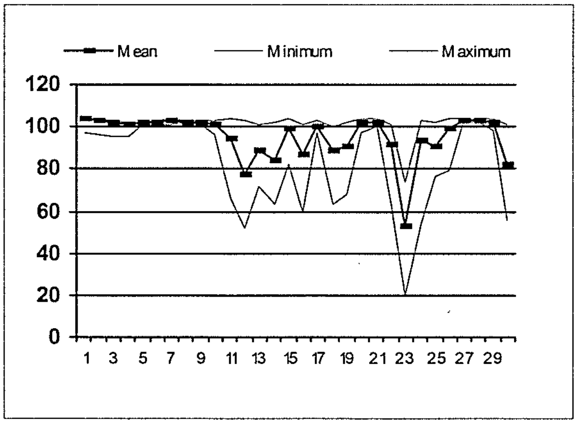
Mount Mansfield (West 2900'): November - Relative Humidity (%)



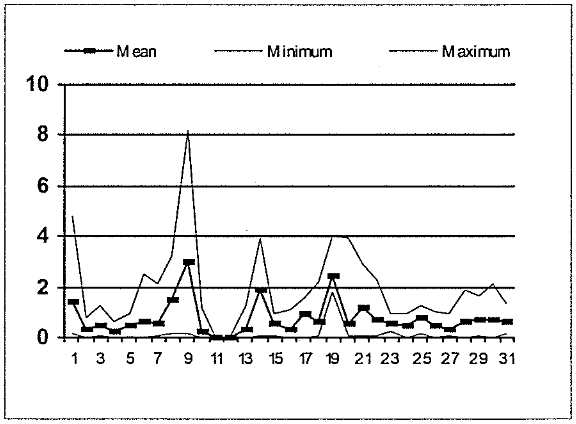
Mount Mansfield (West 2900'): February - Resultant Wind Speed (m/s)



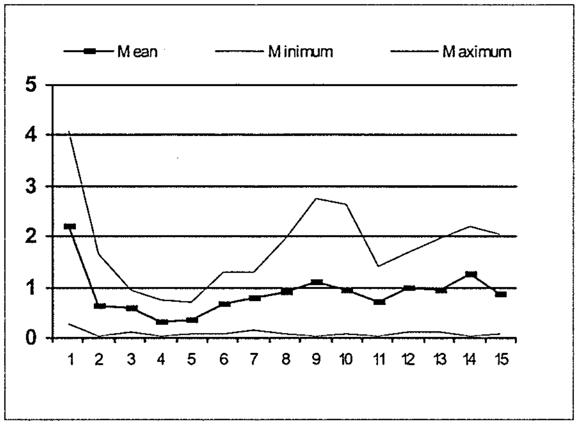
Mount Mansfield (West 2900'): December - Relative Humidity (%)



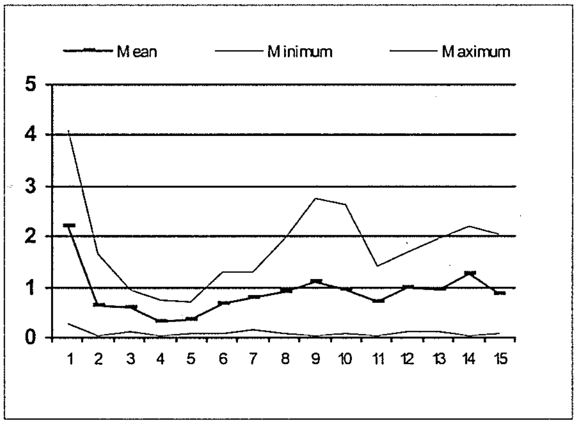
Mount Mansfield (West 2900'): March - Resultant Wind Speed (m/s)



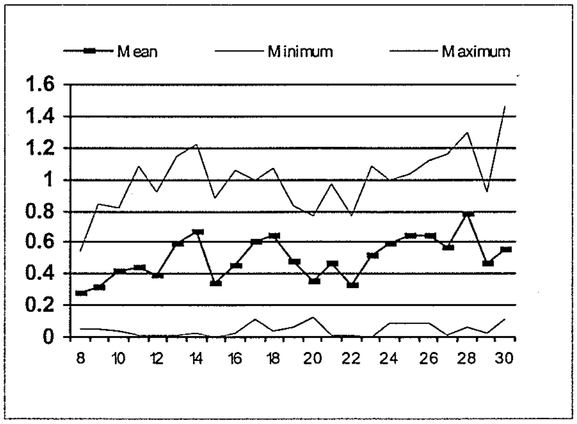
Mount Mansfield (West 2900'): April - Resultant Wind Speed (m/s)



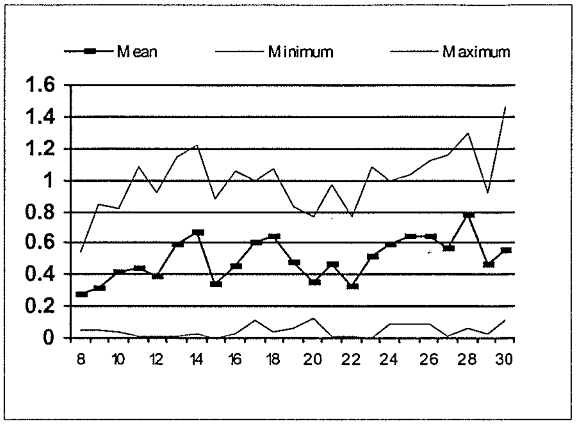
Mount Mansfield (West 2900'): June - Resultant Wind Speed (m/s)



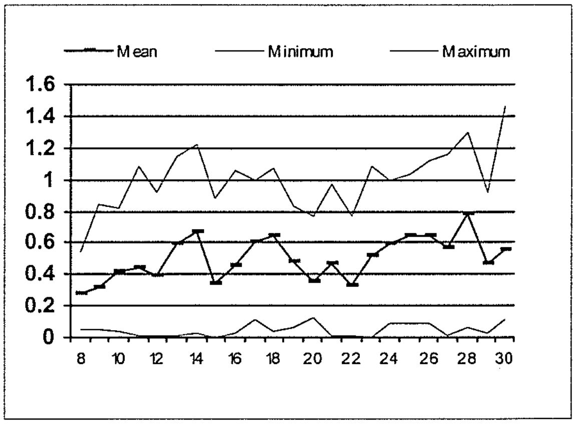
Mount Mansfield (West 2900'): September - Resultant Wind Speed (m/s)



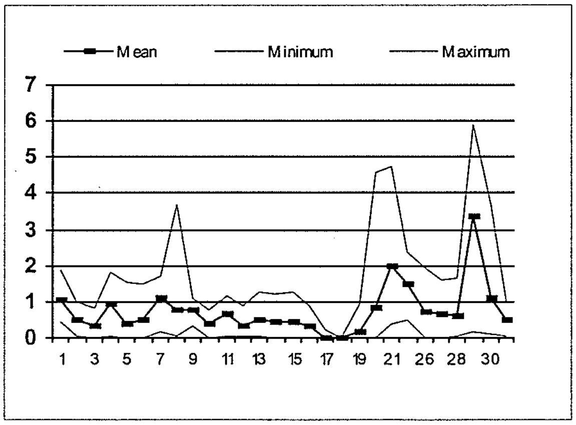
Mount Mansfield (West 2900'): October - Resultant Wind Speed (m/s)



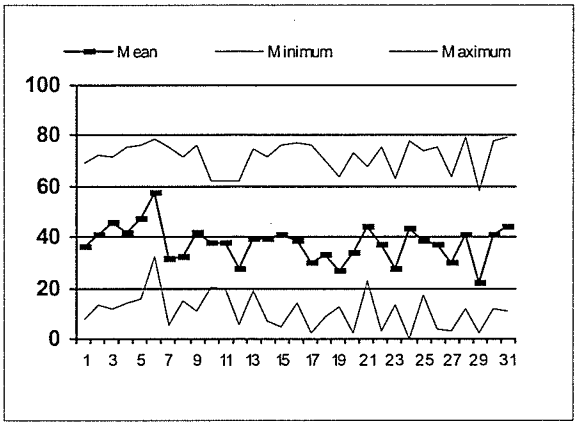
Mount Mansfield (West 2900'): November - Resultant Wind Speed (m/s)



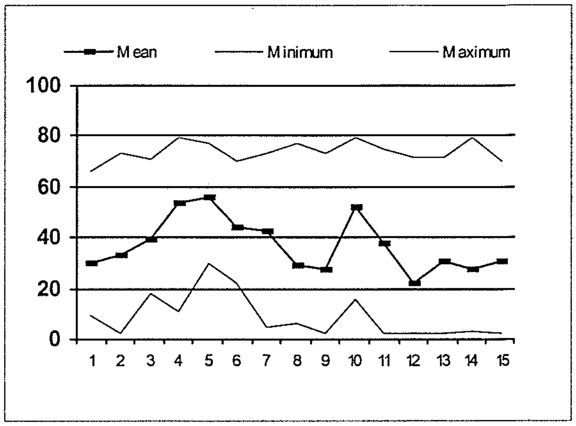
Mount Mansfield (West 2900'): December - Resultant Wind Speed (m/s)



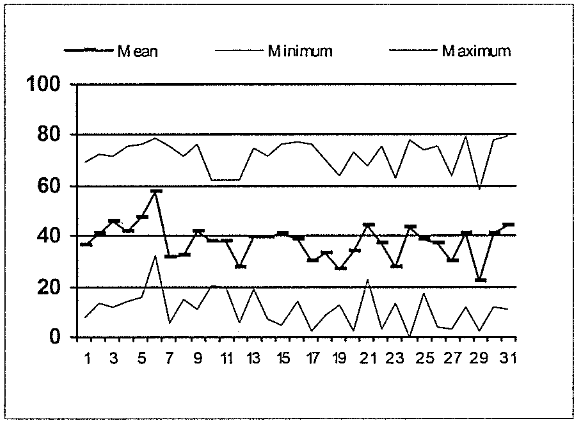
Mount Mansfield (West 2900'): January - Stand Deviation Wind Direction



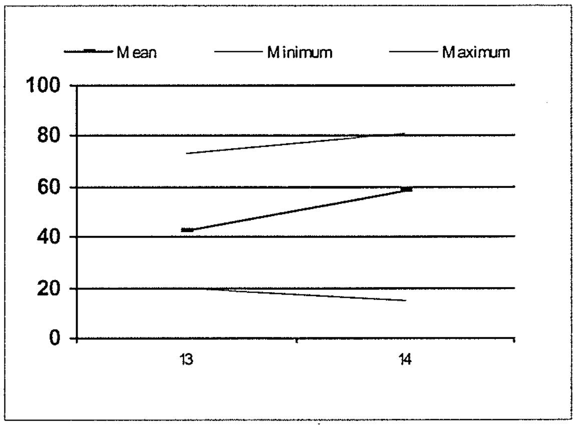
Mount Mansfield (West 2900'): April - Stand Deviation Wind Direction



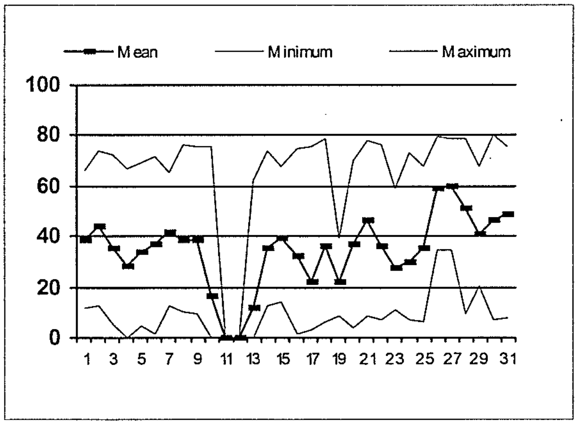
Mount Mansfield (West 2900'): February - Stand Deviation Wind Direction



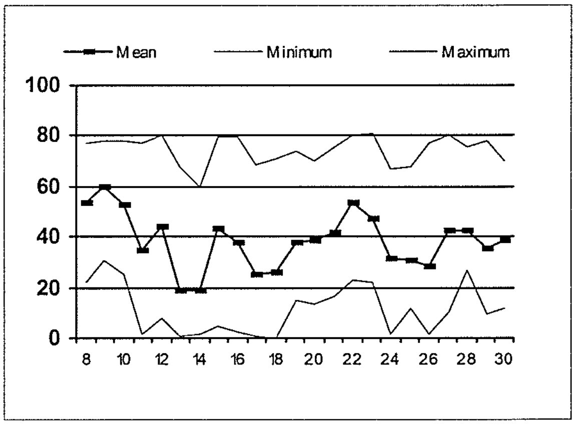
Mount Mansfield (West 2900'): June - Stand Deviation Wind Direction



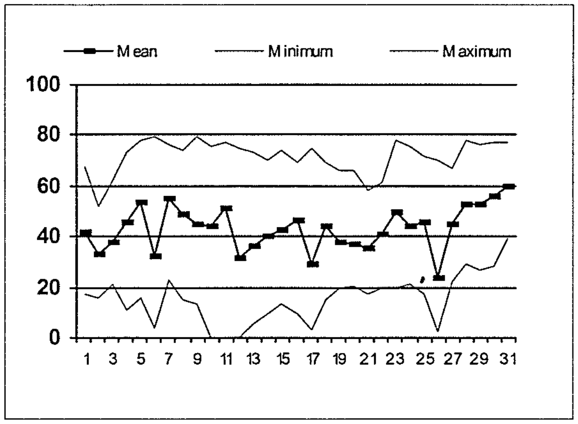
Mount Mansfield (West 2900'): March - Stand Deviation Wind Direction



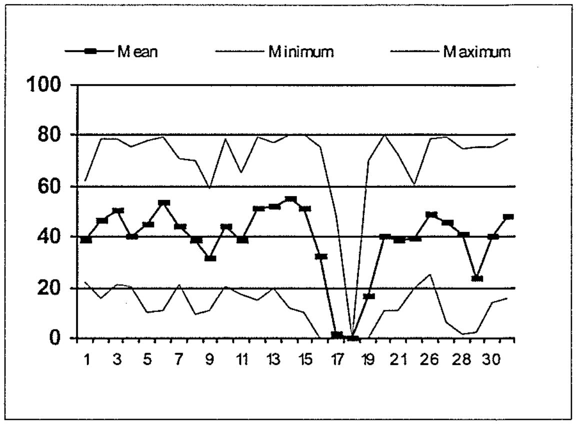
Mount Mansfield (West 2900'): September - Stand Deviation Wind Direction



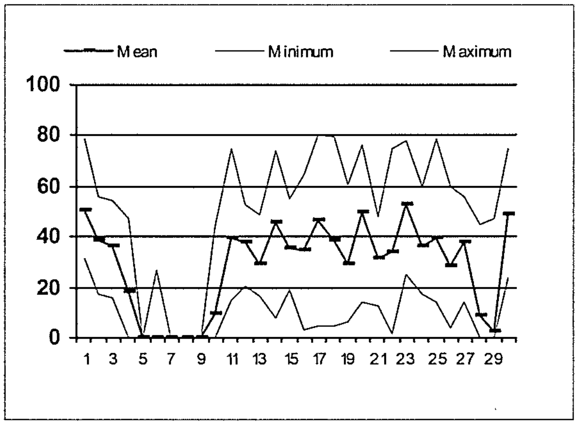
Mount Mansfield (West 2900'): October - Stand Deviation Wind Direction



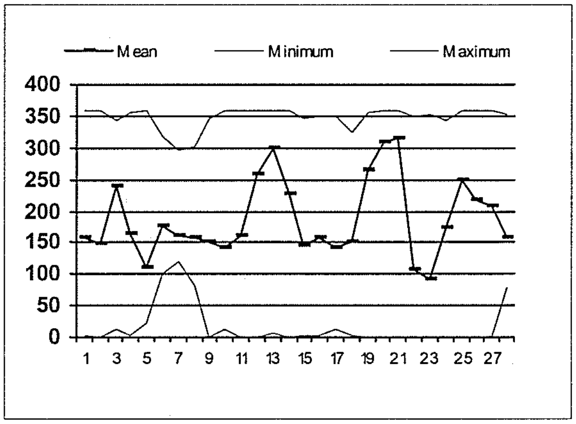
Mount Mansfield (West 2900'): January - Wind Direction (degrees)



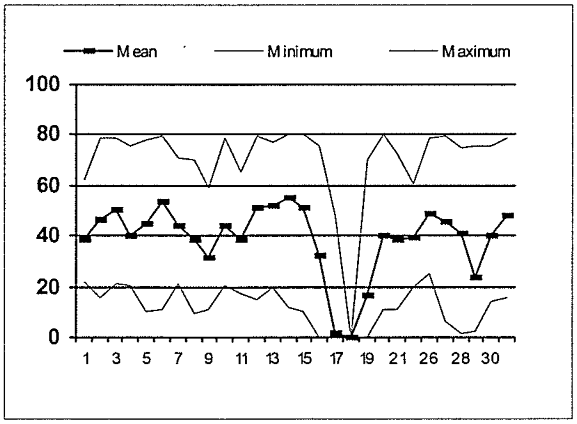
Mount Mansfield (West 2900'): November - Stand Deviation Wind Direction



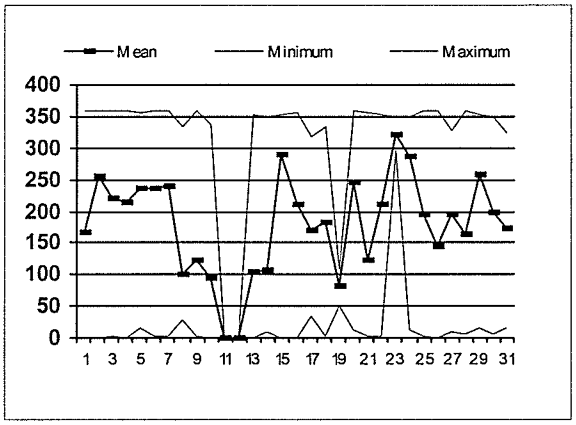
Mount Mansfield (West 2900'): February - Wind Direction (degrees)



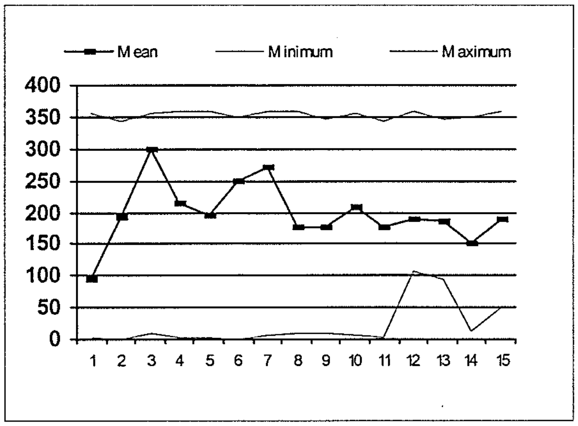
Mount Mansfield (West 2900'): December - Stand Deviation Wind Direction



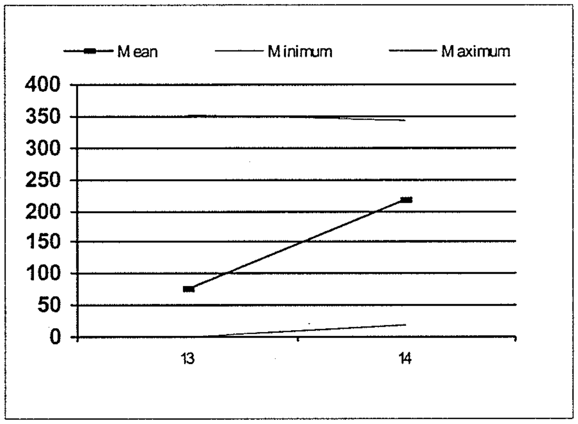
Mount Mansfield (West 2900'): March - Wind Direction (degrees)



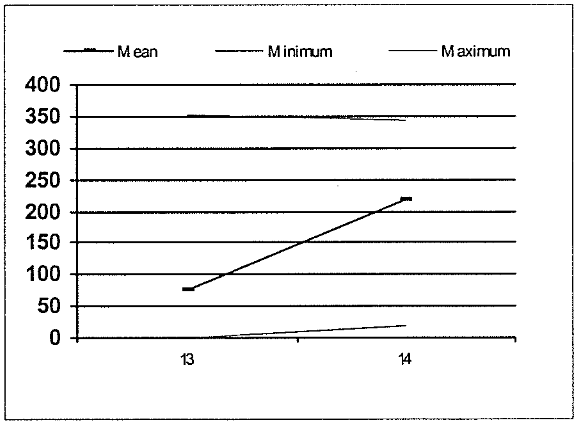
Mount Mansfield (West 2900'): April - Wind Direction (degrees)



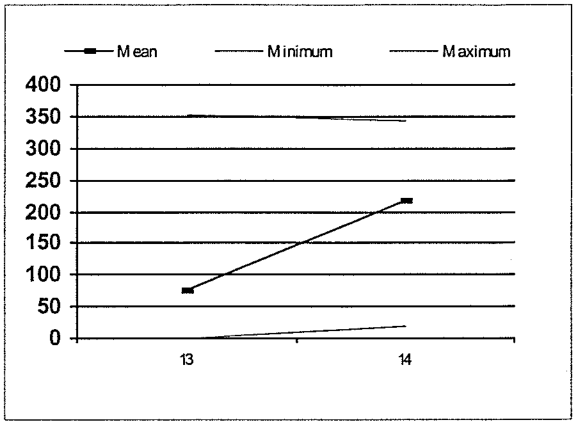
Mount Mansfield (West 2900'): June - Wind Direction (degrees)



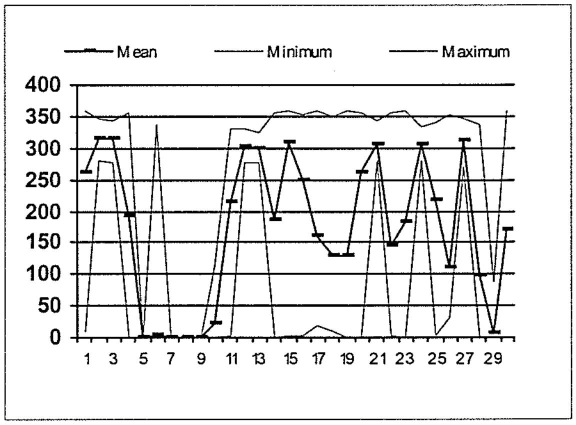
Mount Mansfield (West 2900'): September - Wind Direction (degrees)



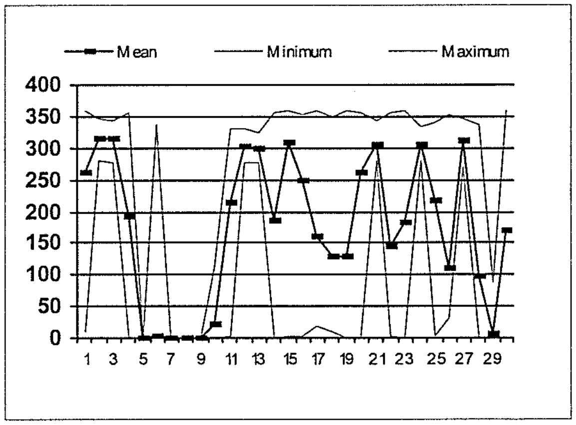
Mount Mansfield (West 2900'): October - Wind Direction (degrees)



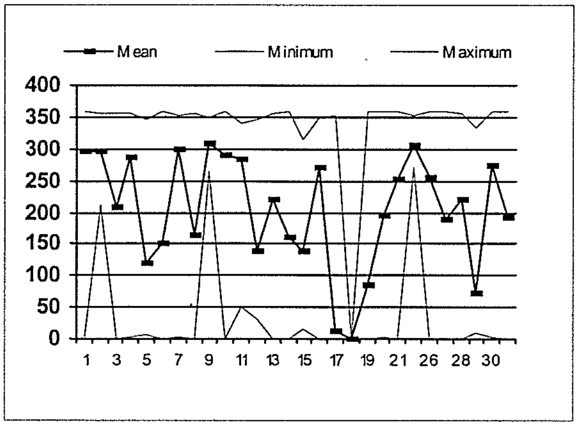
Mount Mansfield (West 2900'): November - Wind Direction (degrees)



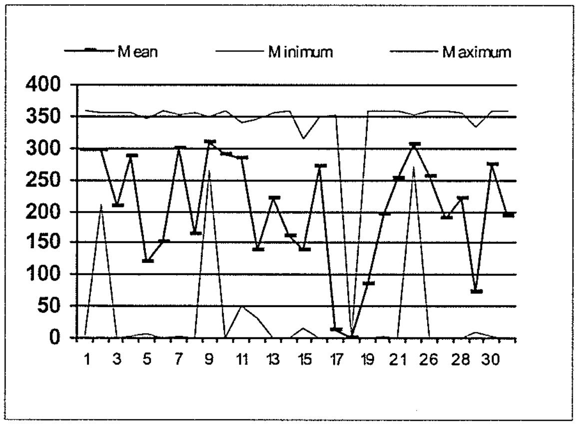
Mount Mansfield (West 2900'): December - Wind Direction (degrees)



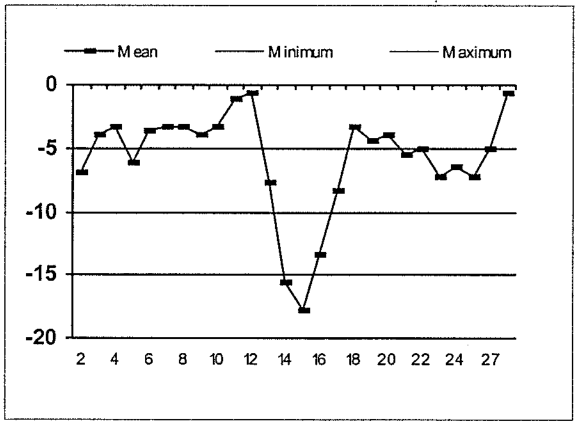
Mount Mansfield Summit: January - Air Temperature (degrees C)



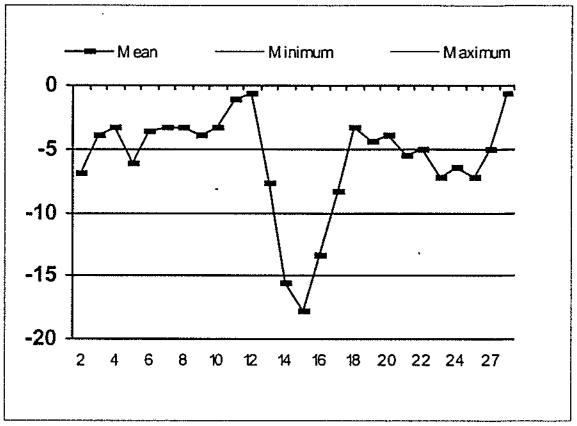
Mount Mansfield Summit: February - Air Temperature (degrees C)



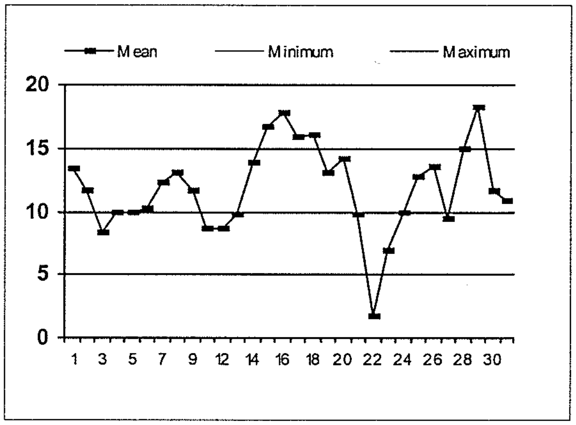
Mount Mansfield Summit: March - Air Temperature (degrees C)



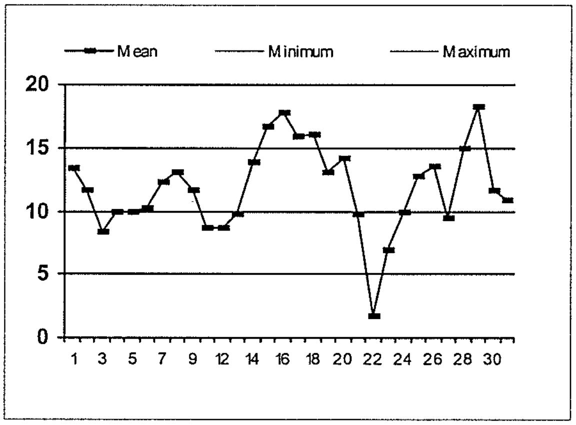
Mount Mansfield Summit: April - Air Temperature (degrees C)



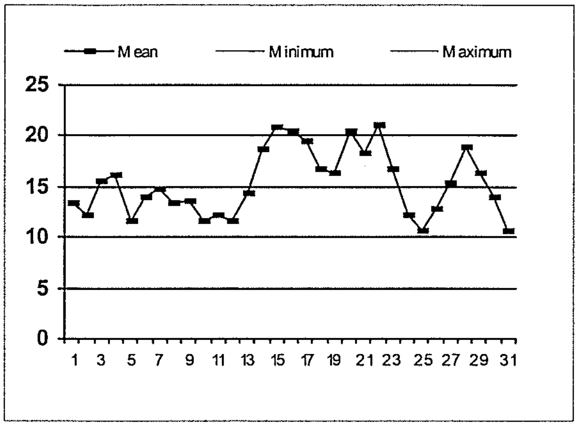
Mount Mansfield Summit: May - Air Temperature (degrees C)



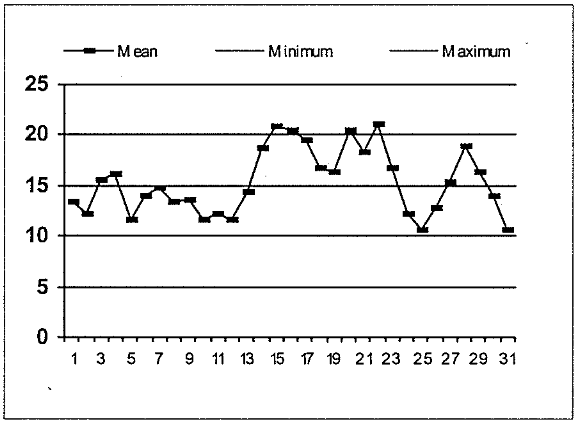
Mount Mansfield Summit: June - Air Temperature (degrees C)



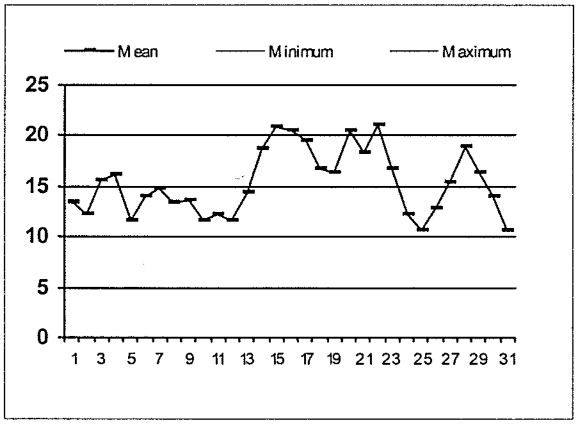
Mount Mansfield Summit: July - Air Temperature (degrees C)



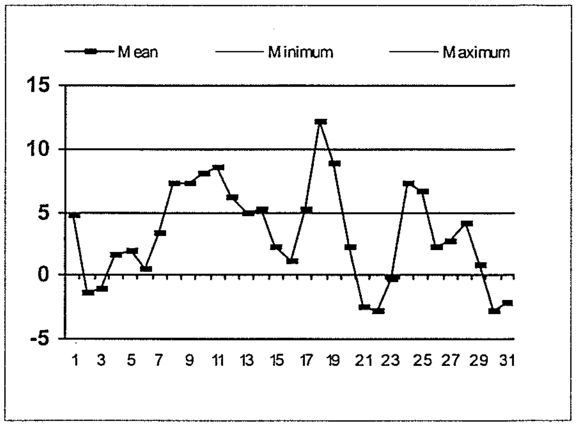
Mount Mansfield Summit: August - Air Temperature (degrees C)



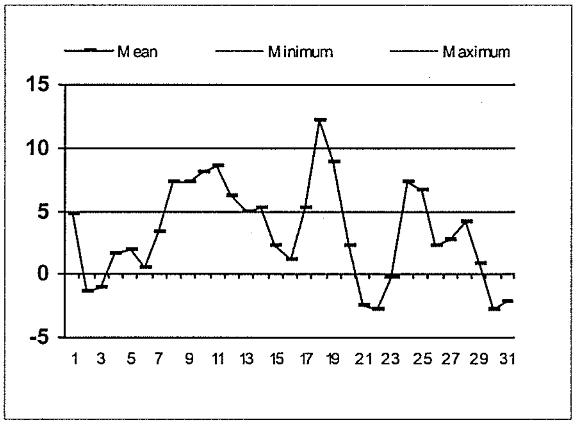
Mount Mansfield Summit: September - Air Temperature (degrees C)



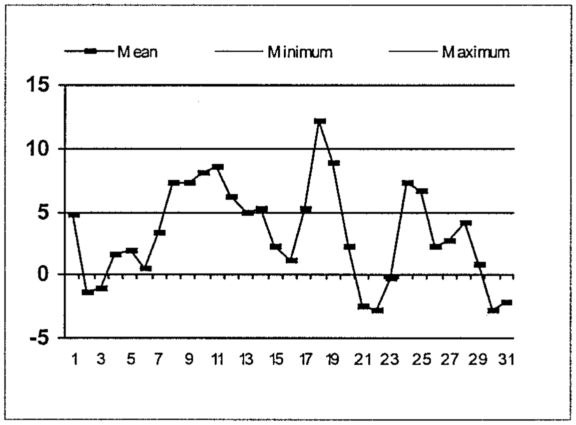
Mount Mansfield Summit: October - Air Temperature (degrees C)



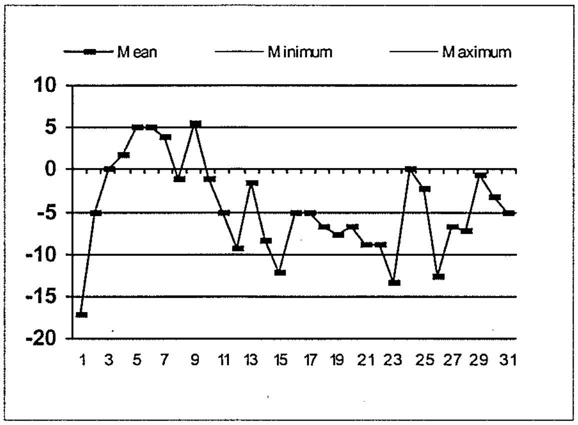
Mount Mansfield Summit: November - Air Temperature (degrees C)



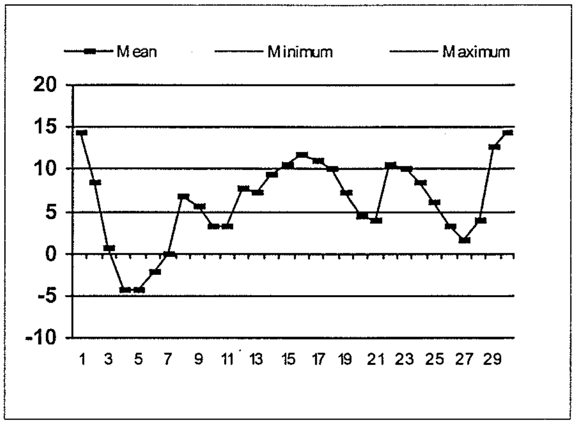
Mount Mansfield Summit: December - Air Temperature (degrees C)



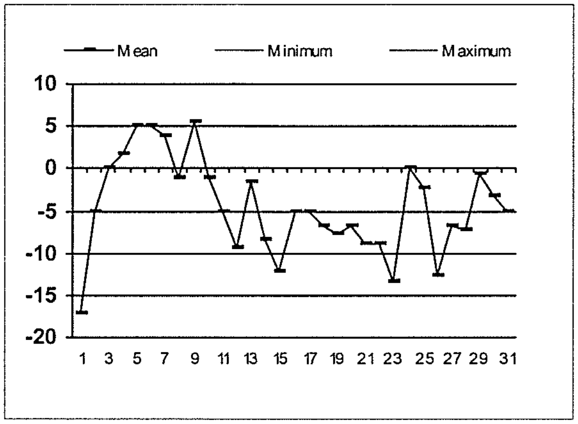
Mount Mansfield Summit: January - Air Temperature Maximum (degrees C)



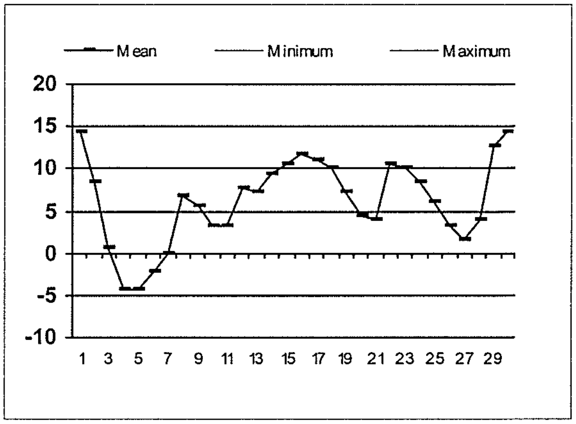
Mount Mansfield Summit: April - Air Temperature Maximum (degrees C)



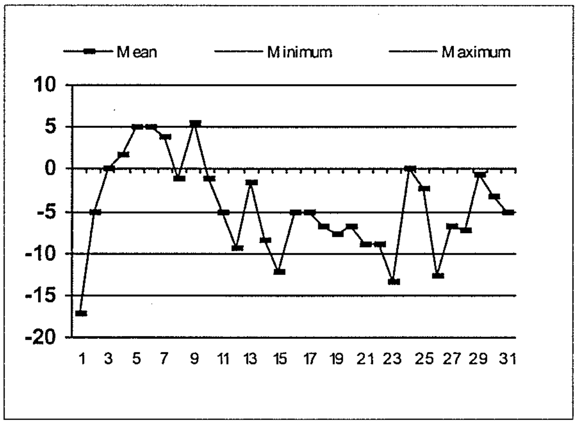
Mount Mansfield Summit: February - Air Temperature Maximum (degrees C)



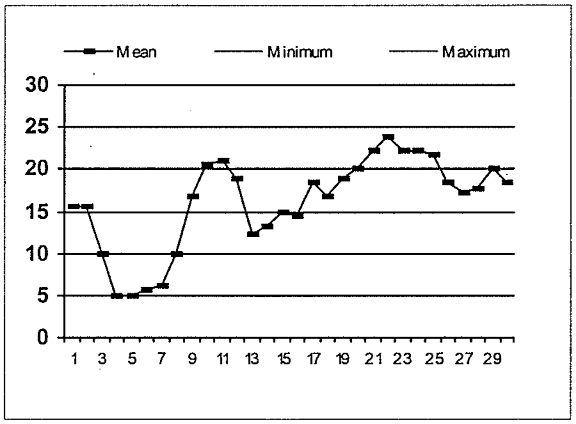
Mount Mansfield Summit: May - Air Temperature Maximum (degrees C)



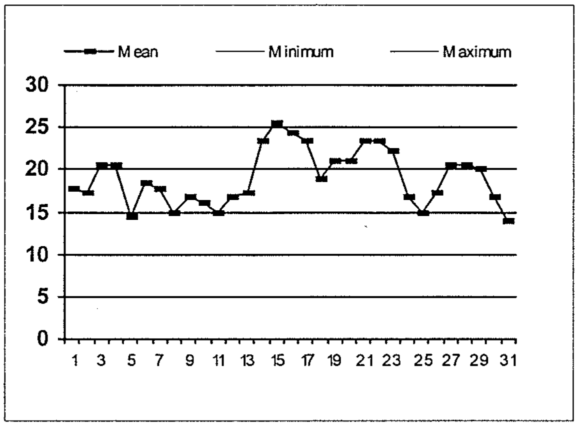
Mount Mansfield Summit: March - Air Temperature Maximum (degrees C)



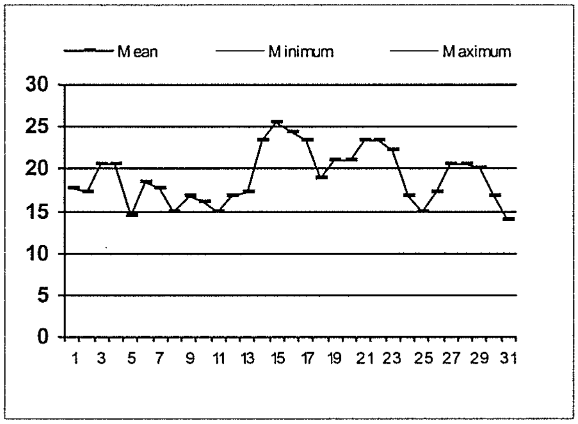
Mount Mansfield Summit: June - Air Temperature Maximum (degrees C)



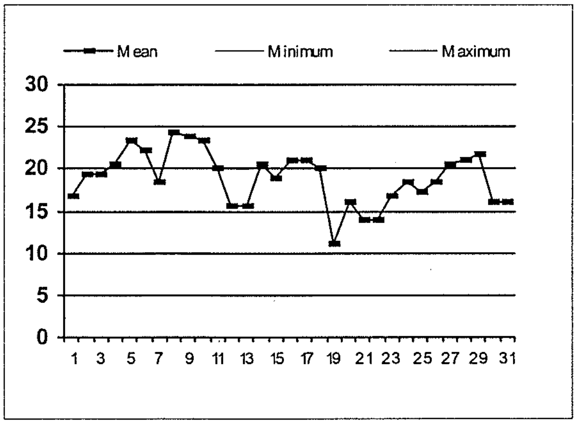
Mount Mansfield Summit: July - Air Temperature Maximum (degrees C)



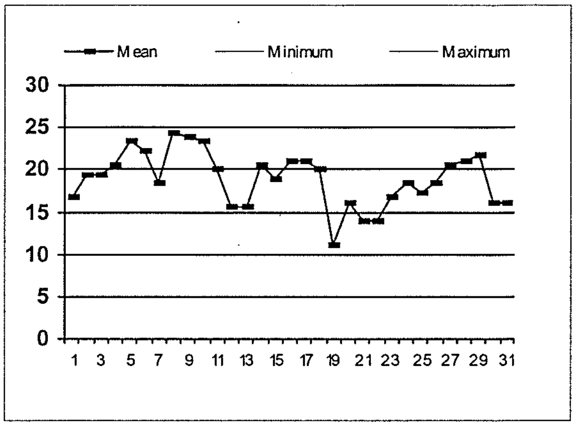
Mount Mansfield Summit: August - Air Temperature Maximum (degrees C)



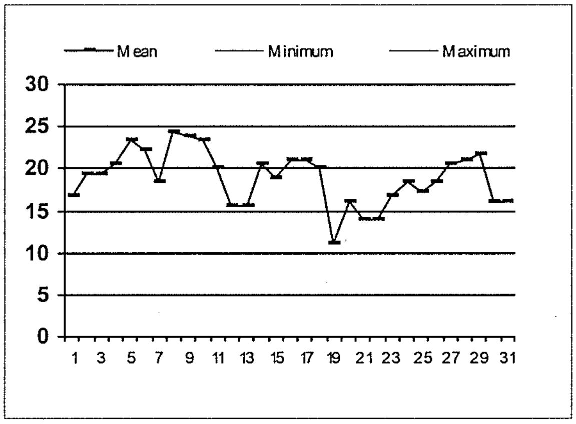
Mount Mansfield Summit: September - Air Temperature Maximum (degrees C)



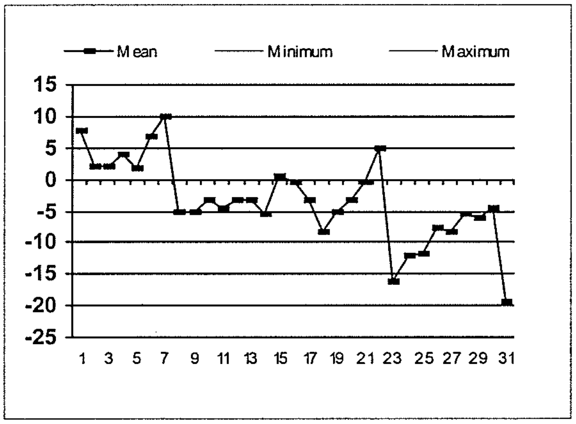
Mount Mansfield Summit: October - Air Temperature Maximum (degrees C)



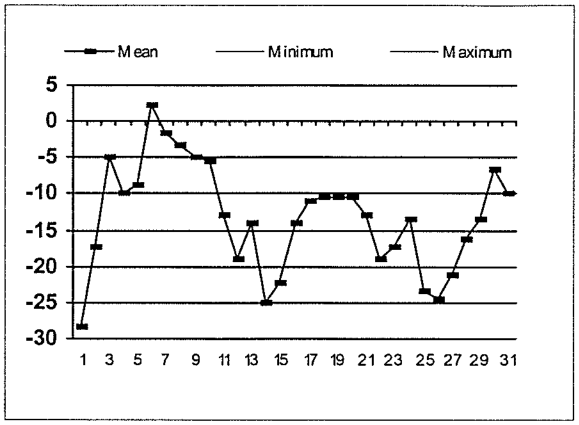
Mount Mansfield Summit: November - Air Temperature Maximum (degrees C)



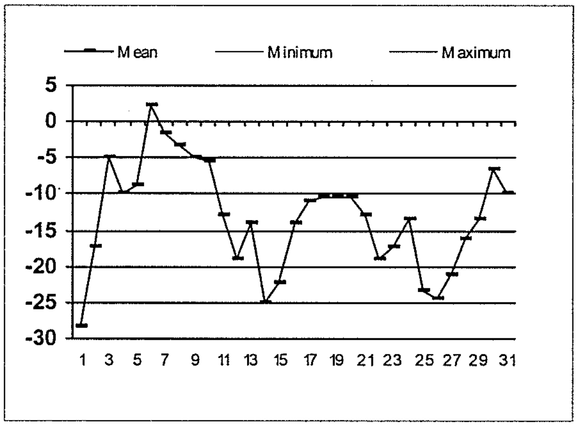
Mount Mansfield Summit: December - Air Temperature Maximum (degrees C)



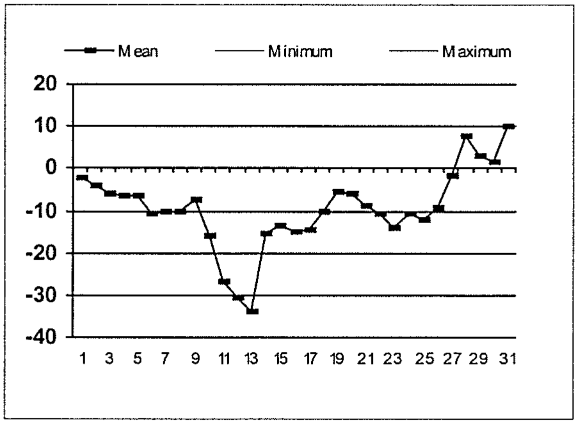
Mount Mansfield Summit: January - Air Temperature Minimum (degrees C)



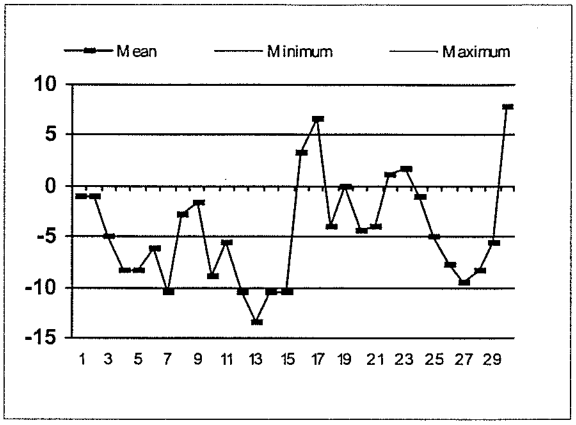
Mount Mansfield Summit: February - Air Temperature Minimum (degrees C)



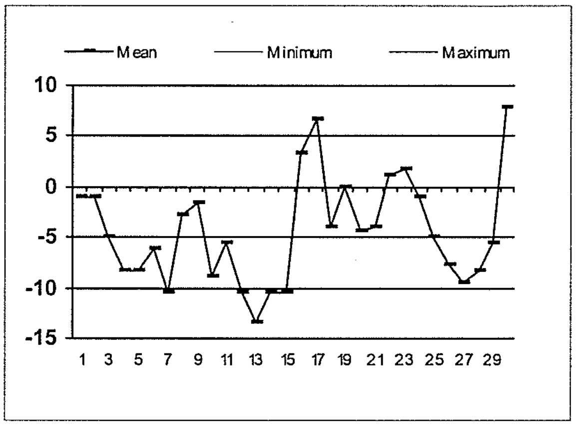
Mount Mansfield Summit: March - Air Temperature Minimum (degrees C)



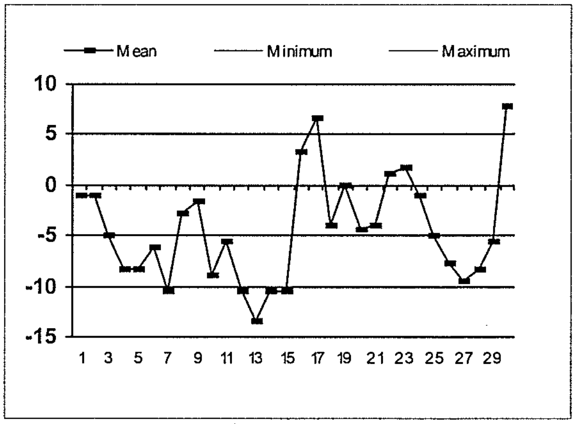
Mount Mansfield Summit: April - Air Temperature Minimum (degrees C)



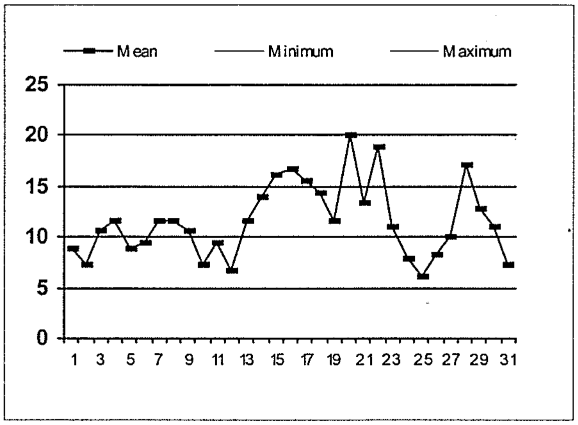
Mount Mansfield Summit: May - Air Temperature Minimum (degrees C)



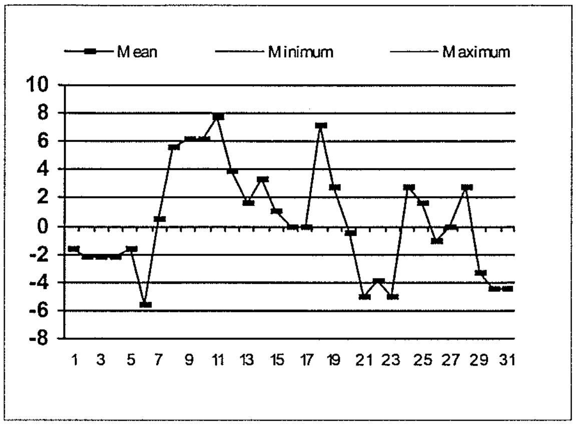
Mount Mansfield Summit: June - Air Temperature Minimum (degrees C)



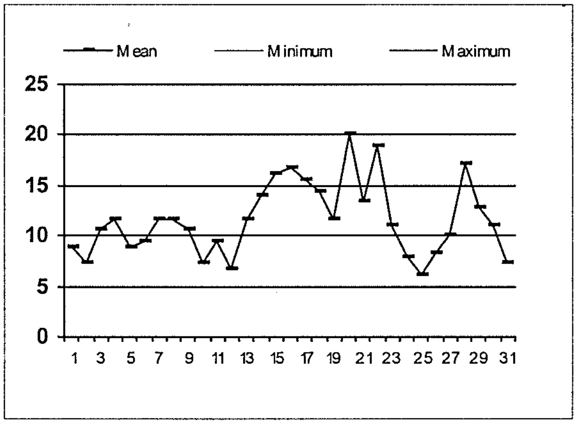
Mount Mansfield Summit: July - Air Temperature Minimum (degrees C)



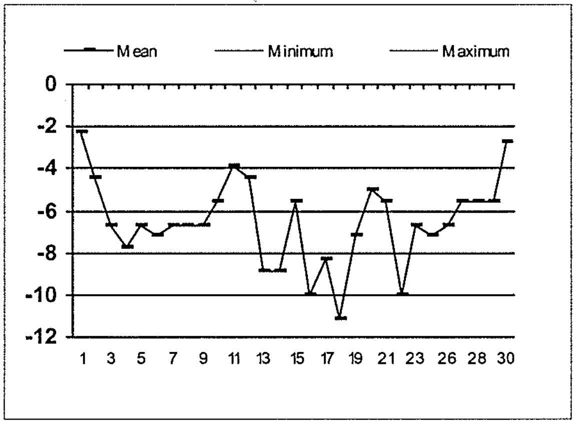
Mount Mansfield Summit: October - Air Temperature Minimum (degrees C)



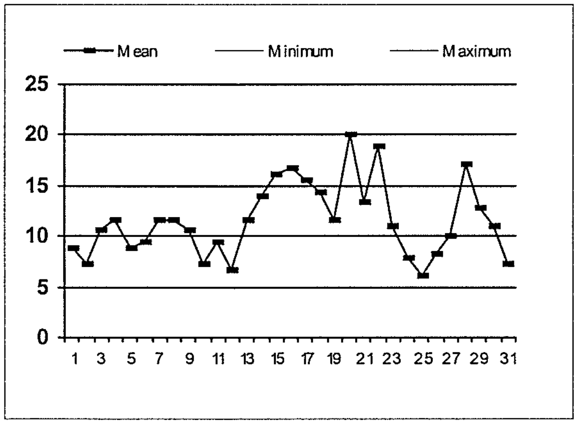
Mount Mansfield Summit: August - Air Temperature Minimum (degrees C)



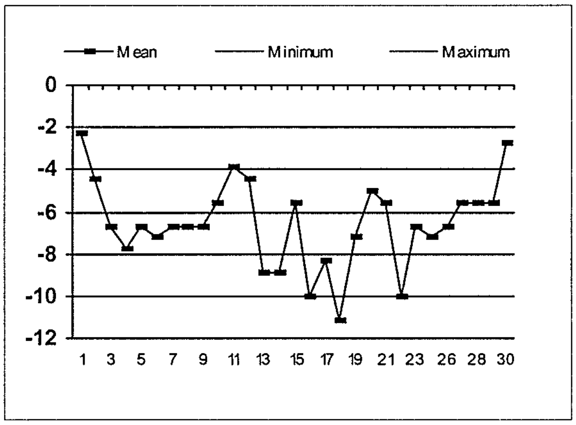
Mount Mansfield Summit: November - Air Temperature Minimum (degrees C)



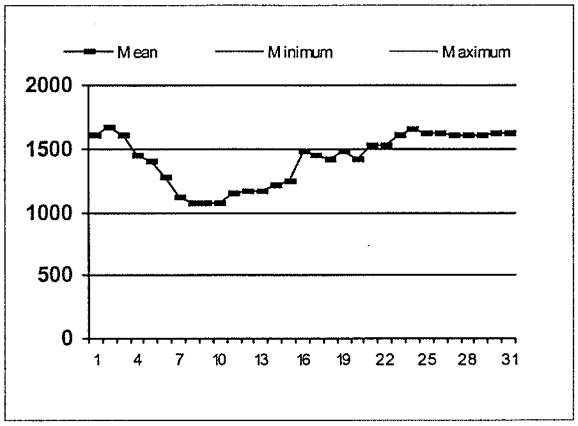
Mount Mansfield Summit: September - Air Temperature Minimum (degrees C)



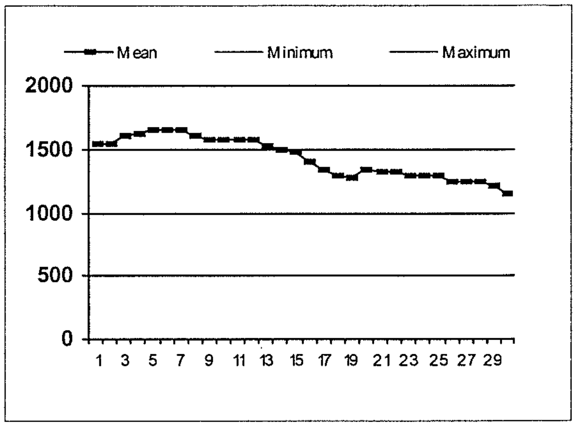
Mount Mansfield Summit: December - Air Temperature Minimum (degrees C)



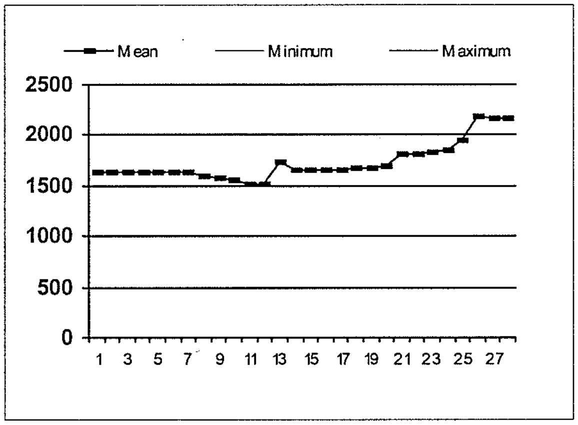
Mount Mansfield Summit: January - Snow Depth (mm)



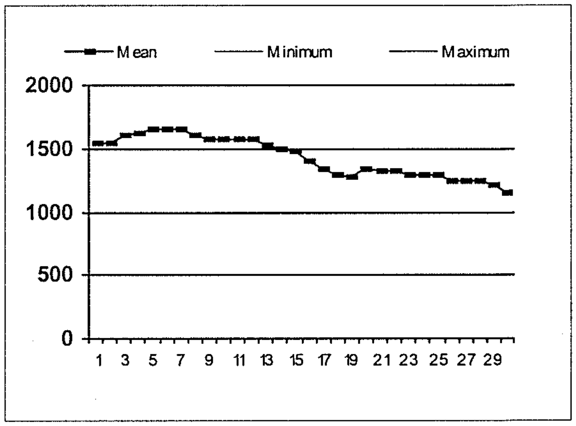
Mount Mansfield Summit: April - Snow Depth (mm)



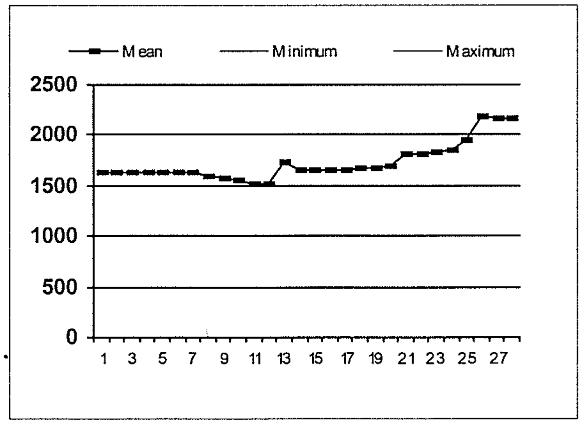
Mount Mansfield Summit: February - Snow Depth (mm)



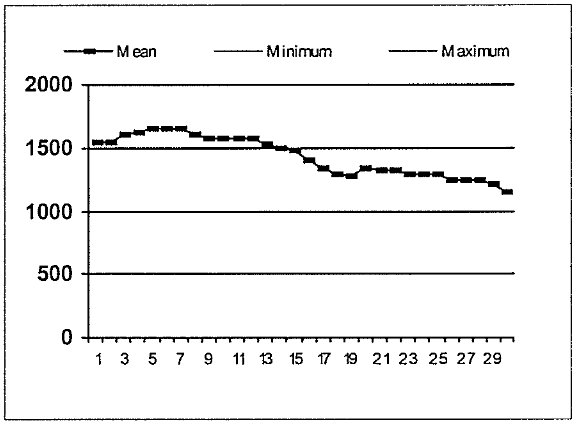
Mount Mansfield Summit: May - Snow Depth (mm)



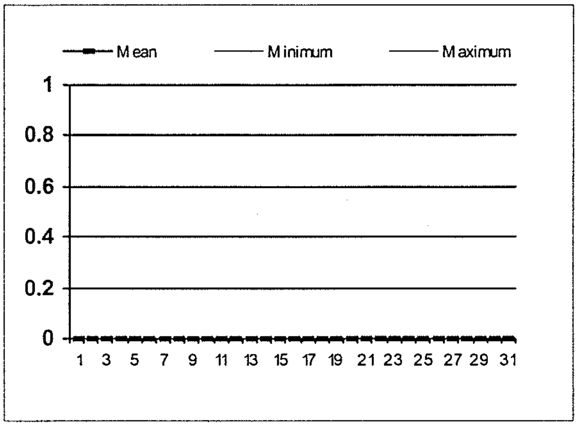
Mount Mansfield Summit: March - Snow Depth (mm)



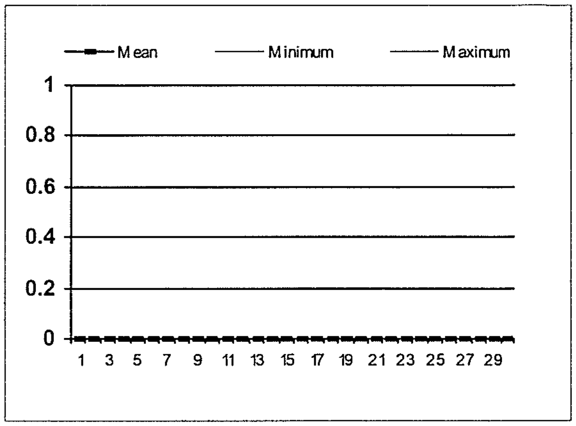
Mount Mansfield Summit: June - Snow Depth (mm)



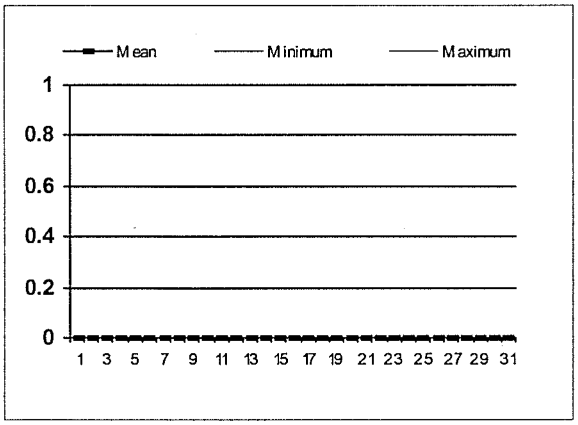
Mount Mansfield Summit: July - Snow Depth (mm)



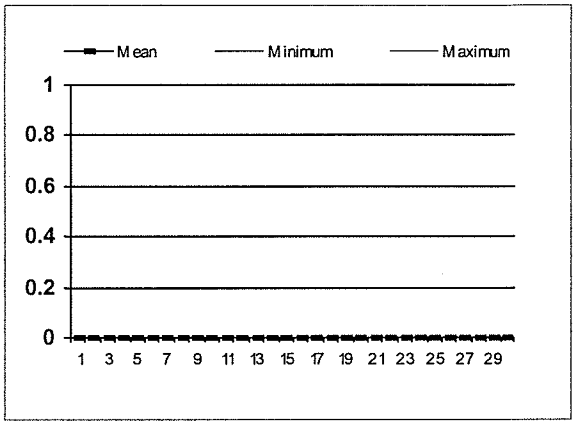
Mount Mansfield Summit: October - Snow Depth (mm)



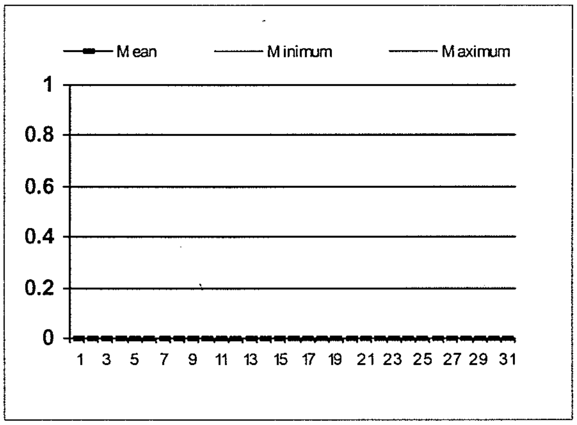
Mount Mansfield Summit: August - Snow Depth (mm)



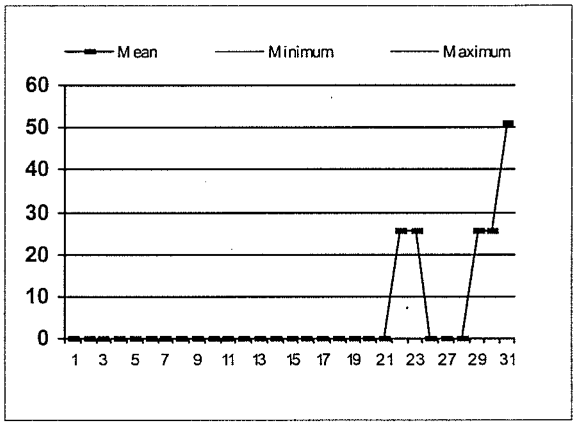
Mount Mansfield Summit: November - Snow Depth (mm)



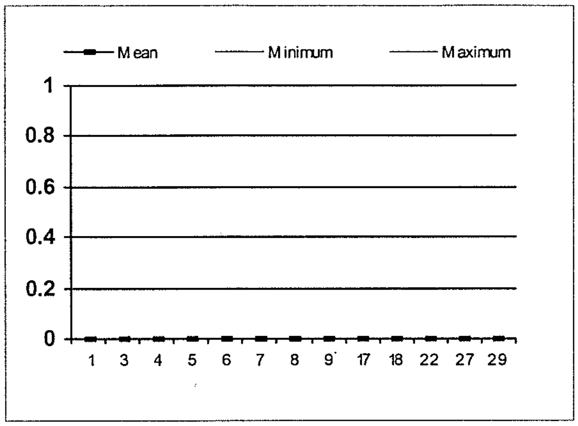
Mount Mansfield Summit: September - Snow Depth (mm)



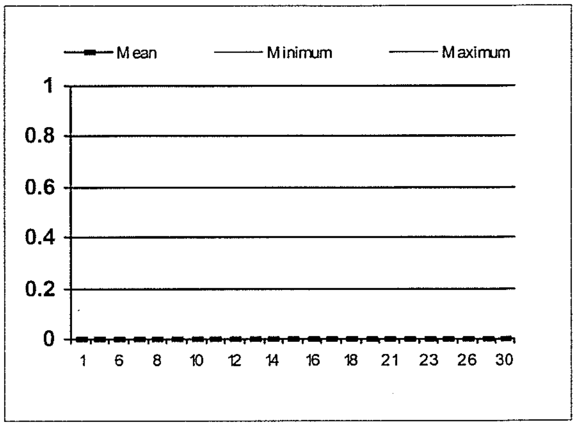
Mount Mansfield Summit: December - Snow Depth (mm)



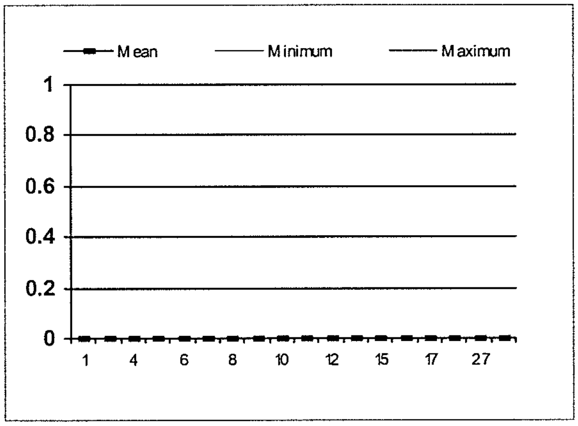
Mount Mansfield Summit: January - Snowfall (mm)



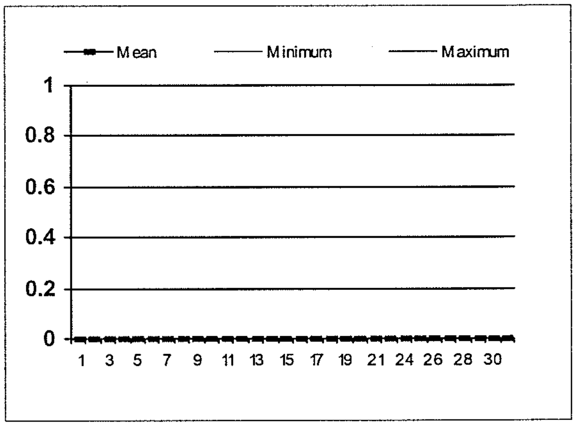
Mount Mansfield Summit: April - Snowfall (mm)



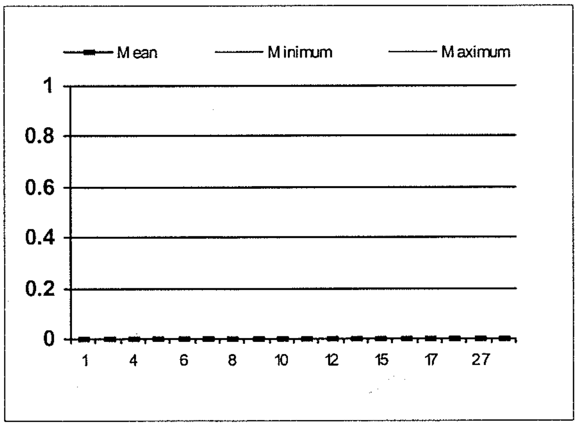
Mount Mansfield Summit: February - Snowfall (mm)



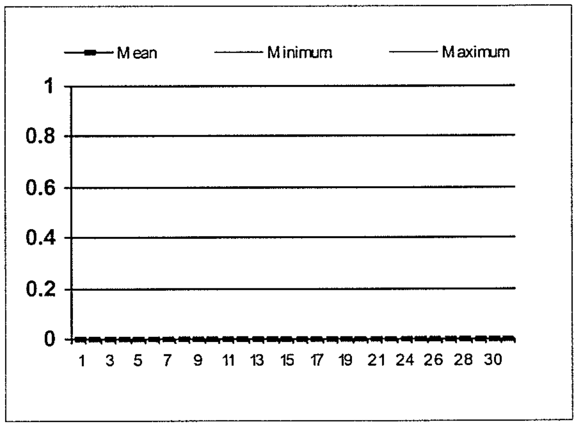
Mount Mansfield Summit: May - Snowfall (mm)



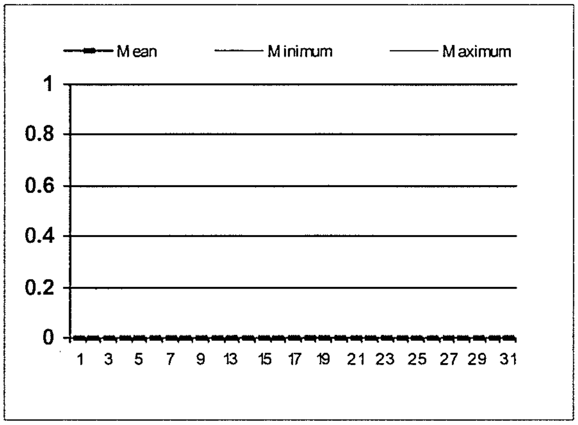
Mount Mansfield Summit: March - Snowfall (mm)



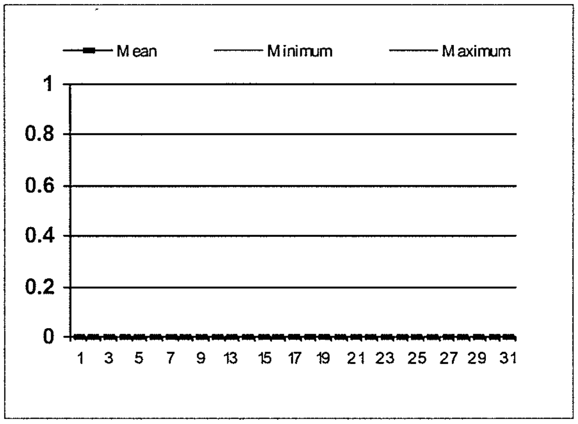
Mount Mansfield Summit: June - Snowfall (mm)



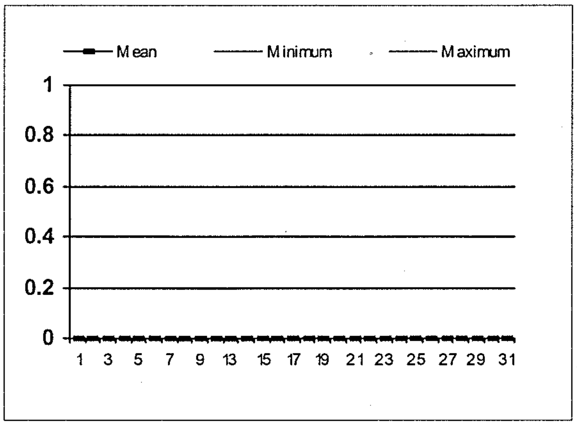
Mount Mansfield Summit: July - Snowfall (mm)



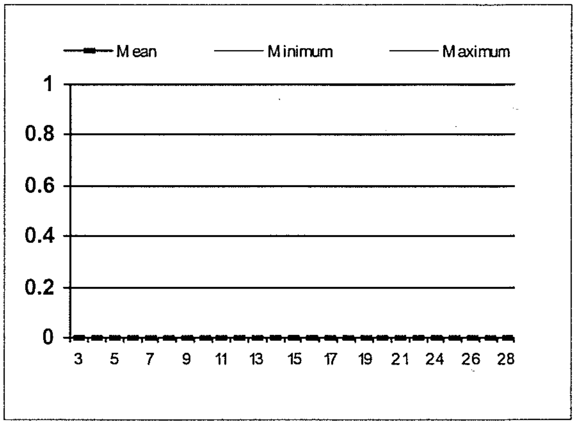
Mount Mansfield Summit: August - Snowfall (mm)



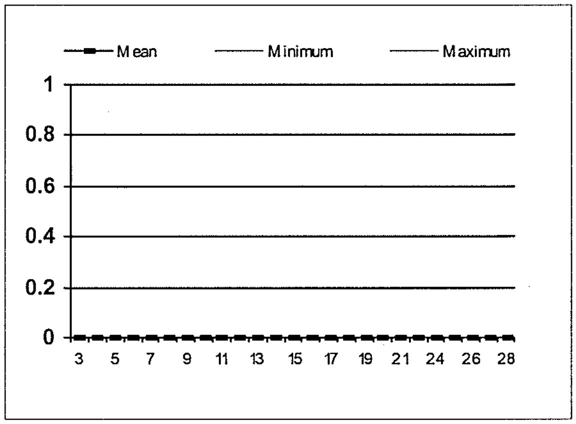
Mount Mansfield Summit: September - Snowfall (mm)



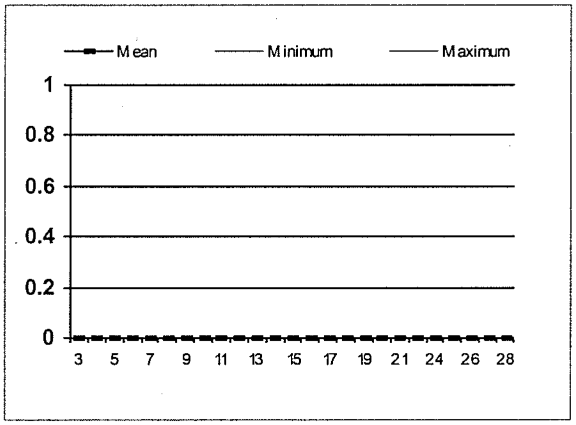
Mount Mansfield Summit: October - Snowfall (mm)



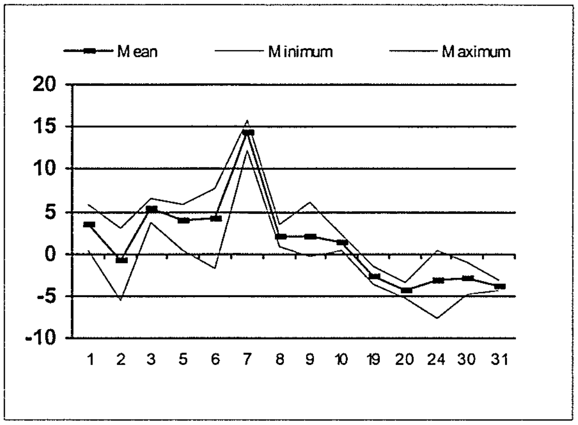
Mount Mansfield Summit: November - Snowfall (mm)



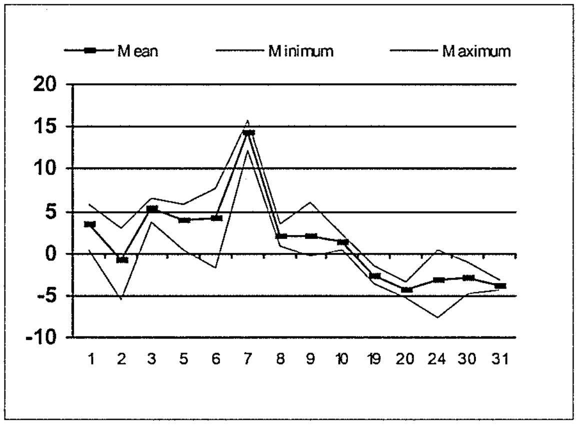
Mount Mansfield Summit: December - Snowfall (mm)



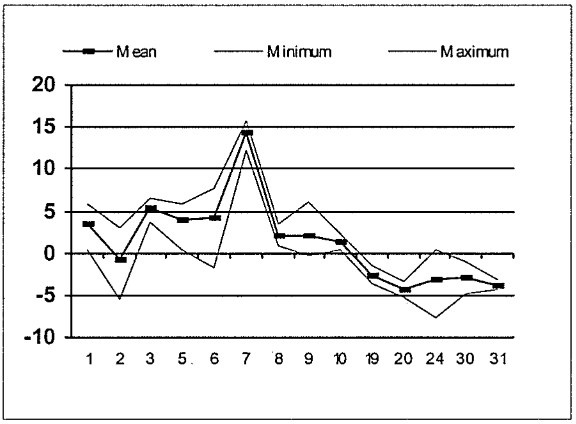
PMRC Air Quality Site: January - Air Temperature (degrees C)



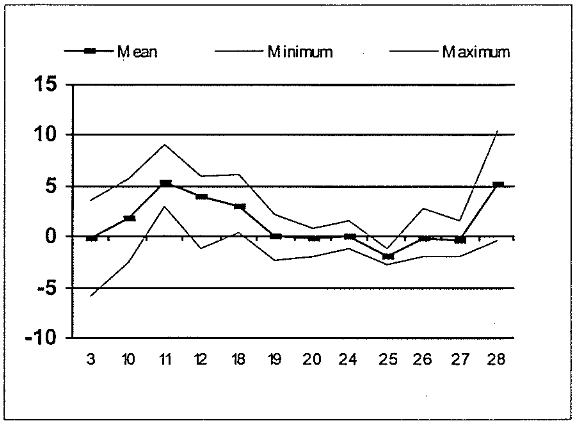
PMRC Air Quality Site: February - Air Temperature (degrees C)



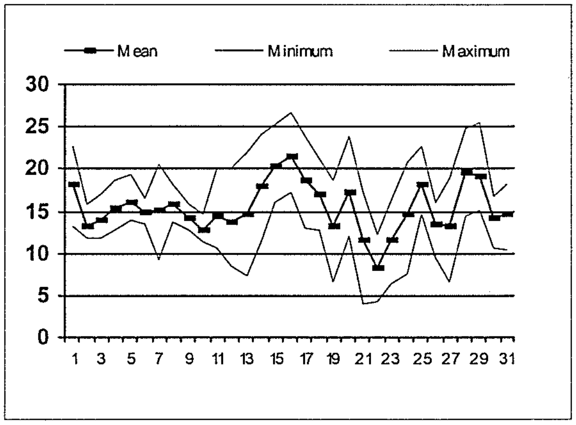
PMRC Air Quality Site: March - Air Temperature (degrees C)



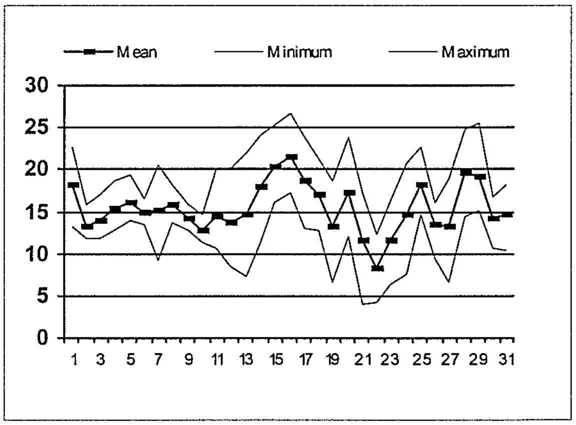
PMRC Air Quality Site: April - Air Temperature (degrees C)



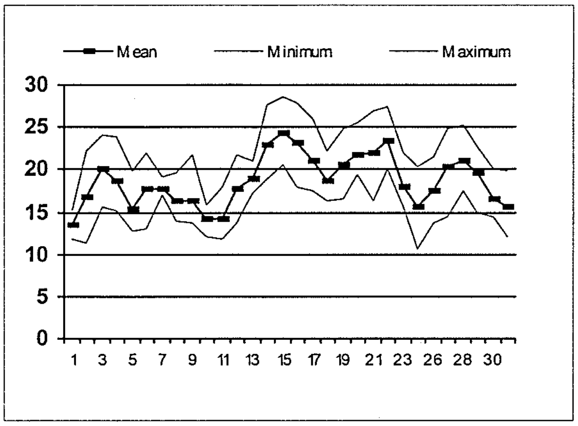
PMRC Air Quality Site: May - Air Temperature (degrees C)



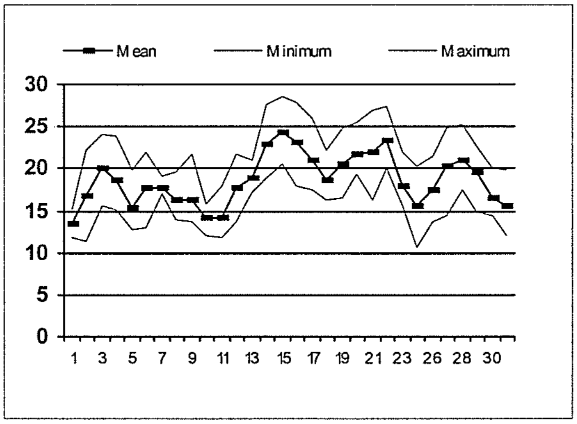
PMRC Air Quality Site: June - Air Temperature (degrees C)



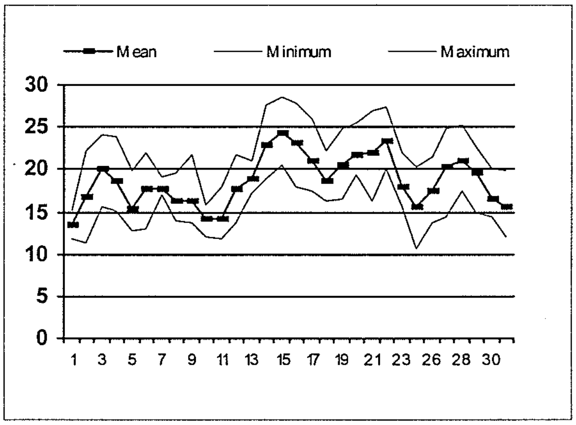
PMRC Air Quality Site: July - Air Temperature (degrees C)



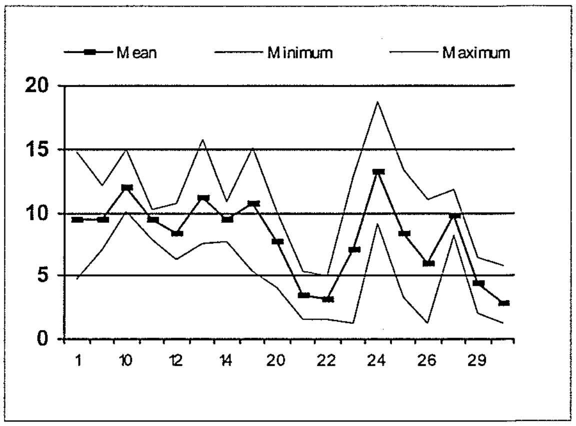
PMRC Air Quality Site: August - Air Temperature (degrees C)



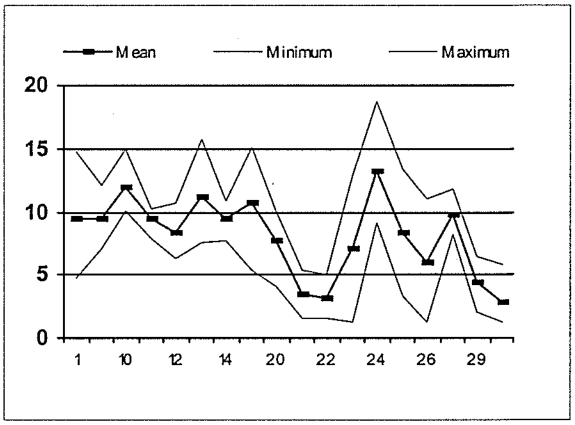
PMRC Air Quality Site: September - Air Temperature (degrees C)



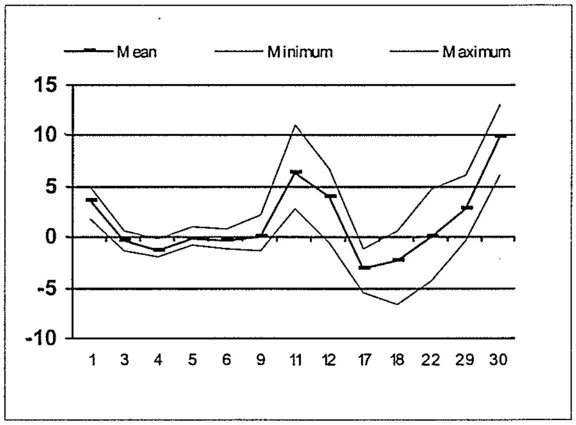
PMRC Air Quality Site: October - Air Temperature (degrees C)



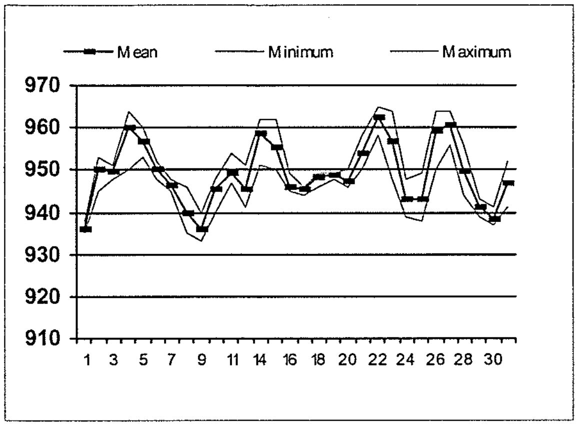
PMRC Air Quality Site: November - Air Temperature (degrees C)



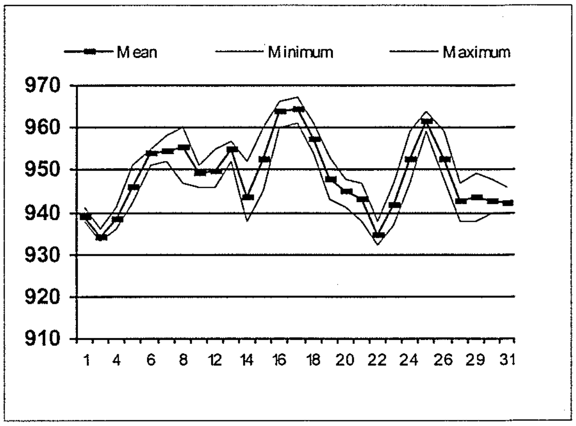
PMRC Air Quality Site: December - Air Temperature (degrees C)



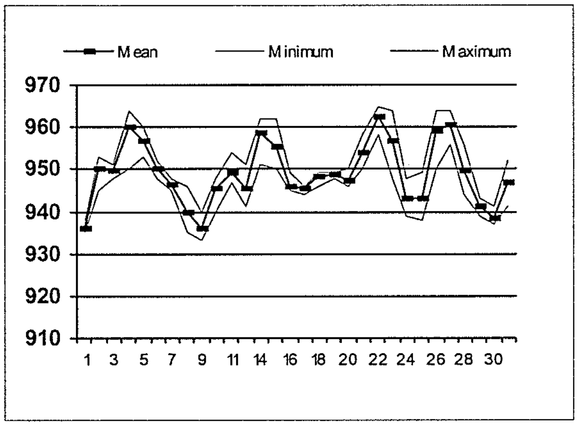
PMRC Air Quality Site: January - Barometric Pressure (mb)



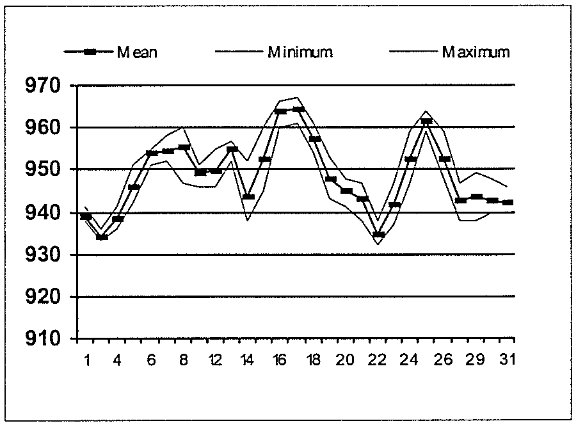
PMRC Air Quality Site: April - Barometric Pressure (mb)



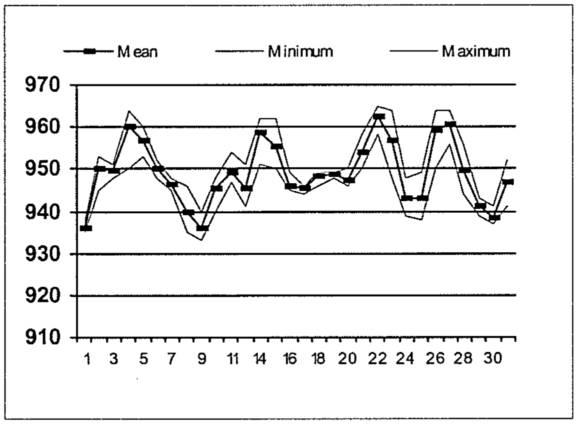
PMRC Air Quality Site: February - Barometric Pressure (mb)



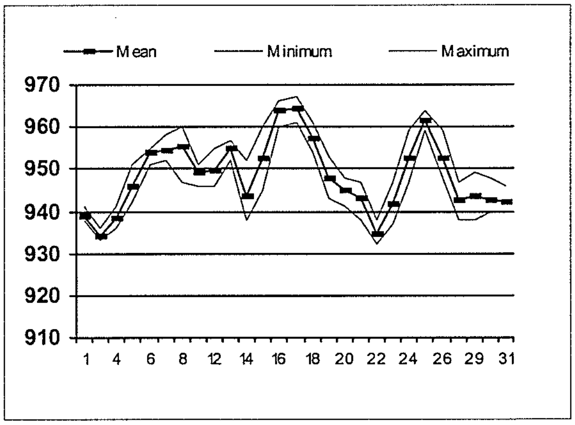
PMRC Air Quality Site: May - Barometric Pressure (mb)



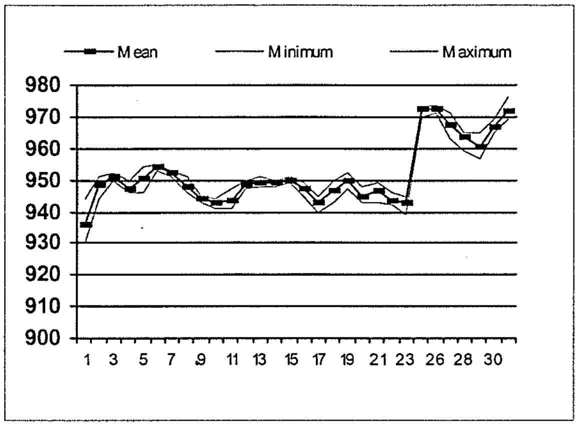
PMRC Air Quality Site: March - Barometric Pressure (mb)



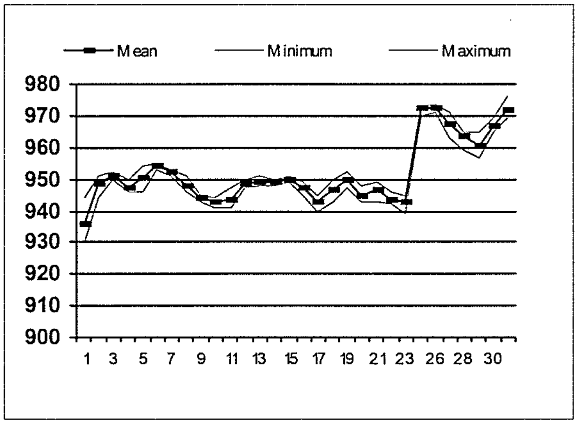
PMRC Air Quality Site: June - Barometric Pressure (mb)



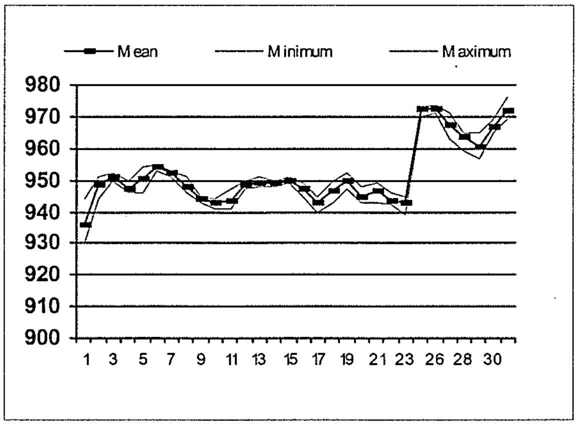
PMRC Air Quality Site: July - Barometric Pressure (mb)



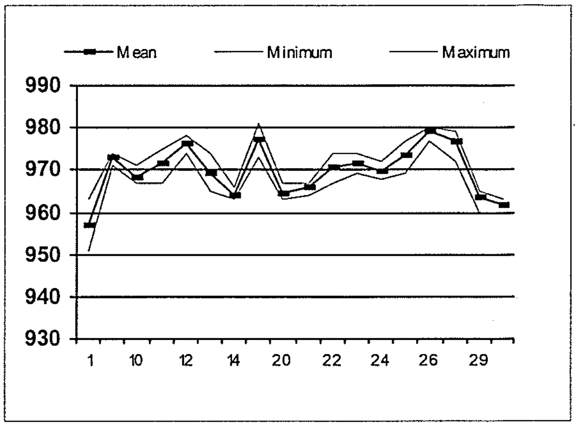
PMRC Air Quality Site: August - Barometric Pressure (mb)



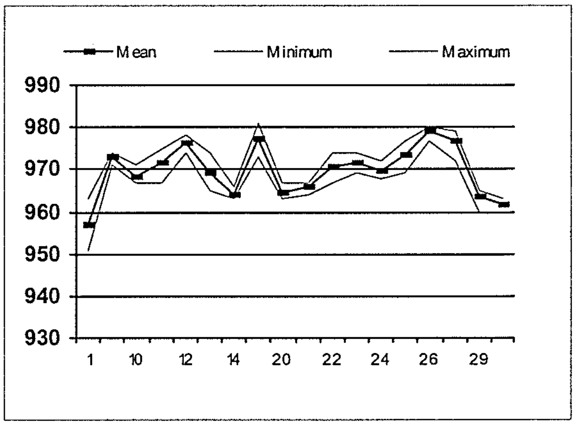
PMRC Air Quality Site: September - Barometric Pressure (mb)



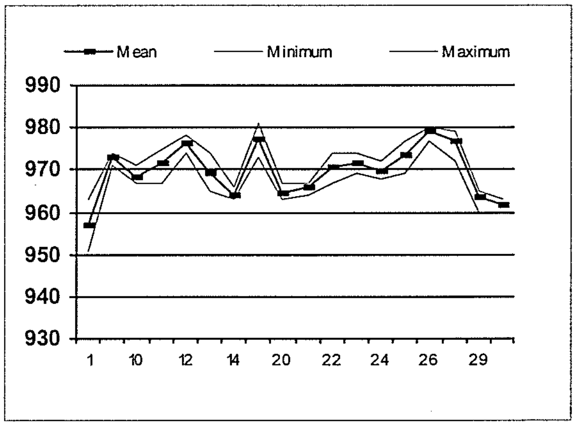
PMRC Air Quality Site: October - Barometric Pressure (mb)



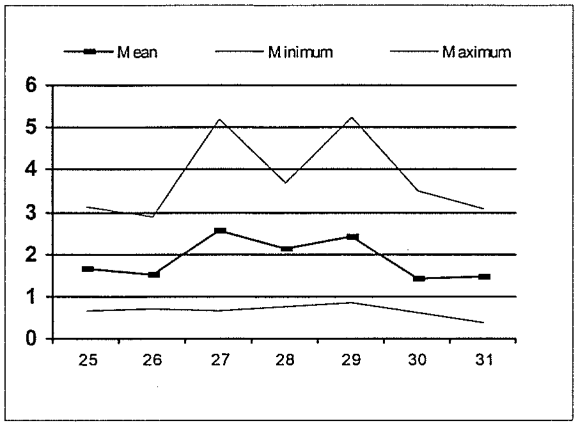
PMRC Air Quality Site: November - Barometric Pressure (mb)



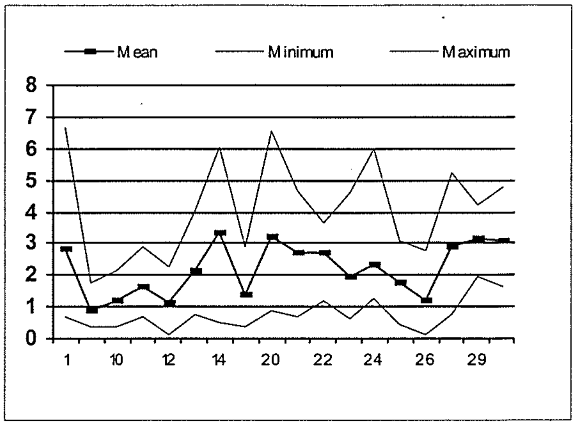
PMRC Air Quality Site: December - Barometric Pressure (mb)



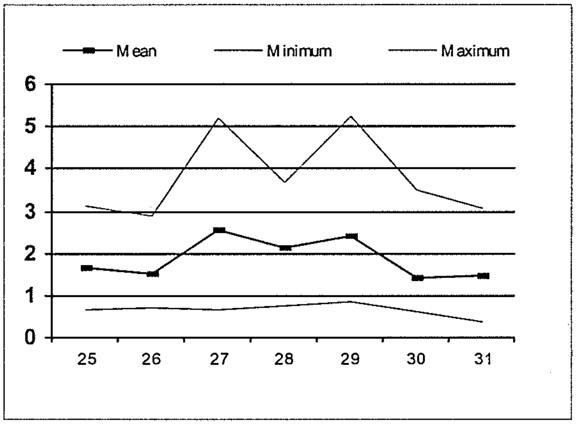
PMRC Air Quality Site: July - Horizontal Wind Speed (ms)



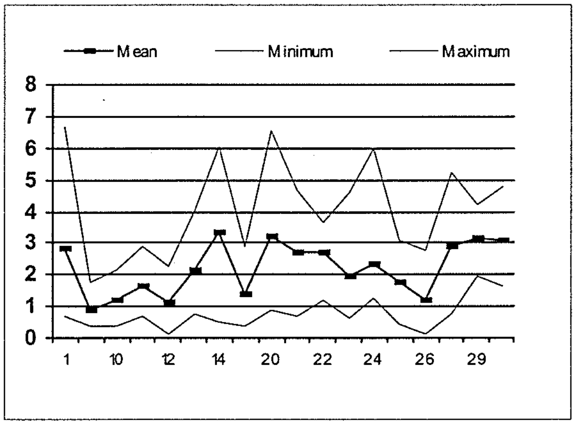
PMRC Air Quality Site: October - Horizontal Wind Speed (ms)



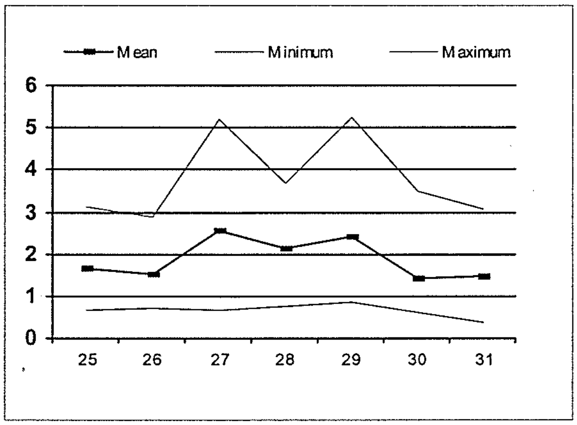
PMRC Air Quality Site: August - Horizontal Wind Speed (ms)



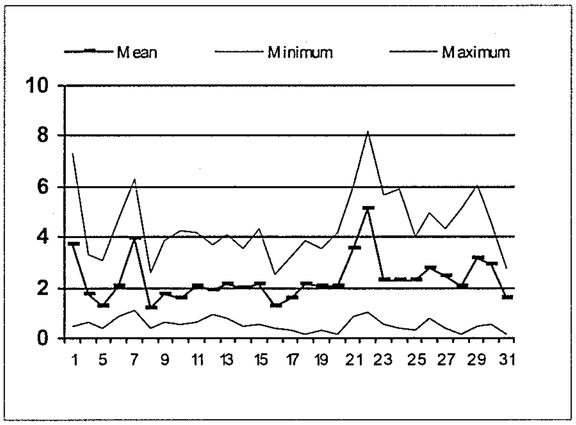
PMRC Air Quality Site: November - Horizontal Wind Speed (ms)



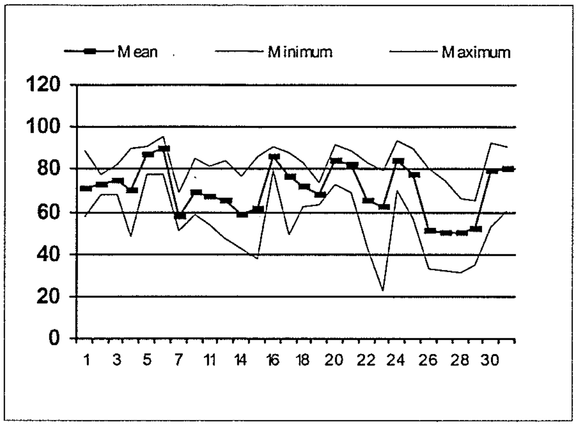
PMRC Air Quality Site: September - Horizontal Wind Speed (ms)



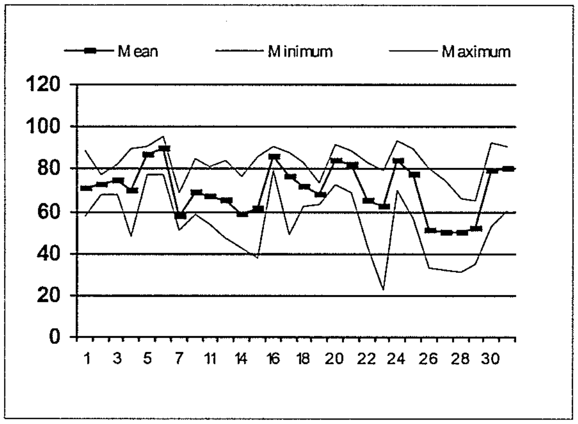
PMRC Air Quality Site: December - Horizontal Wind Speed (ms)



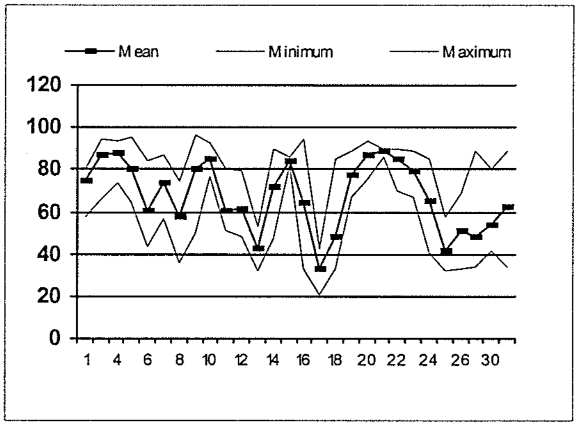
PMRC Air Quality Site: January - Relative Humidity (%)



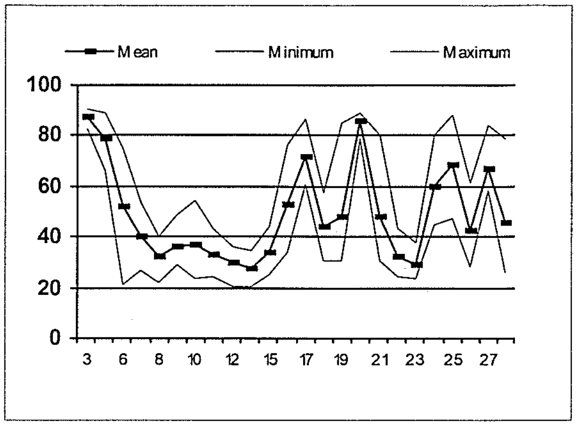
PMRC Air Quality Site: February - Relative Humidity (%)



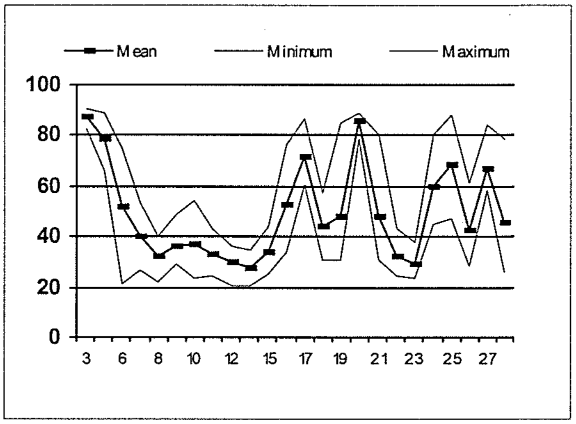
PMRC Air Quality Site: March - Relative Humidity (%)



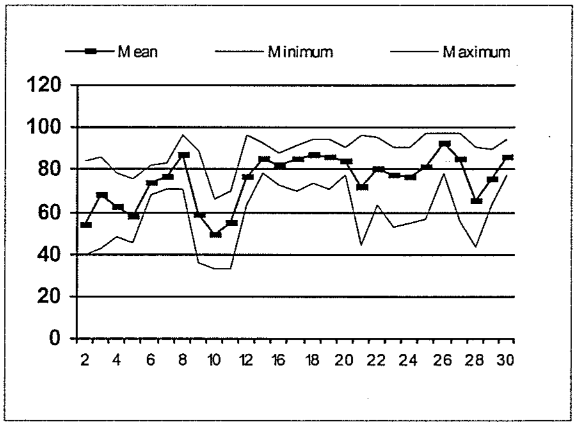
PMRC Air Quality Site: April - Relative Humidity (%)



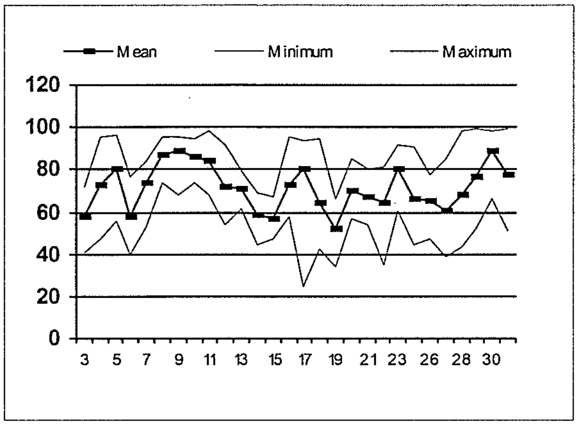
PMRC Air Quality Site: May - Relative Humidity (%)



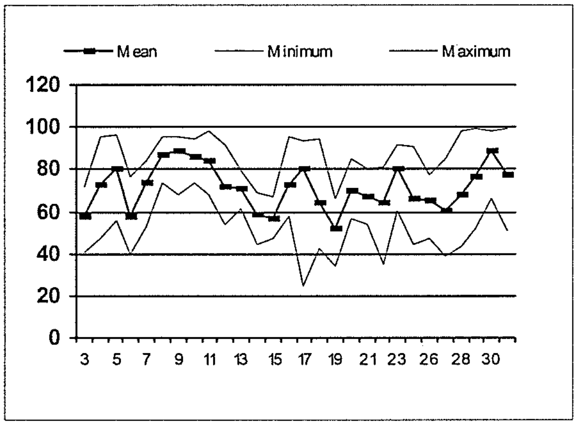
PMRC Air Quality Site: June - Relative Humidity (%)



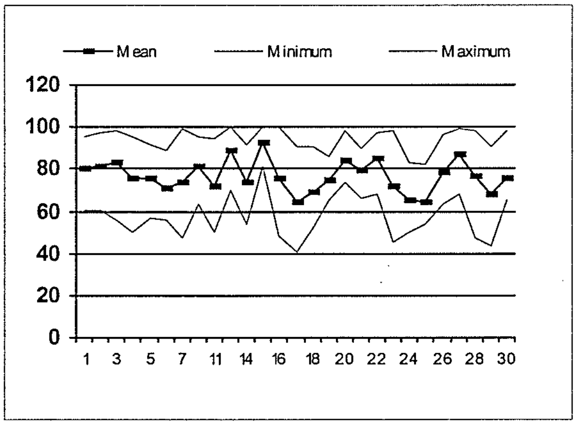
PMRC Air Quality Site: July - Relative Humidity (%)



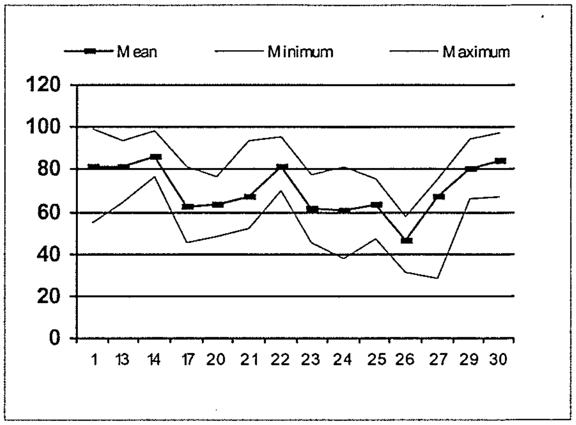
PMRC Air Quality Site: August - Relative Humidity (%)



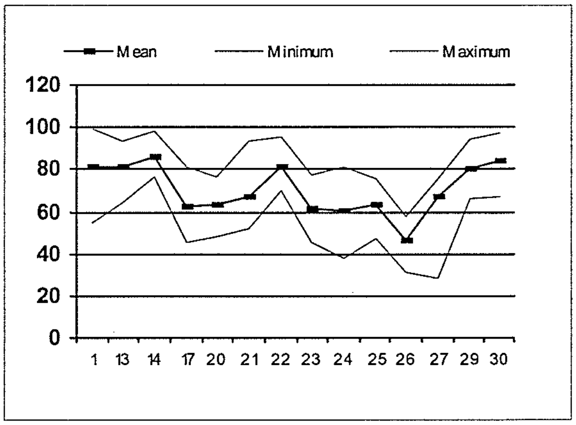
PMRC Air Quality Site: September - Relative Humidity (%)



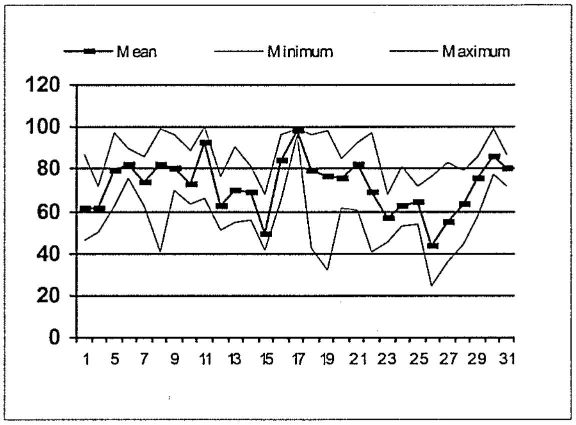
PMRC Air Quality Site: October - Relative Humidity (%)



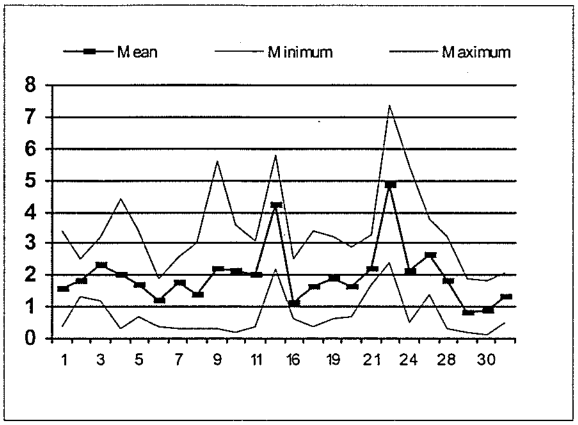
PMRC Air Quality Site: November - Relative Humidity (%)



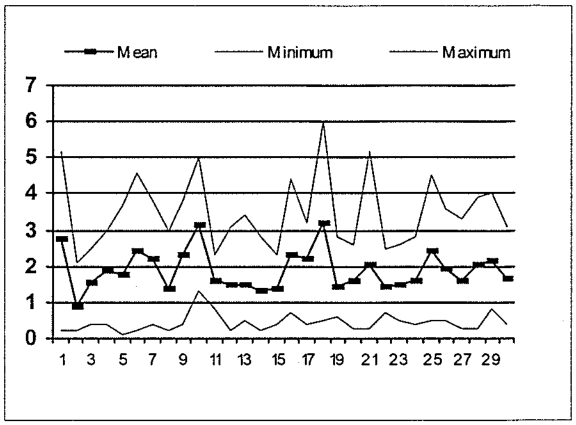
PMRC Air Quality Site: December - Relative Humidity (%)



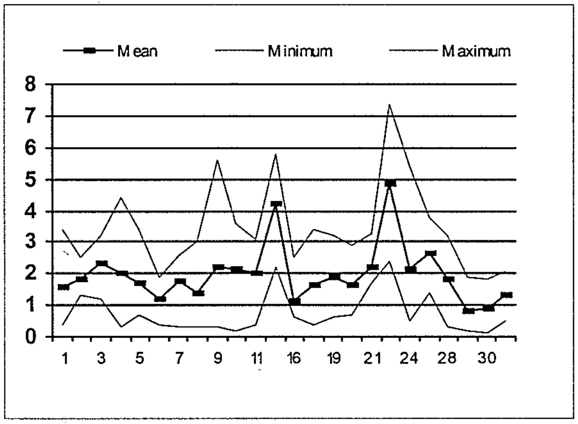
PMRC Air Quality Site: January - Resultant Wind Speed (m/s)



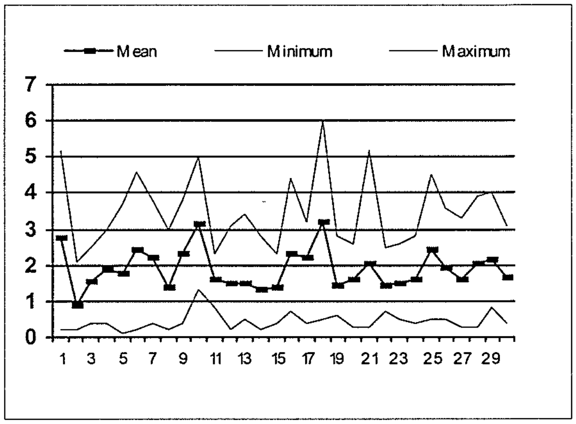
PMRC Air Quality Site: April - Resultant Wind Speed (m/s)



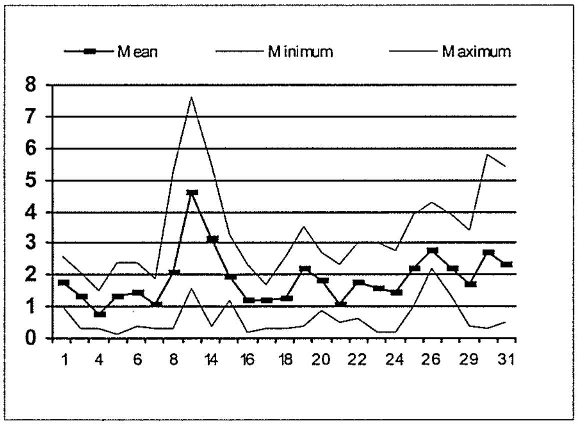
PMRC Air Quality Site: February - Resultant Wind Speed (m/s)



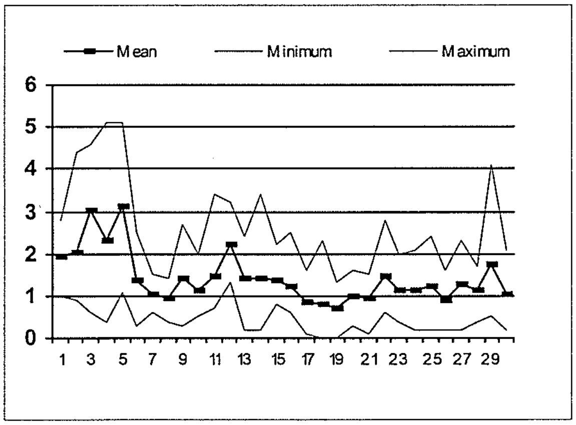
PMRC Air Quality Site: May - Resultant Wind Speed (m/s)



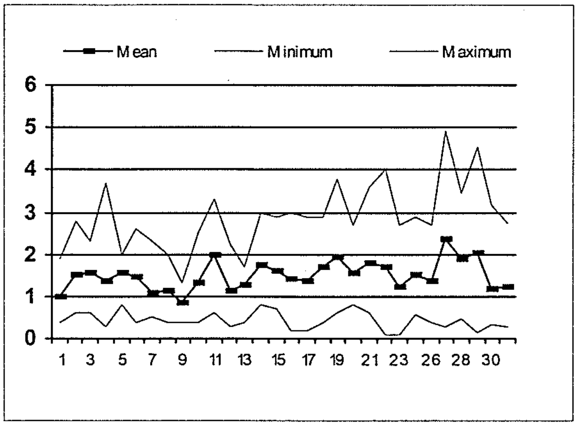
PMRC Air Quality Site: March - Resultant Wind Speed (m/s)



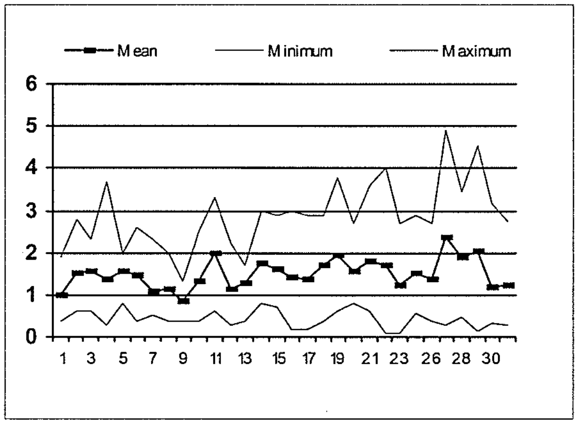
PMRC Air Quality Site: June - Resultant Wind Speed (m/s)



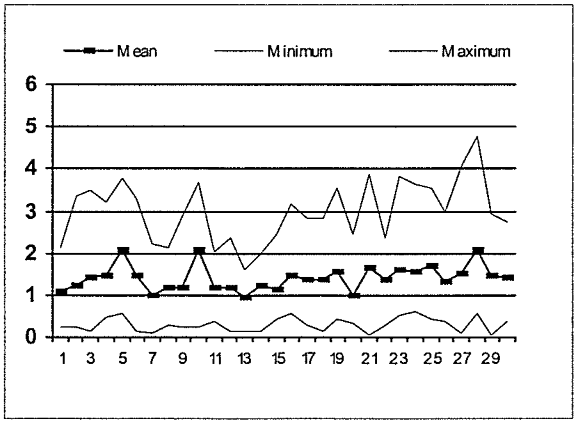
PMRC Air Quality Site: July - Resultant Wind Speed (m/s)



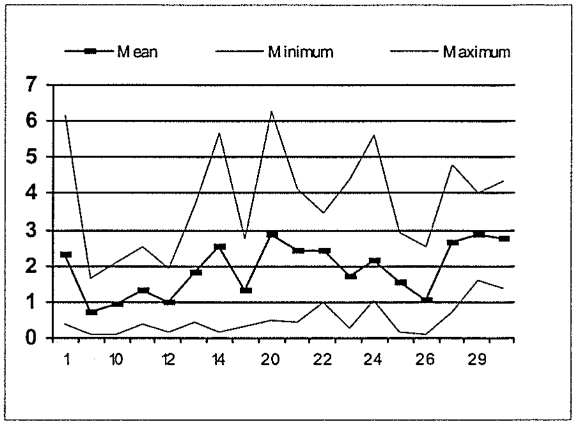
PMRC Air Quality Site: August - Resultant Wind Speed (m/s)



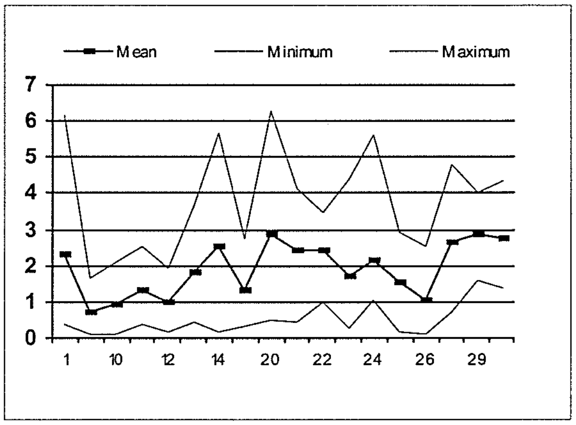
PMRC Air Quality Site: September - Resultant Wind Speed (m/s)



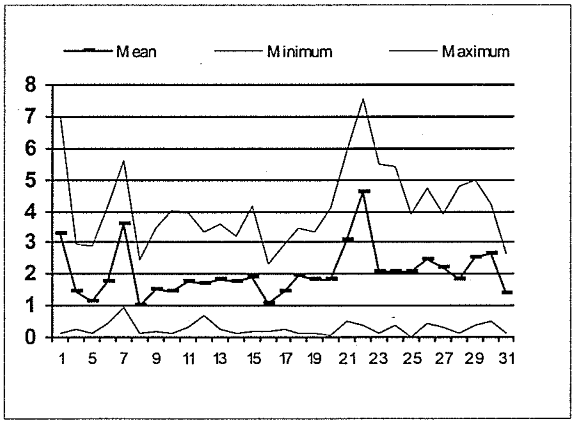
PMRC Air Quality Site: October - Resultant Wind Speed (m/s)



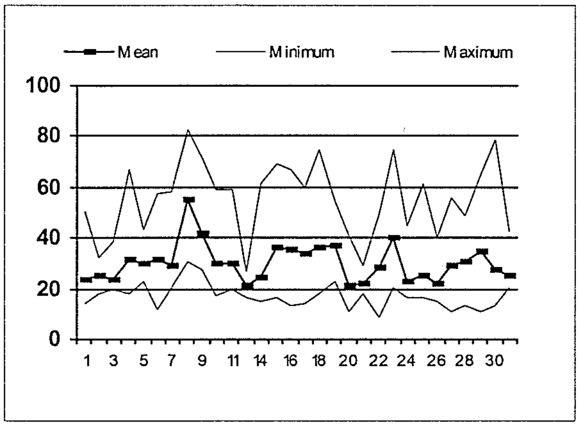
PMRC Air Quality Site: November - Resultant Wind Speed (m/s)



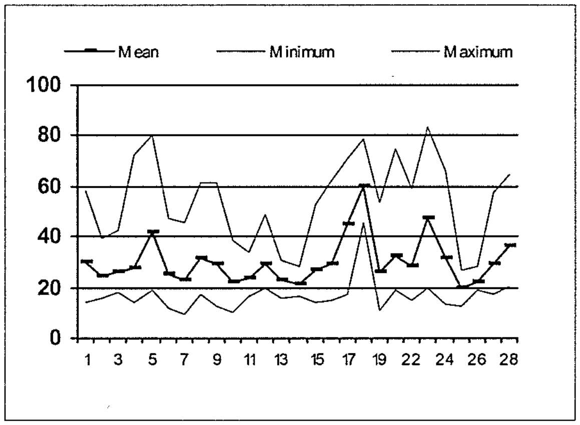
PMRC Air Quality Site: December - Resultant Wind Speed (m/s)



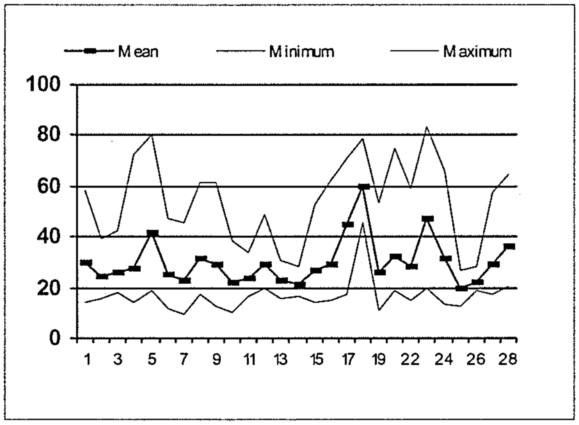
PMRC Air Quality Site: January - Stand Deviation Wind Direction



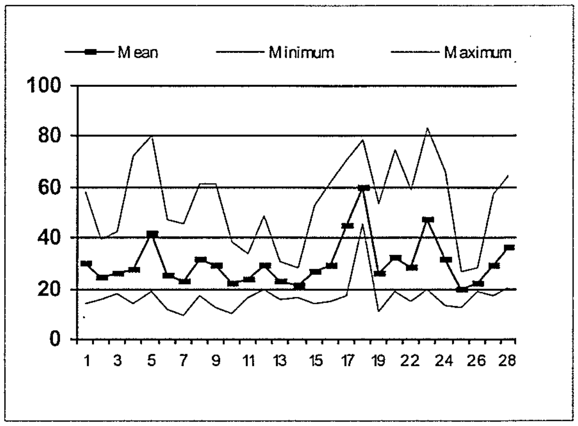
PMRC Air Quality Site: February - Stand Deviation Wind Direction



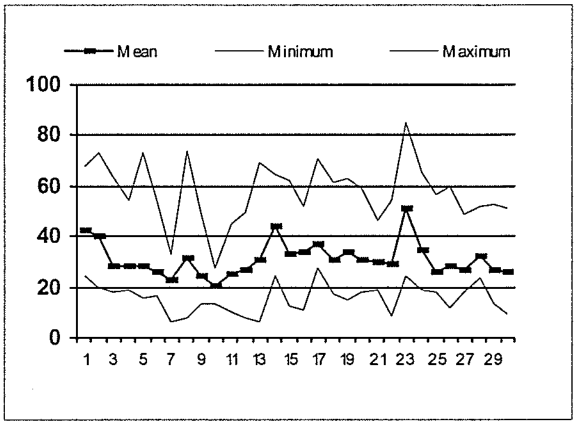
PMRC Air Quality Site: March - Stand Deviation Wind Direction



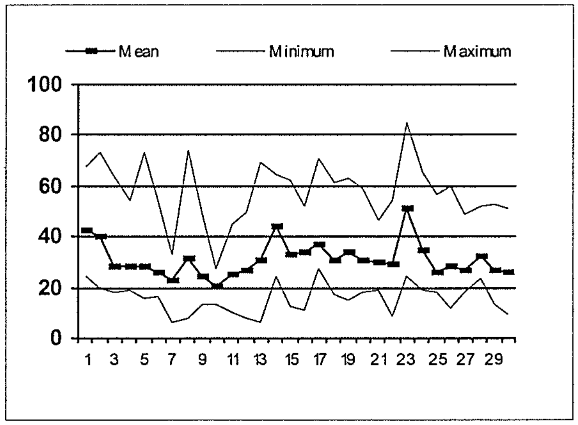
PMRC Air Quality Site: April - Stand Deviation Wind Direction



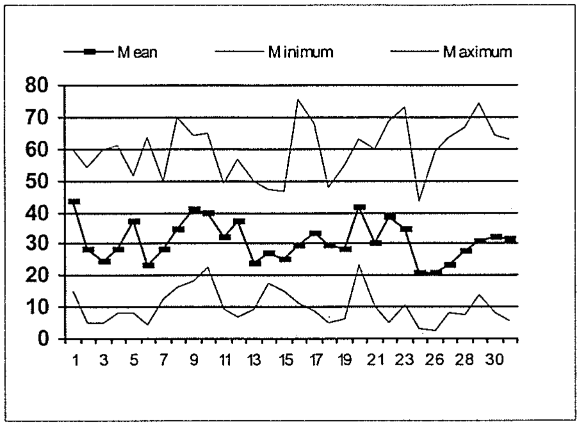
PMRC Air Quality Site: May - Stand Deviation Wind Direction



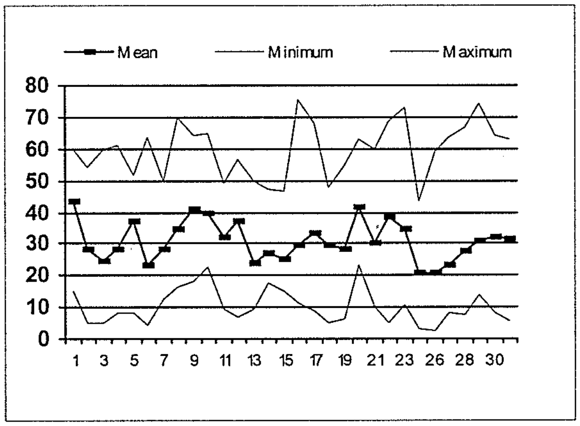
PMRC Air Quality Site: June - Stand Deviation Wind Direction



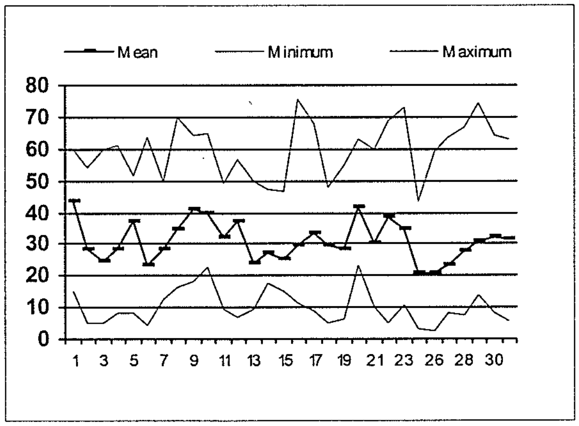
PMRC Air Quality Site: July - Stand Deviation Wind Direction



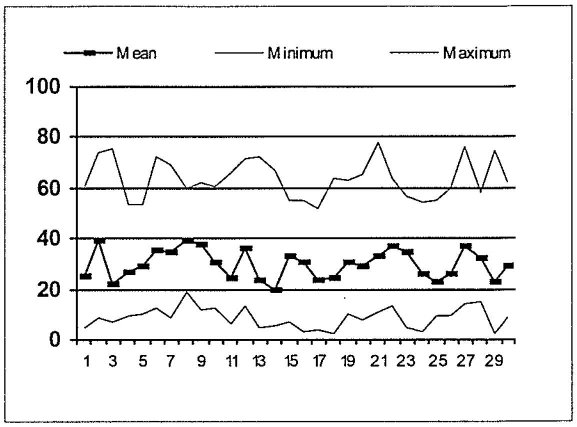
PMRC Air Quality Site: August - Stand Deviation Wind Direction



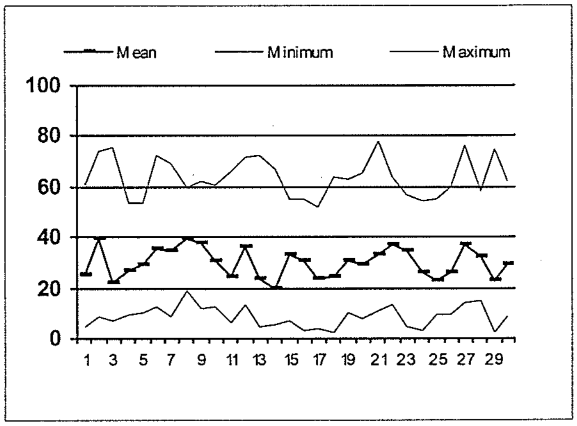
PMRC Air Quality Site: September - Stand Deviation Wind Direction



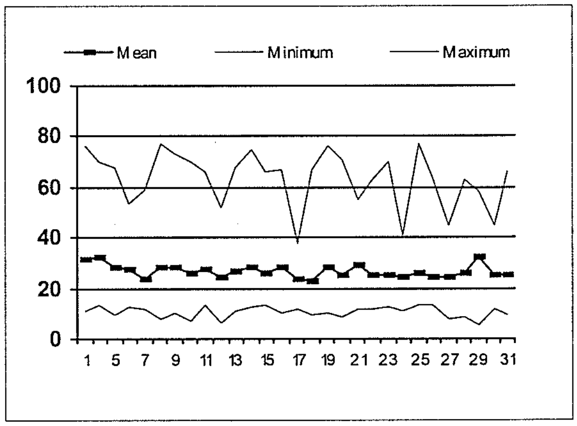
PMRC Air Quality Site: October - Stand Deviation Wind Direction



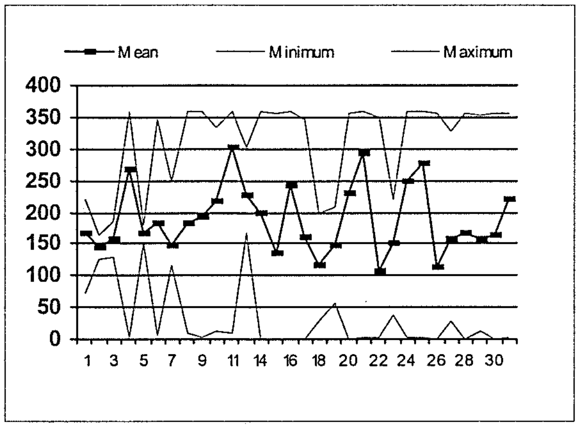
PMRC Air Quality Site: November - Stand Deviation Wind Direction



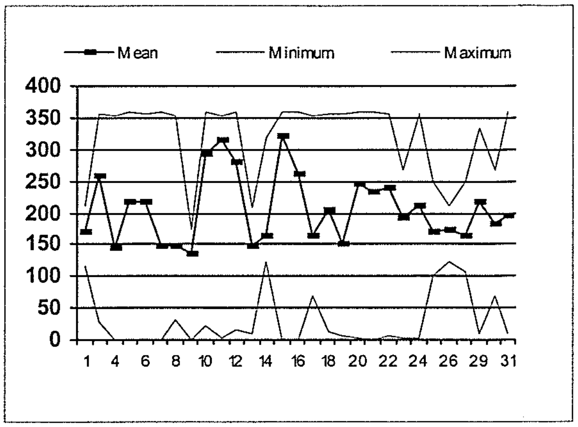
PMRC Air Quality Site: December - Stand Deviation Wind Direction



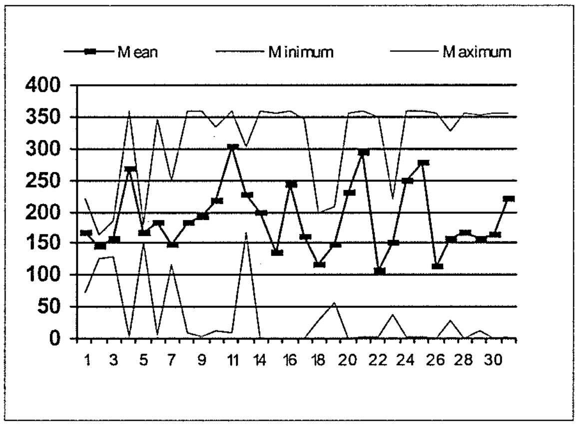
PMRC Air Quality Site: January - Wind Direction (degrees)



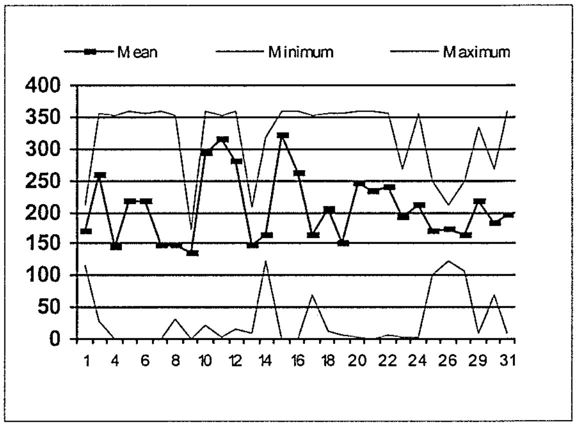
PMRC Air Quality Site: April - Wind Direction (degrees)



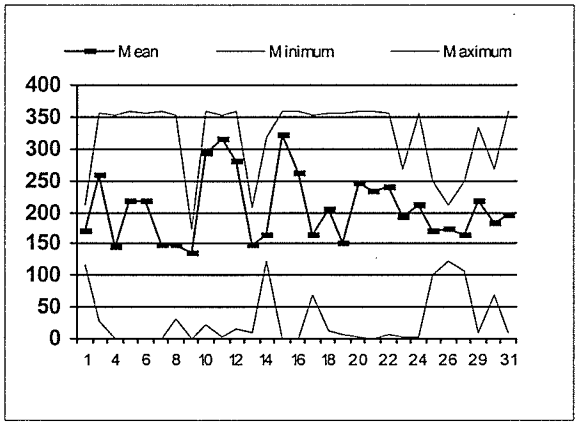
PMRC Air Quality Site: February - Wind Direction (degrees)



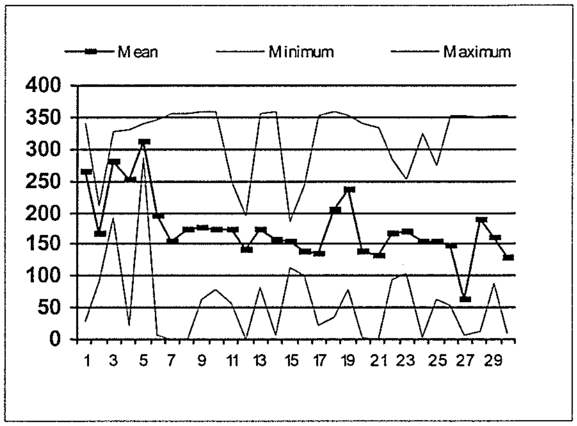
PMRC Air Quality Site: May - Wind Direction (degrees)



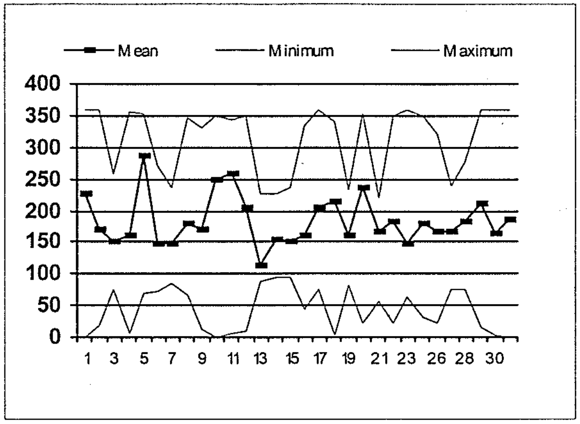
PMRC Air Quality Site: March - Wind Direction (degrees)



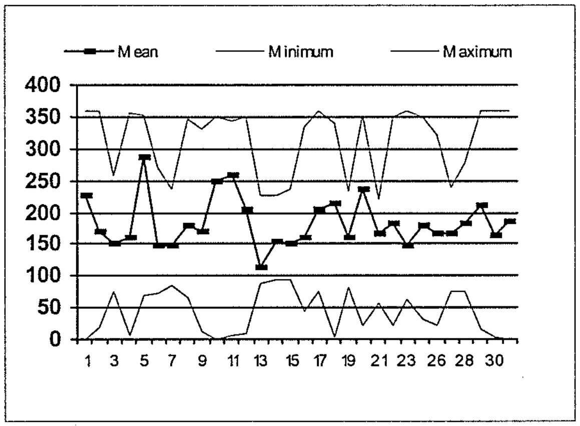
PMRC Air Quality Site: June - Wind Direction (degrees)



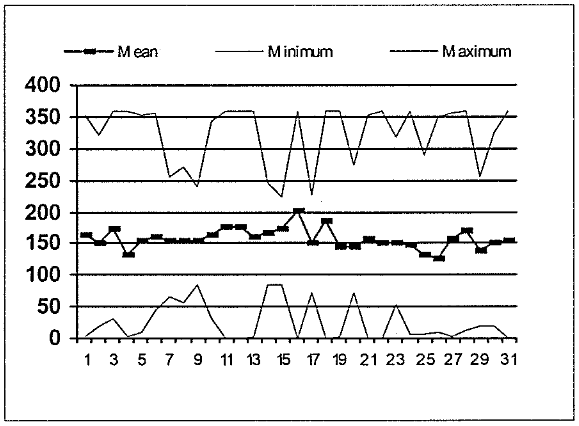
PMRC Air Quality Site: July - Wind Direction (degrees)



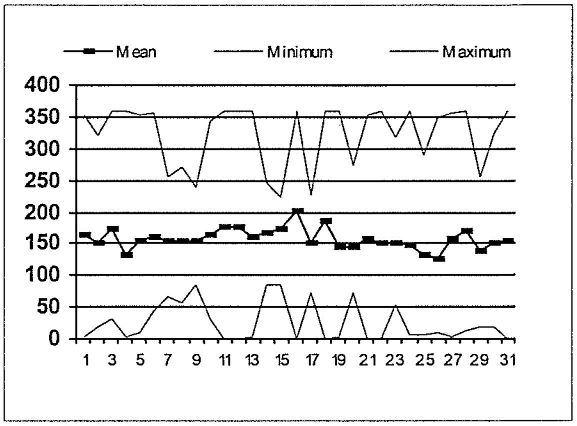
PMRC Air Quality Site: August - Wind Direction (degrees)



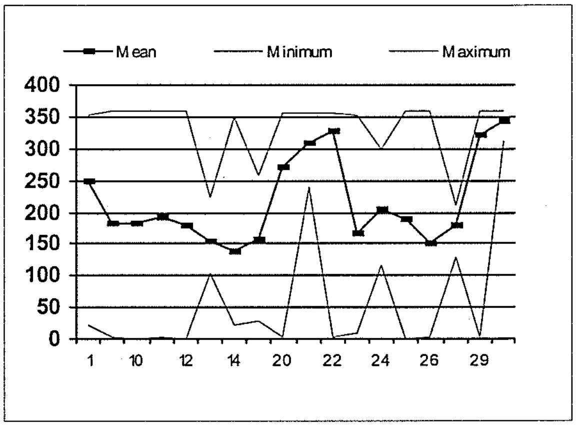
PMRC Air Quality Site: September - Wind Direction (degrees)



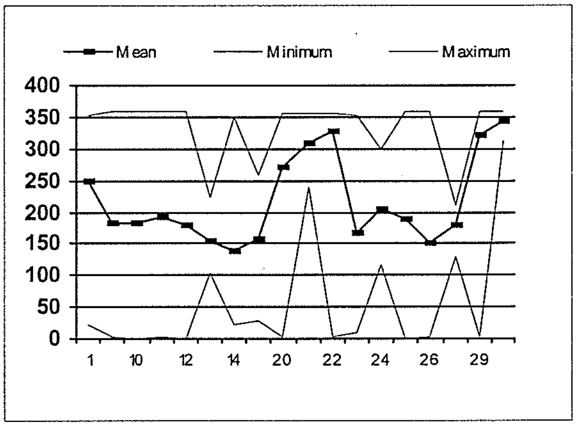
PMRC Air Quality Site: October - Wind Direction (degrees)



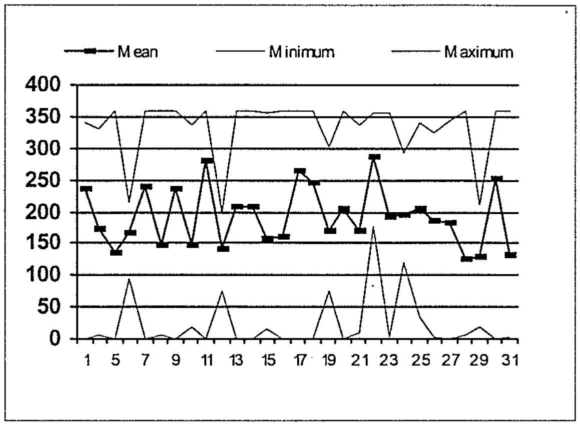
PMRC Air Quality Site: November - Wind Direction (degrees)



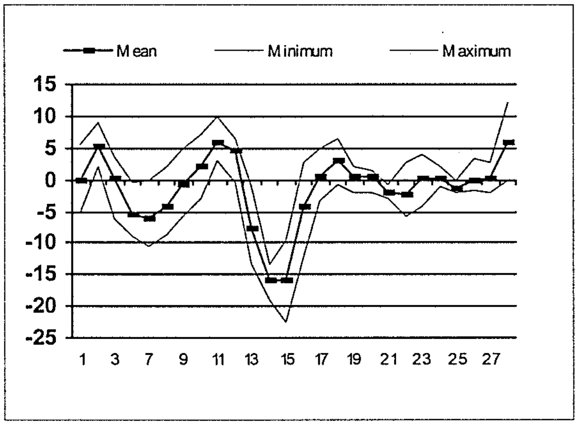
PMRC Air Quality Site: December - Wind Direction (degrees)



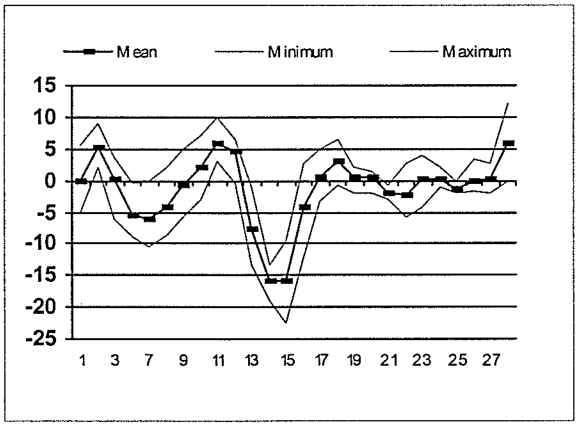
PMRC Tower: January - Air Temperature (degrees C)



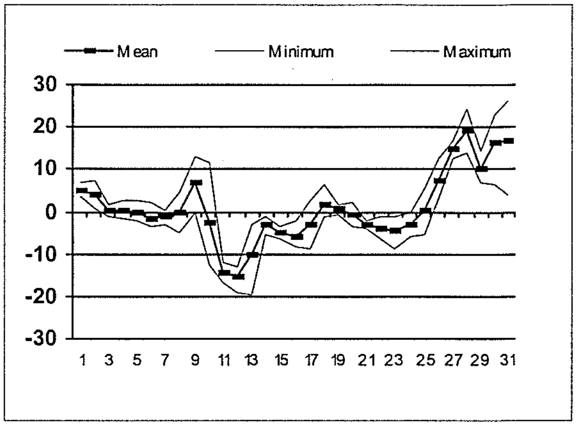
PMRC Tower: February - Air Temperature (degrees C)



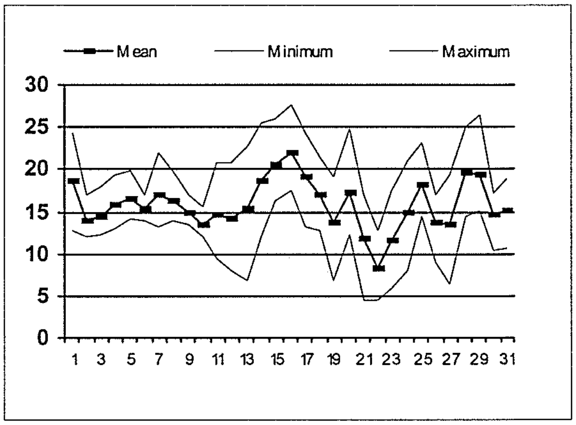
PMRC Tower: March - Air Temperature (degrees C)



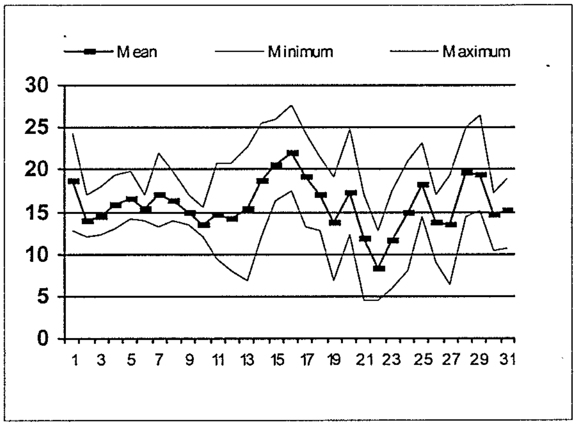
PMRC Tower: April - Air Temperature (degrees C)



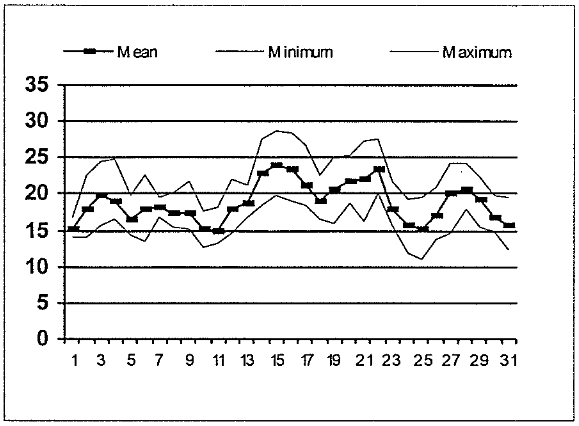
PMRC Tower: May - Air Temperature (degrees C)



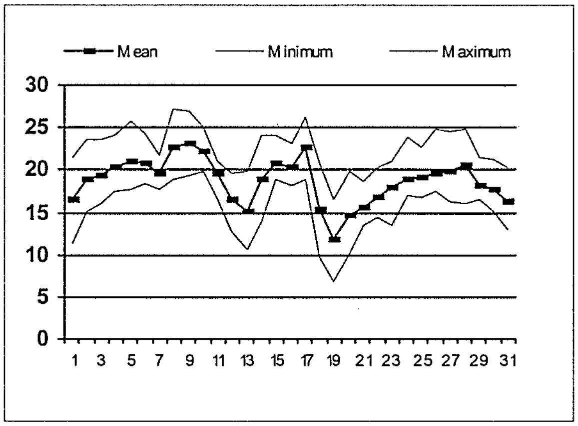
PMRC Tower: June - Air Temperature (degrees C)



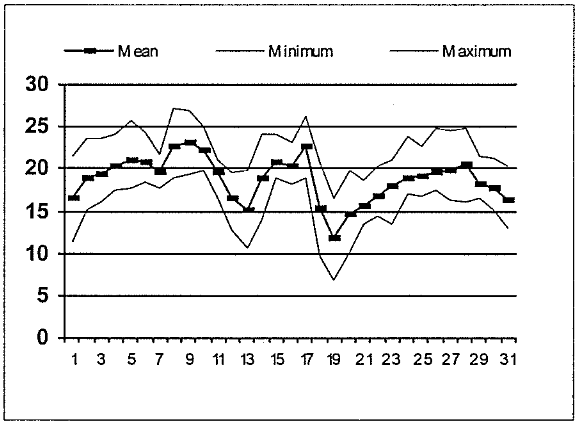
PMRC Tower: July - Air Temperature (degrees C)



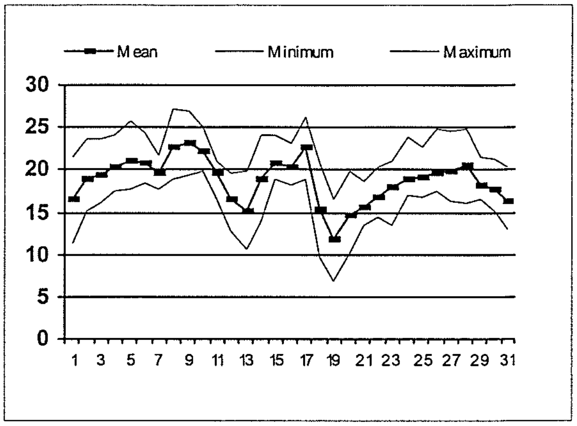
PMRC Tower: August - Air Temperature (degrees C)



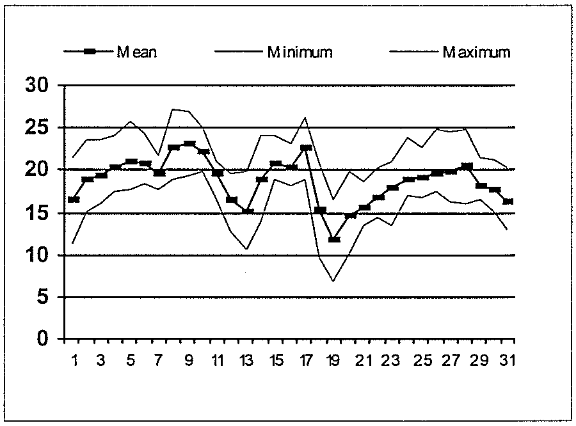
PMRC Tower: September - Air Temperature (degrees C)



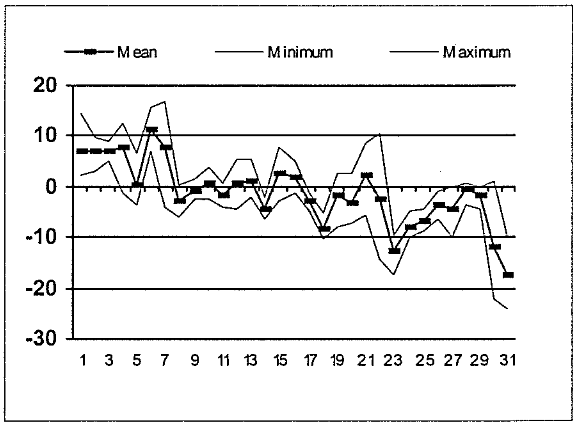
PMRC Tower: October - Air Temperature (degrees C)



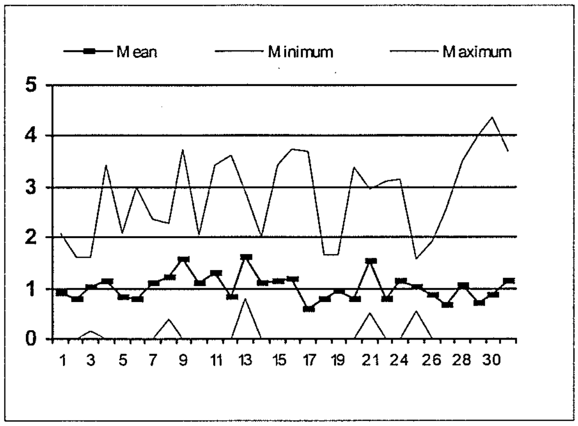
PMRC Tower: November - Air Temperature (degrees C)



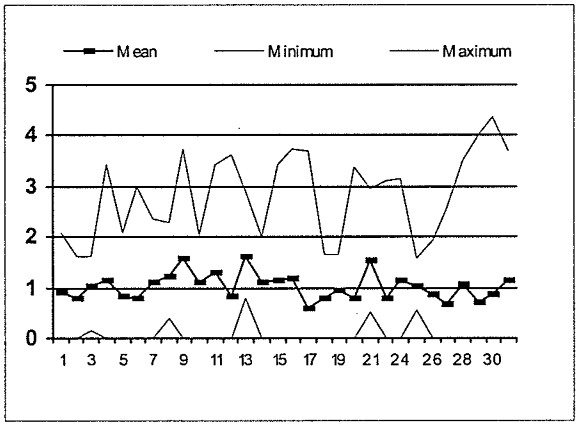
PMRC Tower: December - Air Temperature (degrees C)



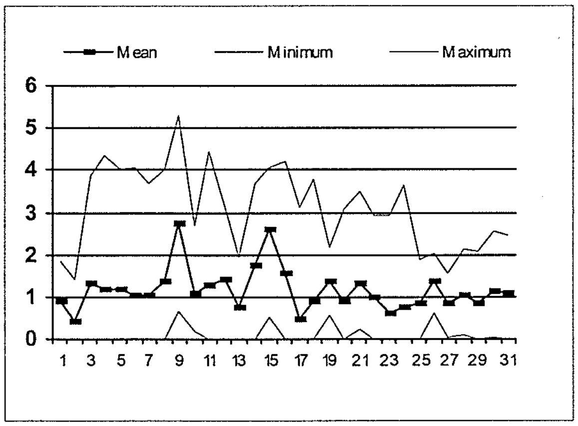
PMRC Tower: January - Horizontal Wind Speed (ms)



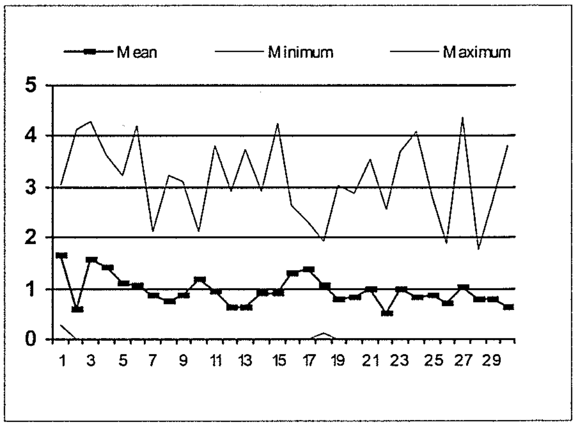
PMRC Tower: February - Horizontal Wind Speed (ms)



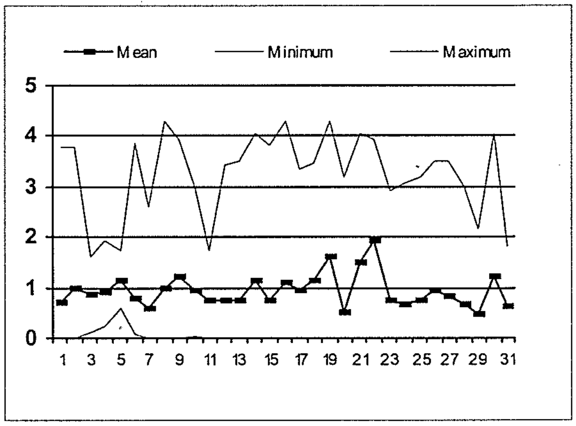
PMRC Tower: March - Horizontal Wind Speed (ms)



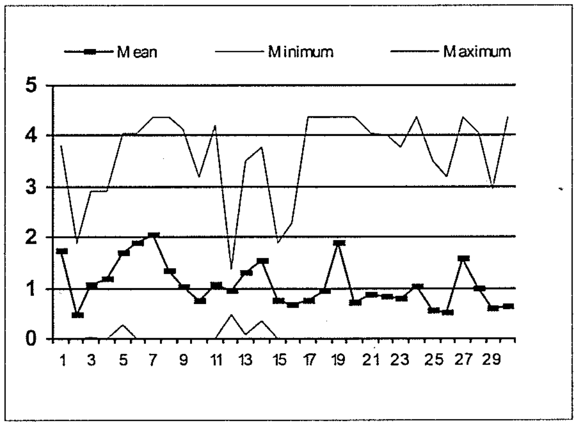
PMRC Tower: April - Horizontal Wind Speed (ms)



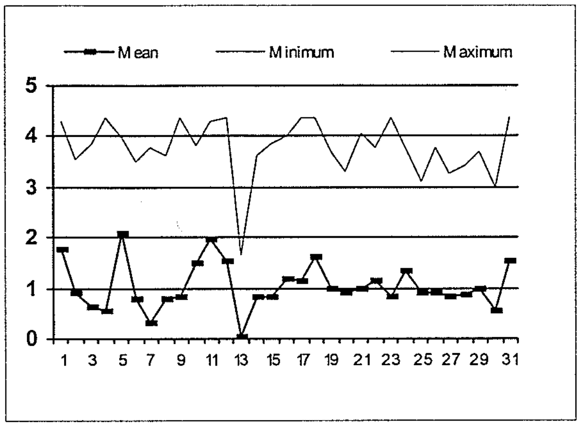
PMRC Tower: May - Horizontal Wind Speed (ms)



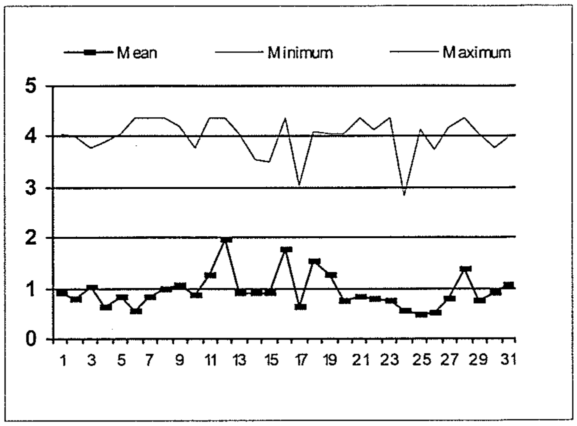
PMRC Tower: June - Horizontal Wind Speed (ms)



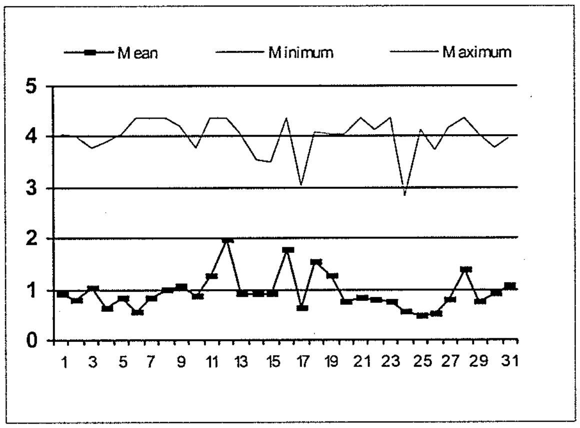
PMRC Tower: July - Horizontal Wind Speed (ms)



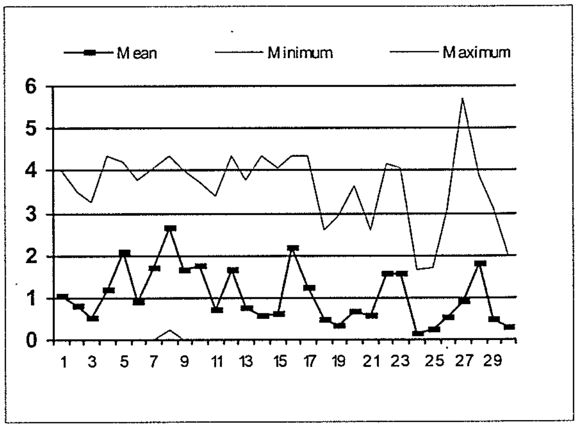
PMRC Tower: October - Horizontal Wind Speed (ms)



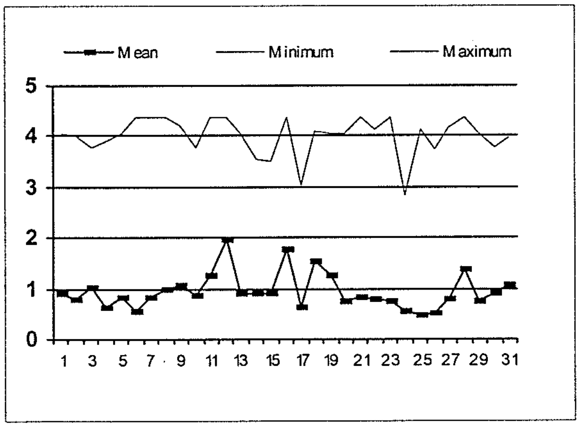
PMRC Tower: August - Horizontal Wind Speed (ms)



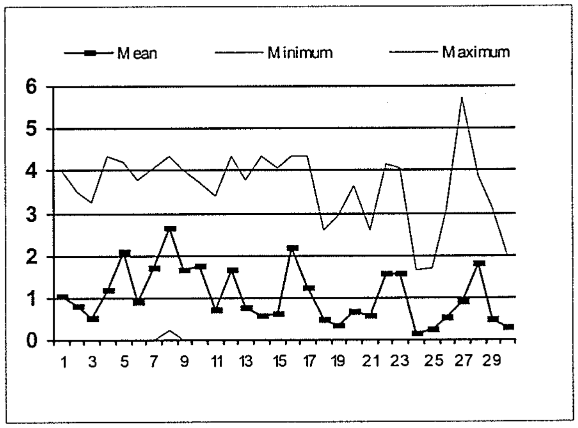
PMRC Tower: November - Horizontal Wind Speed (ms)



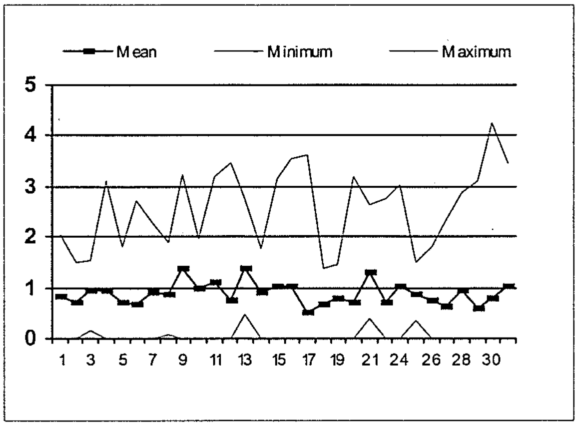
PMRC Tower: September - Horizontal Wind Speed (ms)



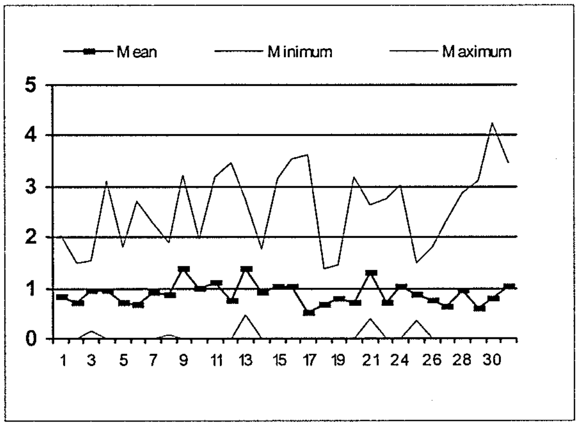
PMRC Tower: December - Horizontal Wind Speed (ms)



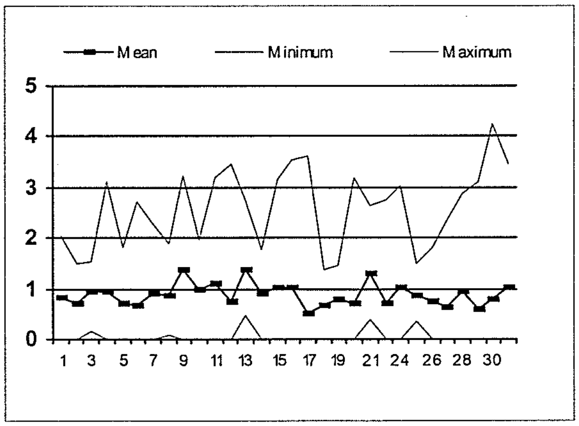
PMRC Tower: January - Resultant Wind Speed (m/s)



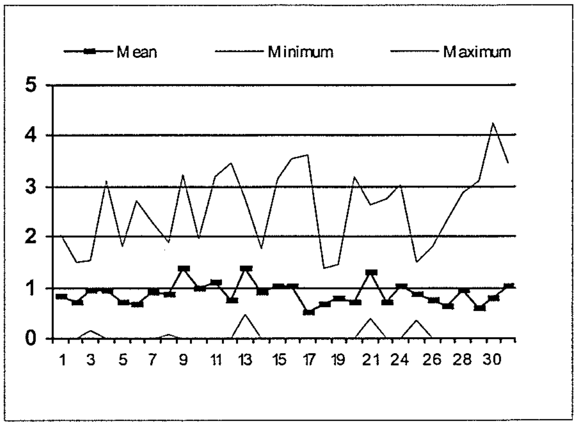
PMRC Tower: February - Resultant Wind Speed (m/s)



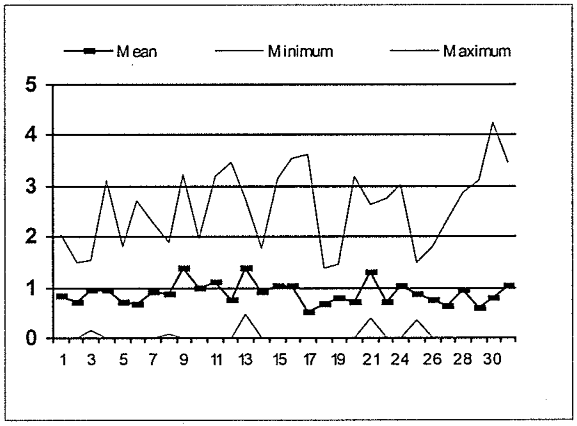
PMRC Tower: March - Resultant Wind Speed (m/s)



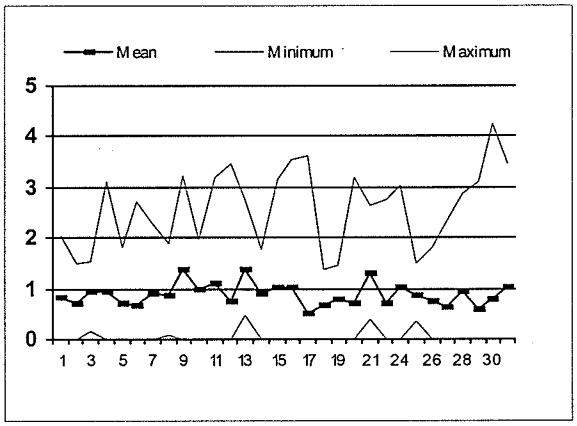
PMRC Tower: April - Resultant Wind Speed (m/s)



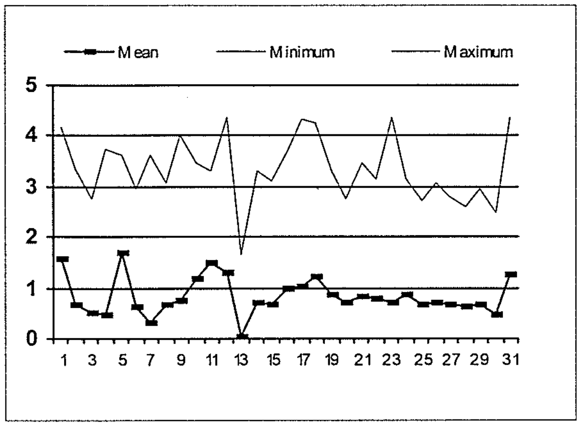
PMRC Tower: May - Resultant Wind Speed (m/s)



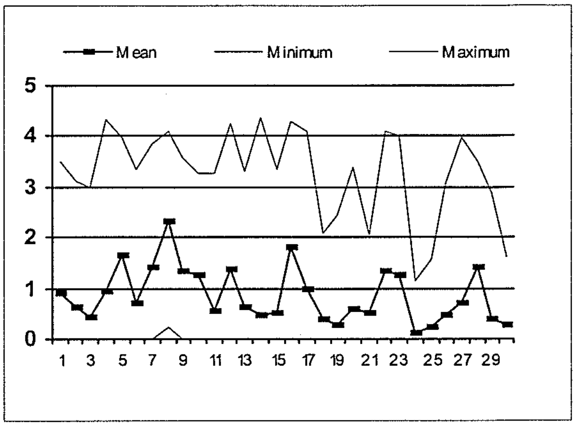
PMRC Tower: June - Resultant Wind Speed (m/s)



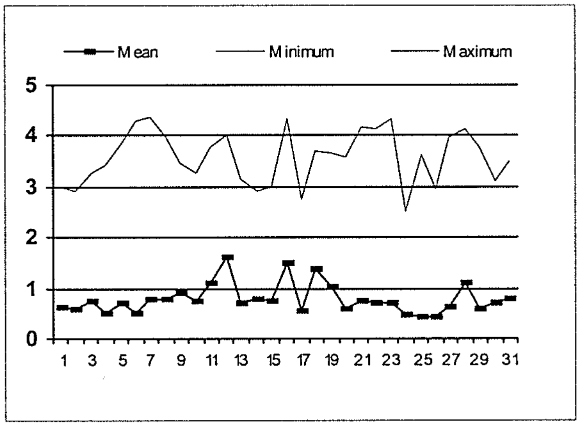
PMRC Tower: July - Resultant Wind Speed (m/s)



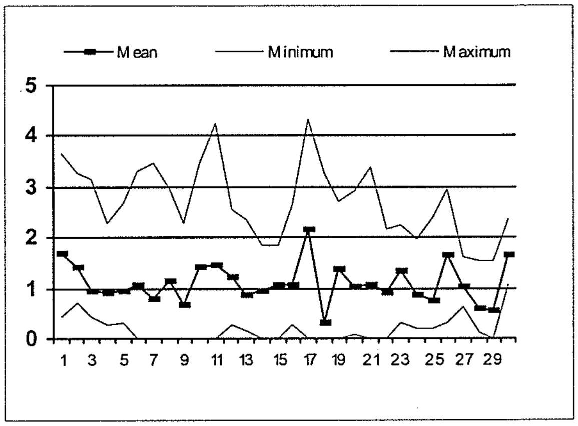
PMRC Tower: October - Resultant Wind Speed (m/s)



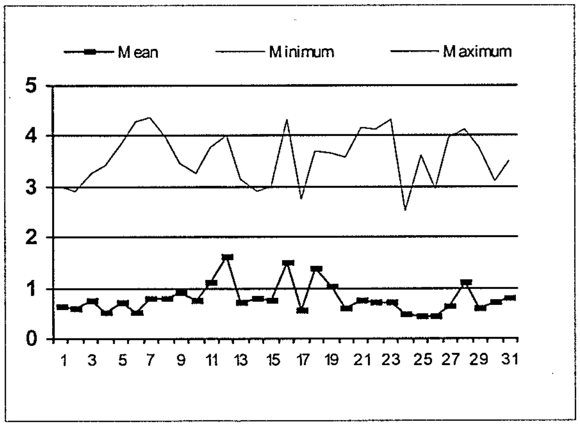
PMRC Tower: August - Resultant Wind Speed (m/s)



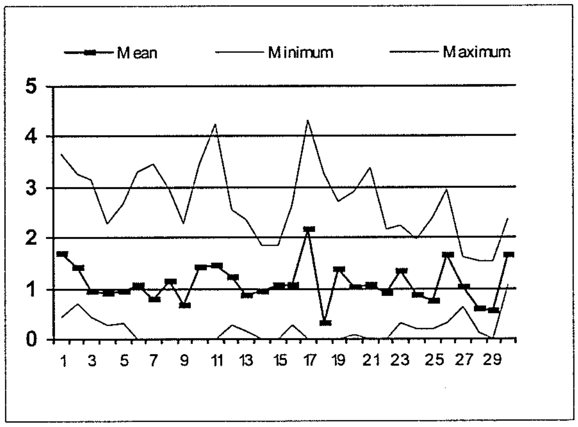
PMRC Tower: November - Resultant Wind Speed (m/s)



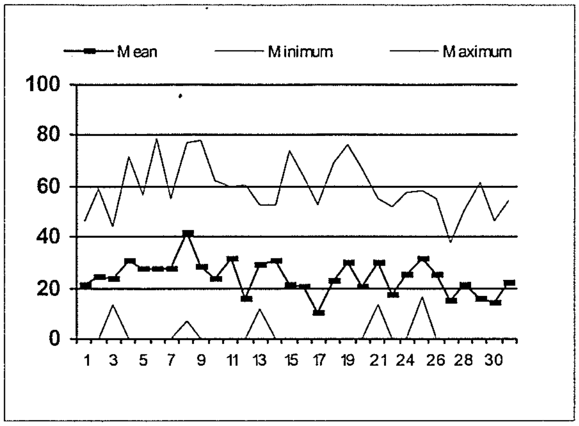
PMRC Tower: September - Resultant Wind Speed (m/s)



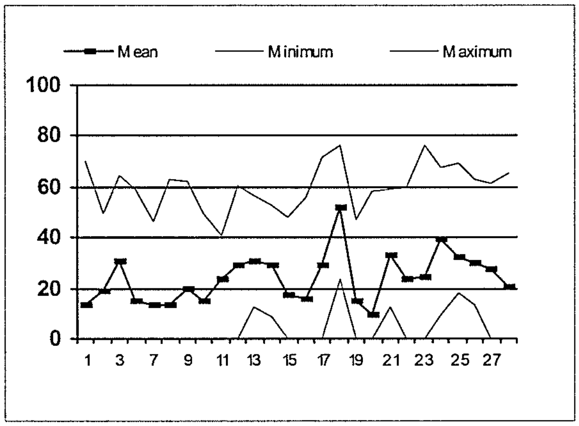
PMRC Tower: December - Resultant Wind Speed (m/s)



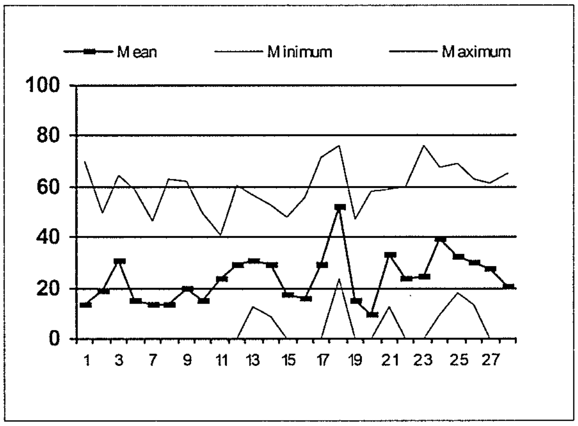
PMRC Tower: January - Stand Deviation Wind Direction



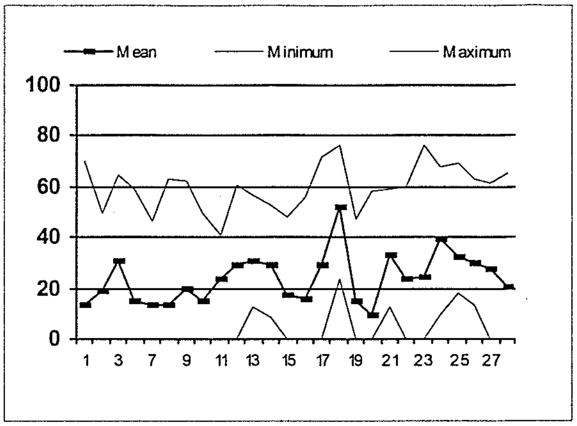
PMRC Tower: February - Stand Deviation Wind Direction



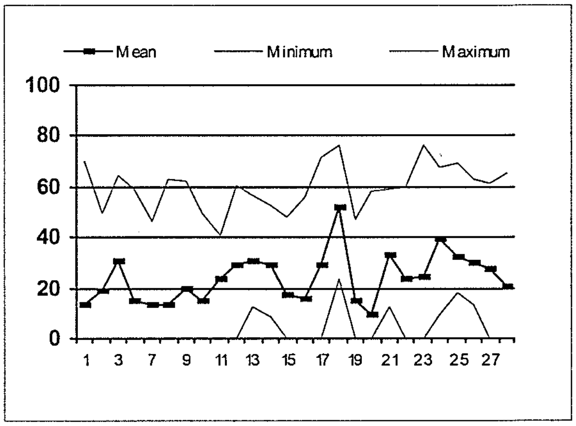
PMRC Tower: March - Stand Deviation Wind Direction



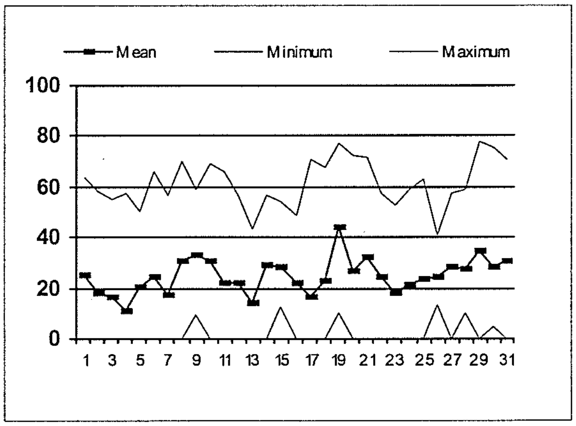
PMRC Tower: April - Stand Deviation Wind Direction



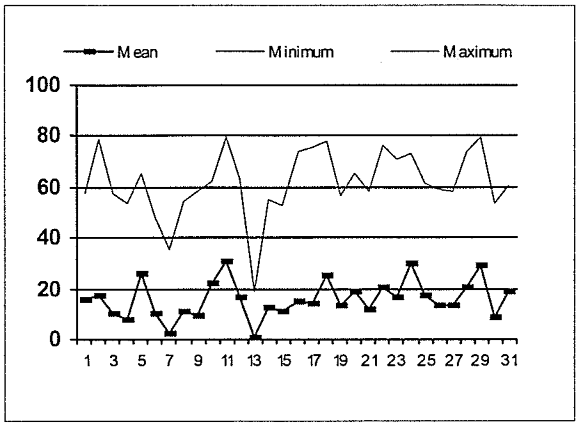
PMRC Tower: May - Stand Deviation Wind Direction



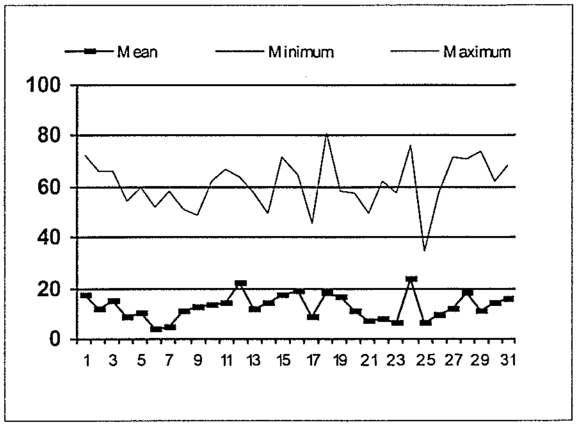
PMRC Tower: June - Stand Deviation Wind Direction



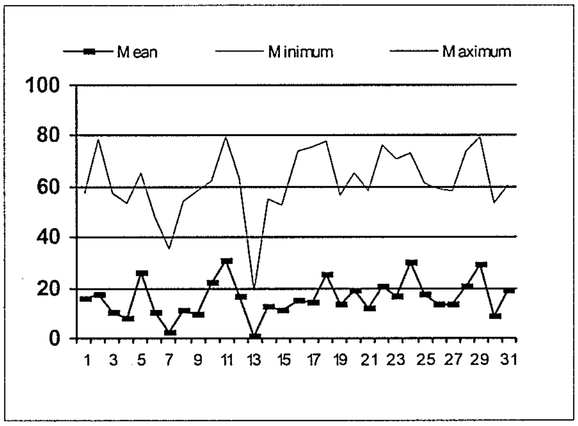
PMRC Tower: July - Stand Deviation Wind Direction



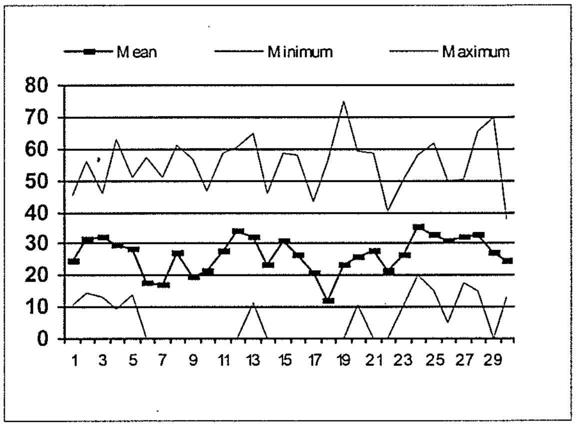
PMRC Tower: October - Stand Deviation Wind Direction



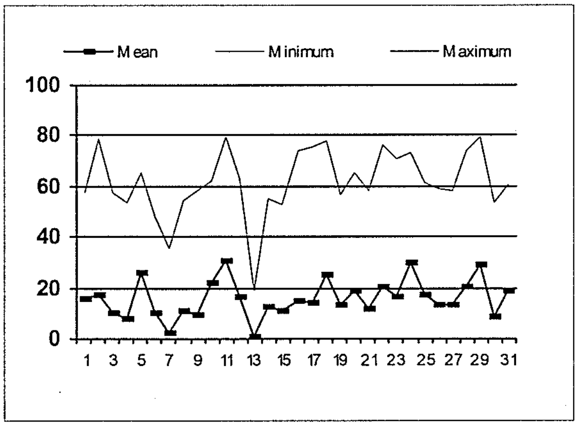
PMRC Tower: August - Stand Deviation Wind Direction



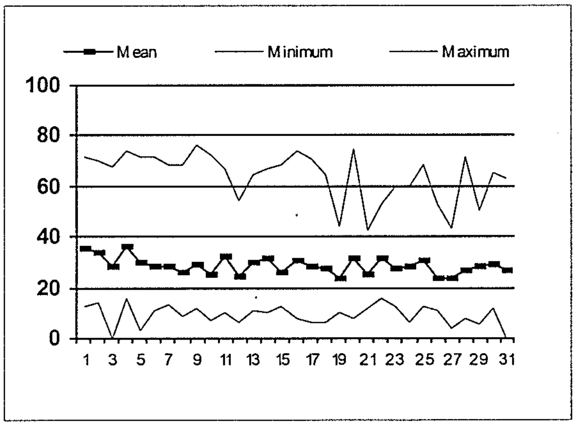
PMRC Tower: November - Stand Deviation Wind Direction



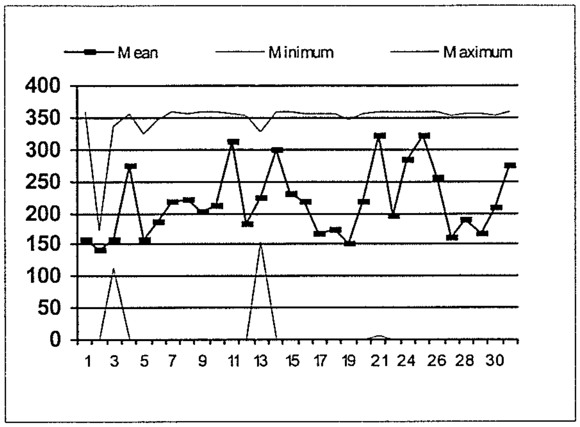
PMRC Tower: September - Stand Deviation Wind Direction



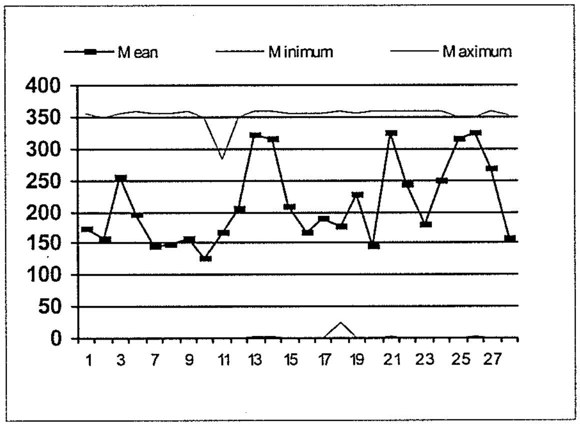
PMRC Tower: December - Stand Deviation Wind Direction



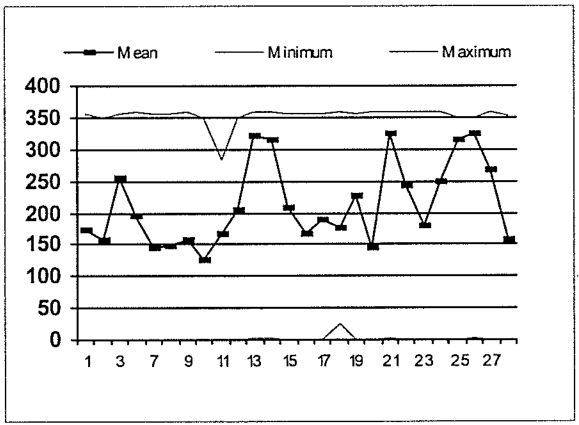
PMRC Tower: January - Wind Direction (degrees)



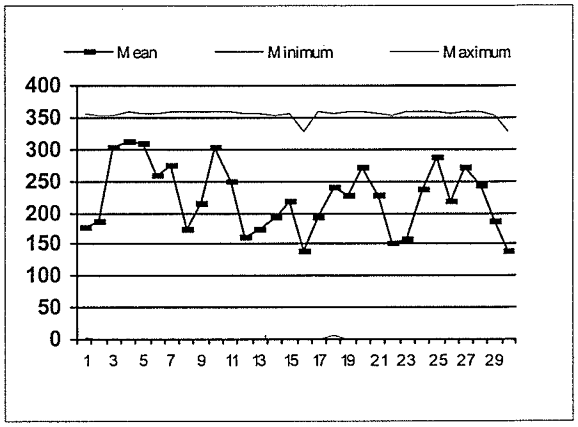
PMRC Tower: February - Wind Direction (degrees)



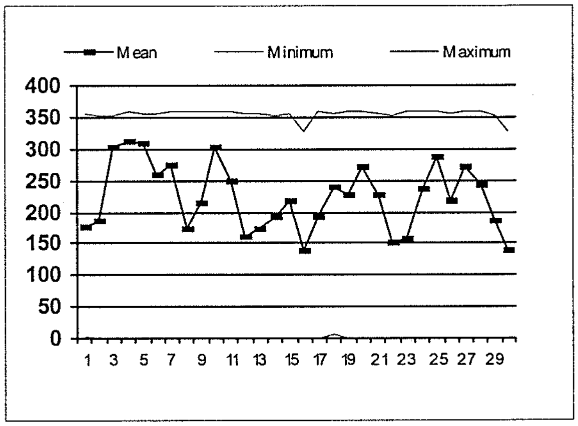
PMRC Tower: March - Wind Direction (degrees)



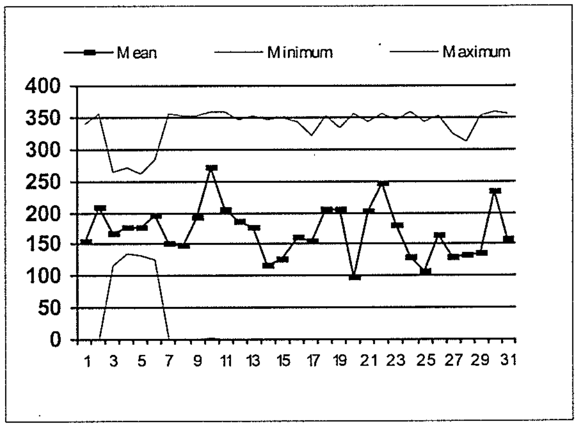
PMRC Tower: April - Wind Direction (degrees)



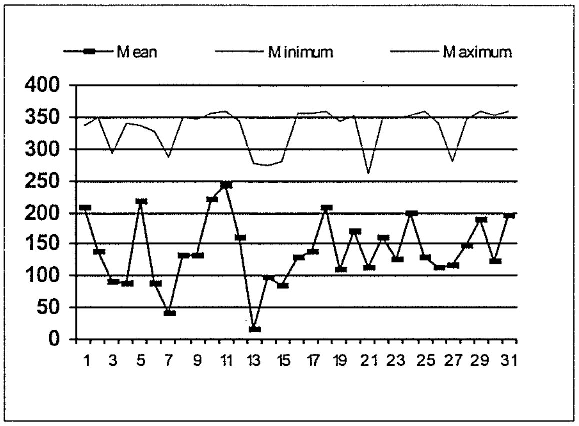
PMRC Tower: May - Wind Direction (degrees)



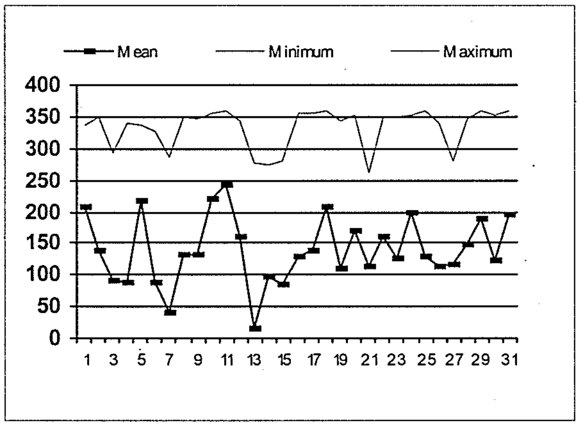
PMRC Tower: June - Wind Direction (degrees)



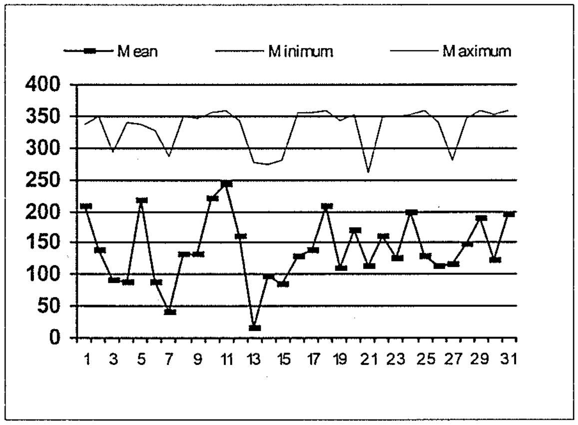
PMRC Tower: July - Wind Direction (degrees)



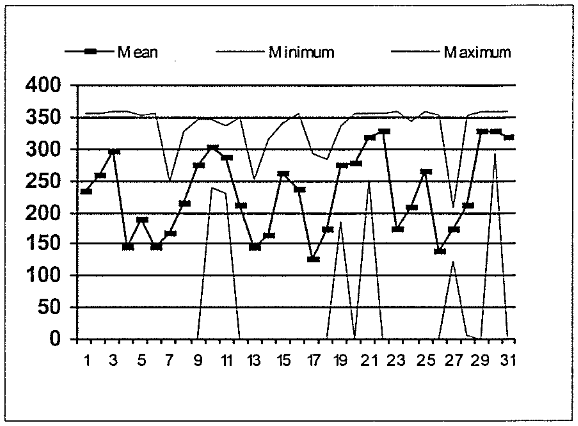
PMRC Tower: August - Wind Direction (degrees)



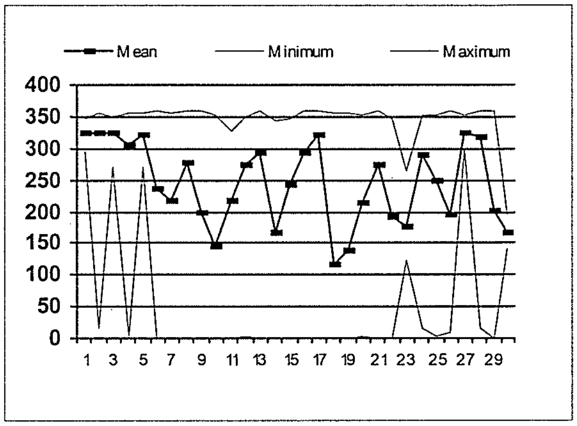
PMRC Tower: September - Wind Direction (degrees)



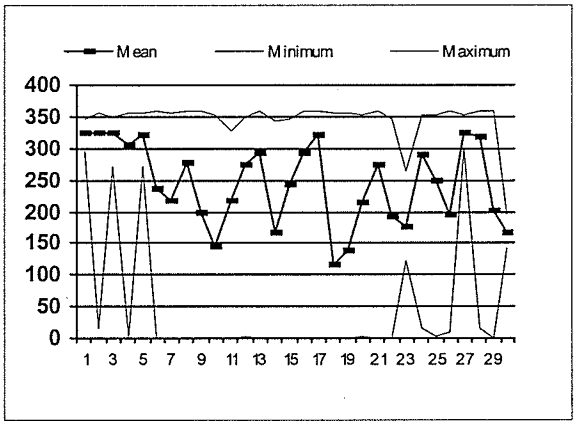
PMRC Tower: October - Wind Direction (degrees)



PMRC Tower: November - Wind Direction (degrees)

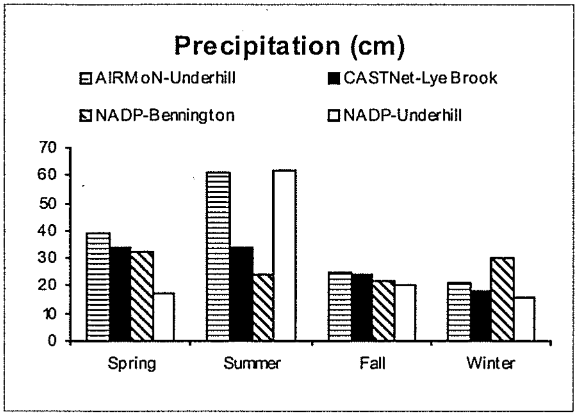


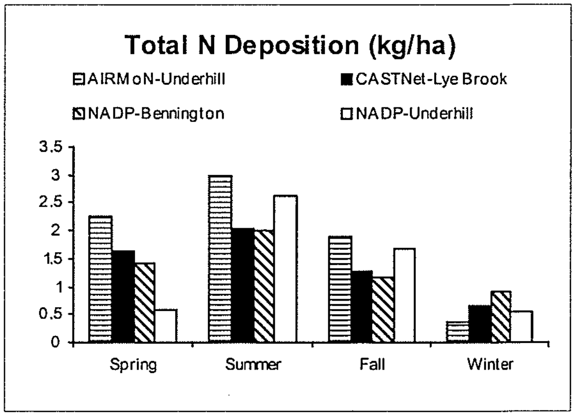
PMRC Tower: December - Wind Direction (degrees)



Appendix B
Precipitation Chemistry

Seasonal Wet Deposition: Precipitation, Total Nitrogen and Sulfur Deposition 1998

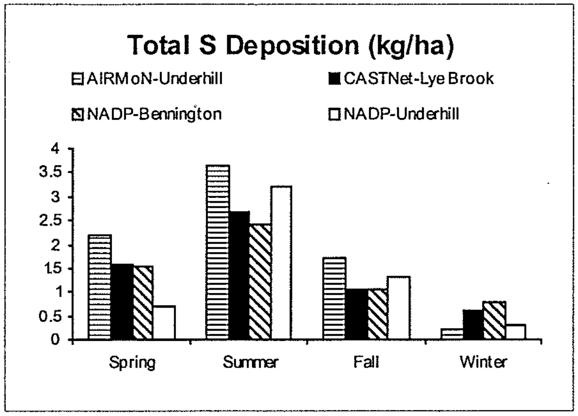




		Precipitation (cm)		
Season	**Location**	**Current Year**	**Period of Record Average**	Years of Data
Spring	AIRMoN-Underhill	39.37	28.54	4
Spring	CASTNet-Lye Brook	34.11	23.16	3
Spring	NADP-Bennington	32.62	25.59	13
Spring	NADP-Underhill	17.04	26.23	13
Summer	AIRMoN-Underhill	61.04	42.21	4
Summer	CASTNet-Lye Brook	33.66	30.61	3
Summer	NADP-Bennington	24.14	24.94	13
Summer	NADP-Underhill	61.57	32.72	13
Fall	AIRMoN-Underhill	24.73	28.44	4
Fall	CASTNet-Lye Brook	23.85	28.81	3
Fall	NADP-Bennington	21.67	25.10	13
Fall	NADP-Underhill	20.07	25.98	13
Winter	AIRMoN-Underhill	21.17	16.93	4
Winter	CASTNet-Lye Brook	17.96	22.45	3
Winter	NADP-Bennington	30.43	18.39	13
Winter	NADP-Underhill	15.91	16.21	13

		Total N Deposition (kg/ha)		
Season	**Location**	**Current Year**	**Period of Record Average**	Years of Data
Spring	AIRMoN-Underhill	2.26	1.83	4
Spring	CASTNet-Lye Brook	1.64	1.58	3
Spring	NADP-Bennington	1.43	1.61	13
Spring	NADP-Underhill	0.59	1.41	13
Summer	AIRMoN-Underhill	2.99	2.12	4
Summer	CASTNet-Lye Brook	2.03	1.68	3
Summer	NADP-Bennington	1.99	1.53	13
Summer	NADP-Underhill	2.62	1.50	13
Fall	AIRMoN-Underhill	1.88	1.25	4
Fall	CASTNet-Lye Brook	1.28	1.08	3
Fall	NADP-Bennington	1.16	1.03	13
Fall	NADP-Underhill	1.68	1.16	13
Winter	AIRMoN-Underhill	0.37	0.68	4
Winter	CASTNet-Lye Brook	0.65	0.88	3
Winter	NADP-Bennington	0.91	0.89	13
Winter	NADP-Underhill	0.55	0.87	13

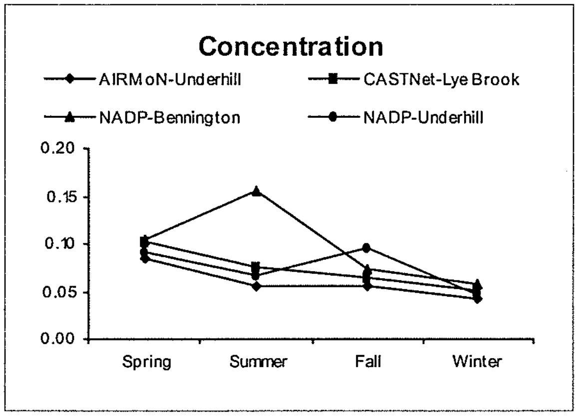
Seasonal Wet Deposition: Precipitation, Total Nitrogen and Sulfur Deposition 1998

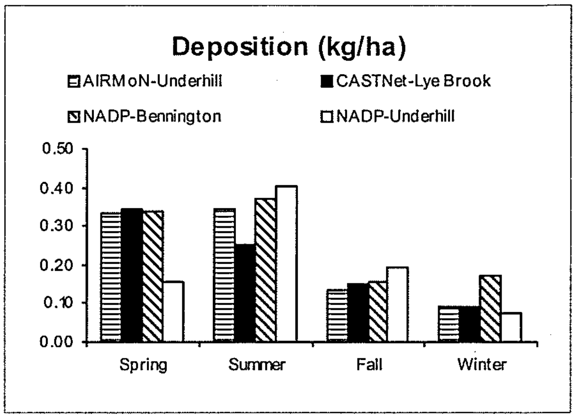


Season	Location	Total S Deposition (kg/ha) Current Year	Total S Deposition (kg/ha) Period of Record Average	Years of Data
Spring	AIRMoN-Underhill	2.22	1.92	4
Spring	CASTNet-Lye Brook	1.58	1.51	3
Spring	NADP-Bennington	1.53	1.89	13
Spring	NADP-Underhill	0.68	1.62	13
Summer	AIRMoN-Underhill	3.67	2.81	4
Summer	CASTNet-Lye Brook	2.70	2.21	3
Summer	NADP-Bennington	2.41	2.39	13
Summer	NADP-Underhill	3.22	2.28	13
Fall	AIRMoN-Underhill	1.69	1.00	4
Fall	CASTNet-Lye Brook	1.05	0.98	3
Fall	NADP-Bennington	1.04	1.10	13
Fall	NADP-Underhill	1.31	1.13	13
Winter	AIRMoN-Underhill	0.24	0.46	4
Winter	CASTNet-Lye Brook	0.62	0.83	3
Winter	NADP-Bennington	0.78	0.75	13
Winter	NADP-Underhill	0.32	0.58	13

Seasonal Wet Deposition by Chemical 1998

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

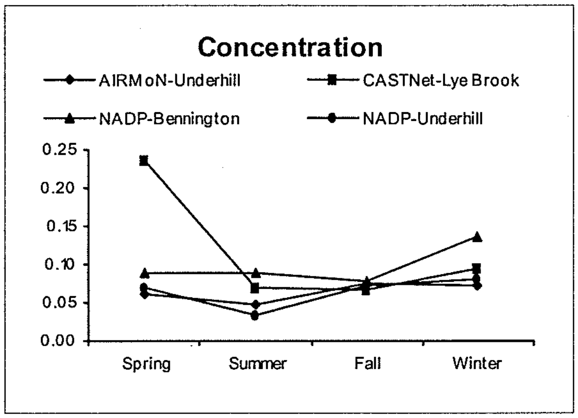


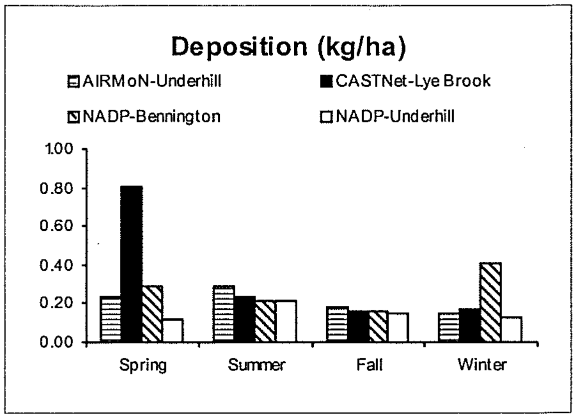


		Concentration		Deposition (kg/ha)		
Season	Location	Current Year	Period of Record Average	Current Year	Period of Record Average	Years of Data
Spring	AIRMoN-Underhill	0.09	0.09	0.33	0.29	4
Spring	CASTNet-Lye Brook	0.10	0.12	0.35	0.29	3
Spring	NADP-Bennington	0.10	0.13	0.34	0.31	13
Spring	NADP-Underhill	0.09	0.11	0.16	0.28	13
Summer	AIRMoN-Underhill	0.06	0.07	0.35	0.27	4
Summer	CASTNet-Lye Brook	0.07	0.08	0.25	0.23	3
Summer	NADP-Bennington	0.15	0.09	0.37	0.22	13
Summer	NADP-Underhill	0.07	0.08	0.40	0.25	13
Fall	AIRMoN-Underhill	0.06	0.05	0.14	0.12	4
Fall	CASTNet-Lye Brook	0.06	0.05	0.15	0.12	3
Fall	NADP-Bennington	0.07	0.09	0.16	0.23	13
Fall	NADP-Underhill	0.10	0.06	0.19	0.16	13
Winter	AIRMoN-Underhill	0.04	0.05	0.09	0.07	4
Winter	CASTNet-Lye Brook	0.05	0.06	0.09	0.13	3
Winter	NADP-Bennington	0.06	0.09	0.17	0.17	13
Winter	NADP-Underhill	0.05	0.06	0.08	0.10	13

Seasonal Wet Deposition by Chemical 1998

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

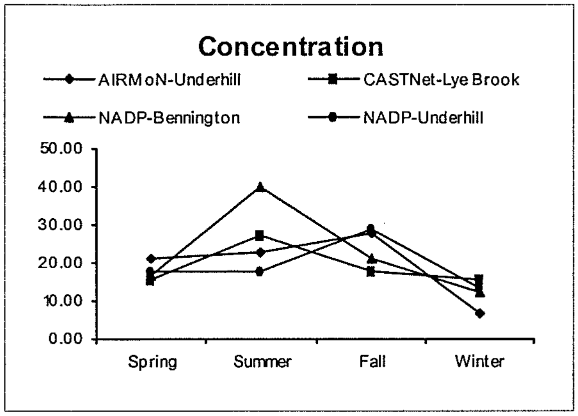




		Concentration		Deposition (kg/ha)		
Season	**Location**	**Current Year**	**Period of Record Average**	**Current Year**	**Period of Record Average**	**Years of Data**
Spring	AIRMoN-Underhill	0.06	0.07	0.24	0.19	4
Spring	CASTNet-Lye Brook	0.24	0.16	0.80	0.41	3
Spring	NADP-Bennington	0.09	0.12	0.29	0.31	13
Spring	NADP-Underhill	0.07	0.08	0.12	0.22	13
Summer	AIRMoN-Underhill	0.05	0.05	0.29	0.22	4
Summer	CASTNet-Lye Brook	0.07	0.07	0.23	0.20	3
Summer	NADP-Bennington	0.09	0.09	0.21	0.23	13
Summer	NADP-Underhill	0.03	0.06	0.21	0.19	13
Fall	AIRMoN-Underhill	0.07	0.05	0.18	0.14	4
Fall	CASTNet-Lye Brook	0.07	0.07	0.16	0.22	3
Fall	NADP-Bennington	0.08	0.13	0.17	0.33	13
Fall	NADP-Underhill	0.07	0.08	0.15	0.19	13
Winter	AIRMoN-Underhill	0.07	0.12	0.15	0.16	4
Winter	CASTNet-Lye Brook	0.10	0.10	0.17	0.25	3
Winter	NADP-Bennington	0.14	0.20	0.41	0.36	13
Winter	NADP-Underhill	0.08	0.11	0.13	0.17	13

Seasonal Wet Deposition by Chemical 1998

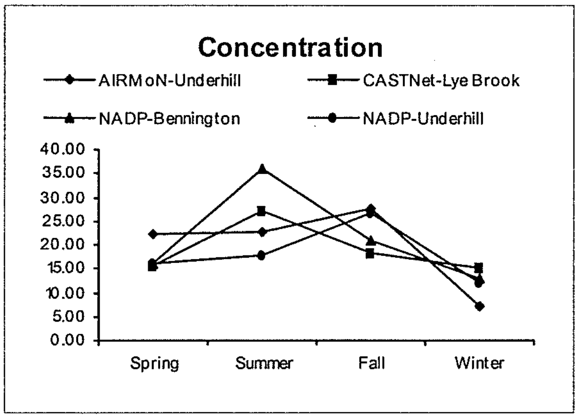
Chemical: Cond-field **Concentration Units:** uS/cm



		Concentration		Deposition (kg/ha)		
Season	Location	Current Year	Period of Record Average	Current Year	Period of Record Average	Years of Data
Spring	AIRMoN-Underhill	20.90	23.05			4
Spring	CASTNet-Lye Brook	15.43	25.65			3
Spring	NADP-Bennington	16.42	27.02			13
Spring	NADP-Underhill	17.53	21.57			13
Summer	AIRMoN-Underhill	22.74	23.14			4
Summer	CASTNet-Lye Brook	27.37	23.94			3
Summer	NADP-Bennington	40.12	34.78			13
Summer	NADP-Underhill	17.75	21.60			13
Fall	AIRMoN-Underhill	27.54	17.02			4
Fall	CASTNet-Lye Brook	17.87	14.91			3
Fall	NADP-Bennington	20.85	19.33			13
Fall	NADP-Underhill	28.71	18.99			13
Winter	AIRMoN-Underhill	6.62	15.81			4
Winter	CASTNet-Lye Brook	15.33	16.11			3
Winter	NADP-Bennington	12.41	21.39			13
Winter	NADP-Underhill	13.15	21.08			13

Seasonal Wet Deposition by Chemical 1998

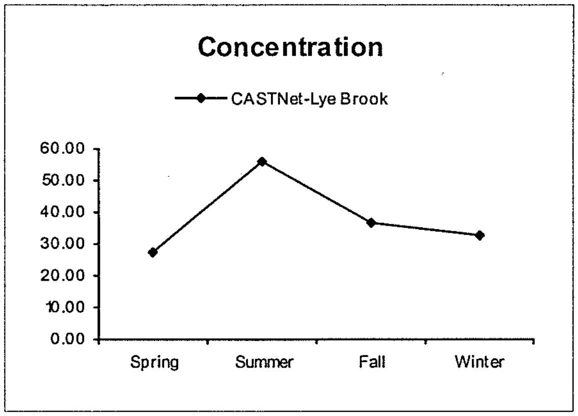
Chemical: Cond-lab **Concentration Units:** uS/cm



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	22.41	23.72			4
Spring	CASTNet-Lye Brook	15.36	25.41			3
Spring	NADP-Bennington	16.07	25.85			13
Spring	NADP-Underhill	15.99	20.04			13
Summer	AIRMoN-Underhill	22.57	23.32			4
Summer	CASTNet-Lye Brook	27.14	23.82			3
Summer	NADP-Bennington	36.20	30.19			13
Summer	NADP-Underhill	17.72	22.05			13
Fall	AIRMoN-Underhill	27.34	17.94			4
Fall	CASTNet-Lye Brook	18.25	14.87			3
Fall	NADP-Bennington	20.78	18.27			13
Fall	NADP-Underhill	26.85	18.28			13
Winter	AIRMoN-Underhill	7.23	17.45			4
Winter	CASTNet-Lye Brook	15.03	15.95			3
Winter	NADP-Bennington	13.02	19.24			13
Winter	NADP-Underhill	11.98	19.90			13

Seasonal Wet Deposition by Chemical 1998

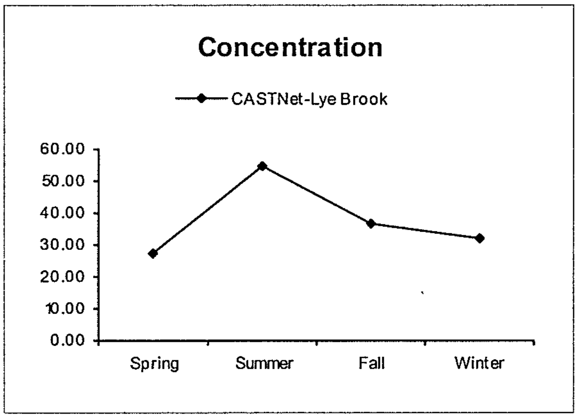
Chemical: H **Concentration Units:** ueq/l



		Concentration		Deposition (kg/ha)		
Season	**Location**	**Current Year**	**Period of Record Average**	**Current Year**	**Period of Record Average**	**Years of Data**
Spring	CASTNet-Lye Brook	27.30	49.19			3
Summer	CASTNet-Lye Brook	56.13	47.97			3
Fall	CASTNet-Lye Brook	36.70	30.94			3
Winter	CASTNet-Lye Brook	32.50	35.92			3

Seasonal Wet Deposition by Chemical 1998

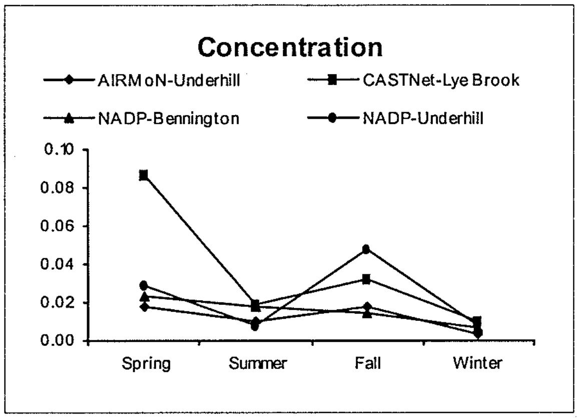
Chemical: H unfiltered **Concentration Units:** ueq/l

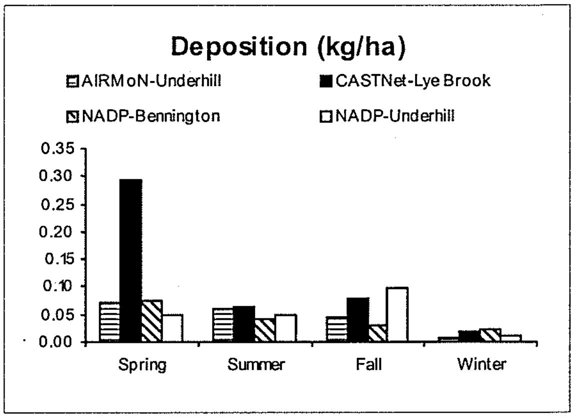


Season	Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
Spring	CASTNet-Lye Brook	27.46	49.39			3
Summer	CASTNet-Lye Brook	54.94	48.24			3
Fall	CASTNet-Lye Brook	36.82	31.14			3
Winter	CASTNet-Lye Brook	32.13	36.84			3

Seasonal Wet Deposition by Chemical 1998

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

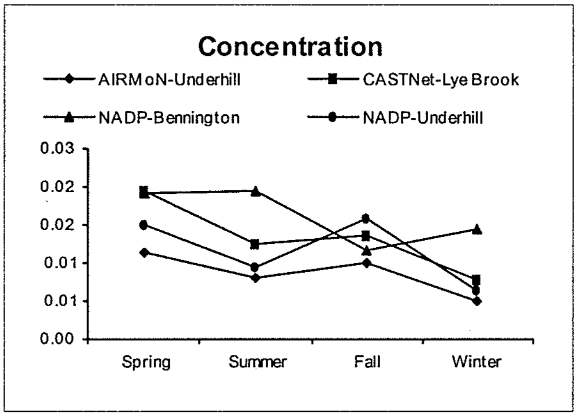


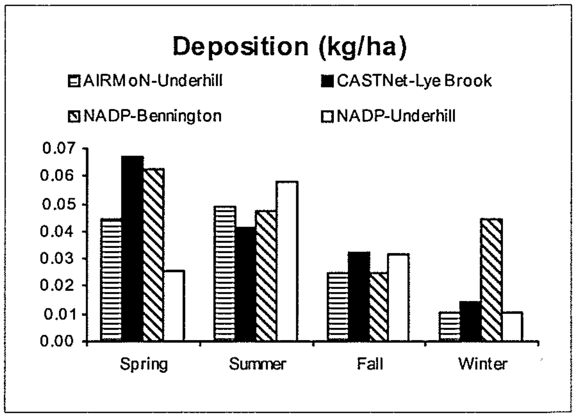


		Concentration		Deposition (kg/ha)		
Season	**Location**	**Current Year**	**Period of Record Average**	**Current Year**	**Period of Record Average**	**Years of Data**
Spring	AIRMoN-Underhill	0.02	0.02	0.07	0.06	4
Spring	CASTNet-Lye Brook	0.09	0.06	0.30	0.14	3
Spring	NADP-Bennington	0.02	0.03	0.08	0.06	13
Spring	NADP-Underhill	0.03	0.02	0.05	0.05	13
Summer	AIRMoN-Underhill	0.01	0.01	0.06	0.05	4
Summer	CASTNet-Lye Brook	0.02	0.02	0.06	0.07	3
Summer	NADP-Bennington	0.02	0.01	0.04	0.03	13
Summer	NADP-Underhill	0.01	0.02	0.05	0.05	13
Fall	AIRMoN-Underhill	0.02	0.01	0.04	0.03	4
Fall	CASTNet-Lye Brook	0.03	0.03	0.08	0.10	3
Fall	NADP-Bennington	0.01	0.02	0.03	0.05	13
Fall	NADP-Underhill	0.05	0.02	0.10	0.06	13
Winter	AIRMoN-Underhill	0.00	0.01	0.01	0.01	4
Winter	CASTNet-Lye Brook	0.01	0.01	0.02	0.02	3
Winter	NADP-Bennington	0.01	0.01	0.02	0.02	13
Winter	NADP-Underhill	0.01	0.01	0.01	0.02	13

Seasonal Wet Deposition by Chemical 1998

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

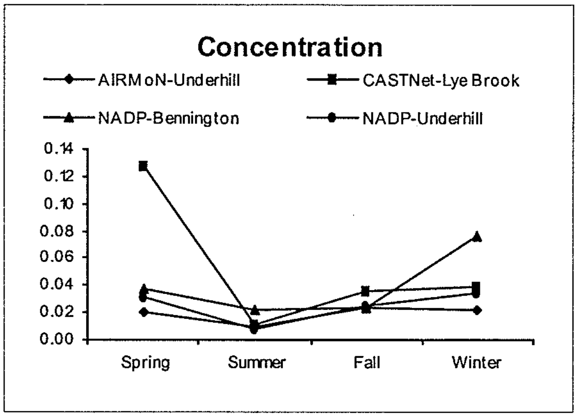


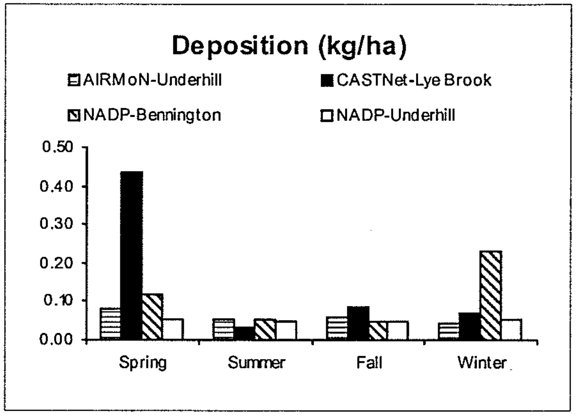


		Concentration		Deposition (kg/ha)		
Season	**Location**	**Current Year**	**Period of Record Average**	**Current Year**	**Period of Record Average**	**Years of Data**
Spring	AIRMoN-Underhill	0.01	0.01	0.04	0.04	4
Spring	CASTNet-Lye Brook	0.02	0.03	0.07	0.06	3
Spring	NADP-Bennington	0.02	0.03	0.06	0.06	13
Spring	NADP-Underhill	0.02	0.02	0.03	0.05	13
Summer	AIRMoN-Underhill	0.01	0.01	0.05	0.04	4
Summer	CASTNet-Lye Brook	0.01	0.01	0.04	0.04	3
Summer	NADP-Bennington	0.02	0.02	0.05	0.04	13
Summer	NADP-Underhill	0.01	0.01	0.06	0.04	13
Fall	AIRMoN-Underhill	0.01	0.01	0.02	0.02	4
Fall	CASTNet-Lye Brook	0.01	0.01	0.03	0.03	3
Fall	NADP-Bennington	0.01	0.02	0.03	0.05	13
Fall	NADP-Underhill	0.02	0.01	0.03	0.03	13
Winter	AIRMoN-Underhill	0.01	0.01	0.01	0.01	4
Winter	CASTNet-Lye Brook	0.01	0.01	0.01	0.03	3
Winter	NADP-Bennington	0.01	0.02	0.04	0.04	13
Winter	NADP-Underhill	0.01	0.01	0.01	0.02	13

Seasonal Wet Deposition by Chemical 1998

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

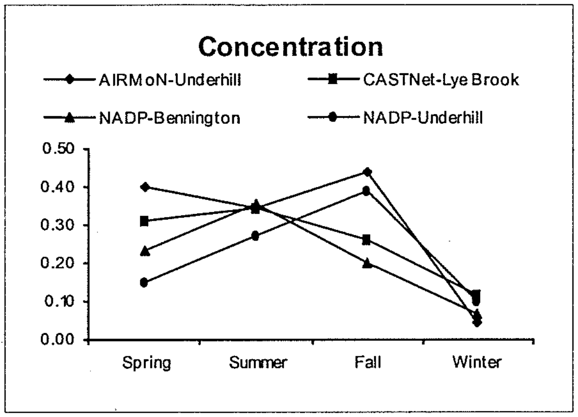


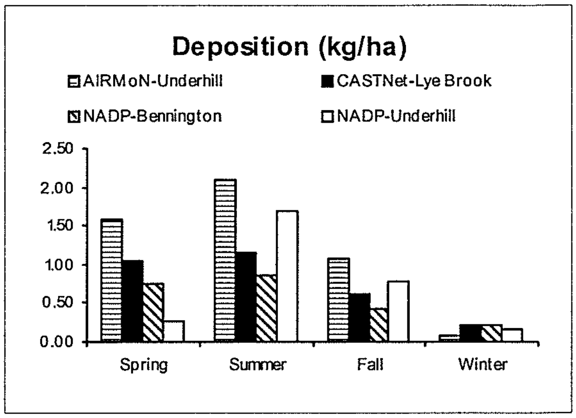


Season	Location	Concentration Current Year	Concentration Period of Record Average	Deposition (kg/ha) Current Year	Deposition (kg/ha) Period of Record Average	Years of Data
Spring	AIRMoN-Underhill	0.02	0.02	0.08	0.06	4
Spring	CASTNet-Lye Brook	0.13	0.07	0.44	0.19	3
Spring	NADP-Bennington	0.04	0.06	0.12	0.15	13
Spring	NADP-Underhill	0.03	0.04	0.05	0.12	13
Summer	AIRMoN-Underhill	0.01	0.01	0.05	0.05	4
Summer	CASTNet-Lye Brook	0.01	0.02	0.03	0.05	3
Summer	NADP-Bennington	0.02	0.04	0.05	0.09	13
Summer	NADP-Underhill	0.01	0.03	0.05	0.09	13
Fall	AIRMoN-Underhill	0.02	0.02	0.06	0.05	4
Fall	CASTNet-Lye Brook	0.04	0.03	0.09	0.09	3
Fall	NADP-Bennington	0.02	0.08	0.05	0.19	13
Fall	NADP-Underhill	0.02	0.04	0.05	0.10	13
Winter	AIRMoN-Underhill	0.02	0.05	0.05	0.06	4
Winter	CASTNet-Lye Brook	0.04	0.05	0.07	0.13	3
Winter	NADP-Bennington	0.08	0.12	0.23	0.22	13
Winter	NADP-Underhill	0.03	0.06	0.05	0.09	13

Seasonal Wet Deposition by Chemical 1998

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

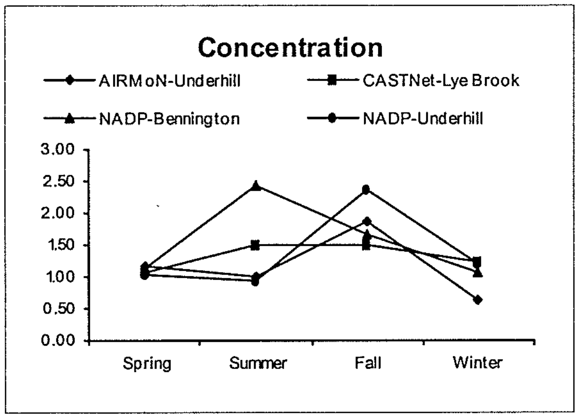


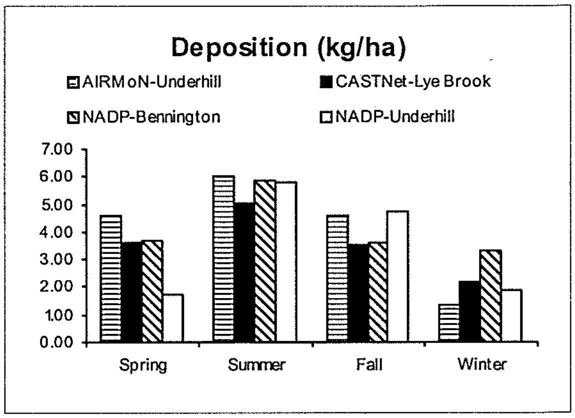


		Concentration		Deposition (kg/ha)		
Season	**Location**	**Current Year**	**Period of Record Average**	**Current Year**	**Period of Record Average**	**Years of Data**
Spring	AIRMoN-Underhill	0.40	0.38	1.58	1.14	4
Spring	CASTNet-Lye Brook	0.31	0.45	1.06	0.91	3
Spring	NADP-Bennington	0.23	0.32	0.75	0.77	13
Spring	NADP-Underhill	0.15	0.28	0.26	0.74	13
Summer	AIRMoN-Underhill	0.34	0.34	2.09	1.43	4
Summer	CASTNet-Lye Brook	0.34	0.31	1.16	0.95	3
Summer	NADP-Bennington	0.36	0.29	0.86	0.75	13
Summer	NADP-Underhill	0.27	0.25	1.68	0.85	13
Fall	AIRMoN-Underhill	0.44	0.23	1.08	0.59	4
Fall	CASTNet-Lye Brook	0.26	0.18	0.62	0.47	3
Fall	NADP-Bennington	0.20	0.14	0.43	0.34	13
Fall	NADP-Underhill	0.39	0.19	0.78	0.48	13
Winter	AIRMoN-Underhill	0.04	0.14	0.09	0.21	4
Winter	CASTNet-Lye Brook	0.11	0.12	0.21	0.28	3
Winter	NADP-Bennington	0.07	0.14	0.21	0.25	13
Winter	NADP-Underhill	0.10	0.16	0.16	0.24	13

Seasonal Wet Deposition by Chemical 1998

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

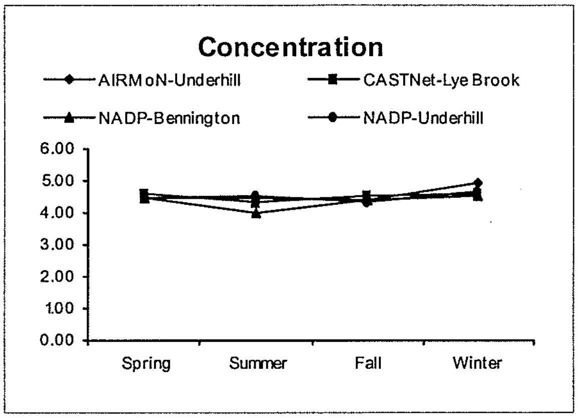




		Concentration		Deposition (kg/ha)		
Season	**Location**	**Current Year**	**Period of Record Average**	**Current Year**	**Period of Record Average**	**Years of Data**
Spring	AIRMoN-Underhill	1.17	1.42	4.60	4.17	4
Spring	CASTNet-Lye Brook	1.06	1.92	3.60	3.84	3
Spring	NADP-Bennington	1.14	1.84	3.72	4.47	13
Spring	NADP-Underhill	1.03	1.41	1.75	3.70	13
Summer	AIRMoN-Underhill	0.99	1.07	6.04	4.48	4
Summer	CASTNet-Lye Brook	1.49	1.37	5.03	4.17	3
Summer	NADP-Bennington	2.43	1.66	5.86	4.18	13
Summer	NADP-Underhill	0.94	1.16	5.78	3.72	13
Fall	AIRMoN-Underhill	1.87	1.34	4.61	3.50	4
Fall	CASTNet-Lye Brook	1.49	1.15	3.55	3.14	3
Fall	NADP-Bennington	1.68	1.37	3.65	3.40	13
Fall	NADP-Underhill	2.37	1.42	4.75	3.49	13
Winter	AIRMoN-Underhill	0.62	1.60	1.32	2.30	4
Winter	CASTNet-Lye Brook	1.22	1.28	2.19	2.95	3
Winter	NADP-Bennington	1.08	1.67	3.29	3.07	13
Winter	NADP-Underhill	1.19	1.95	1.90	3.01	13

Seasonal Wet Deposition by Chemical 1998

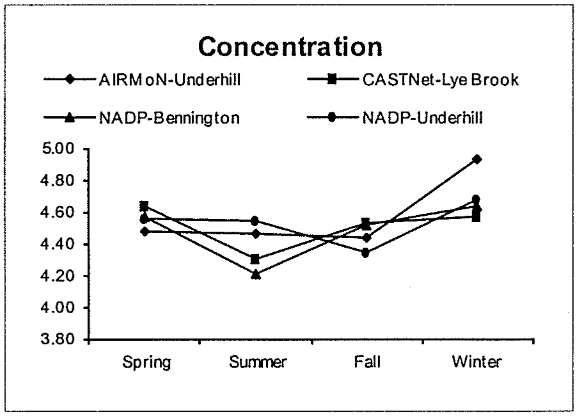
Chemical: pH-field **Concentration Units:**



		Concentration		Deposition (kg/ha)		
Season	**Location**	**Current Year**	**Period of Record Average**	**Current Year**	**Period of Record Average**	**Years of Data**
Spring	AIRMoN-Underhill	4.50	4.45			4
Spring	CASTNet-Lye Brook	4.63	4.38			3
Spring	NADP-Bennington	4.47	4.33			13
Spring	NADP-Underhill	4.50	4.49			13
Summer	AIRMoN-Underhill	4.49	4.45			4
Summer	CASTNet-Lye Brook	4.31	4.41			3
Summer	NADP-Bennington	4.03	4.21			13
Summer	NADP-Underhill	4.56	4.44			13
Fall	AIRMoN-Underhill	4.42	4.64			4
Fall	CASTNet-Lye Brook	4.56	4.60			3
Fall	NADP-Bennington	4.40	4.51			13
Fall	NADP-Underhill	4.35	4.55			13
Winter	AIRMoN-Underhill	4.96	4.59			4
Winter	CASTNet-Lye Brook	4.57	4.50			3
Winter	NADP-Bennington	4.56	4.43			13
Winter	NADP-Underhill	4.65	4.47			13

Seasonal Wet Deposition by Chemical 1998

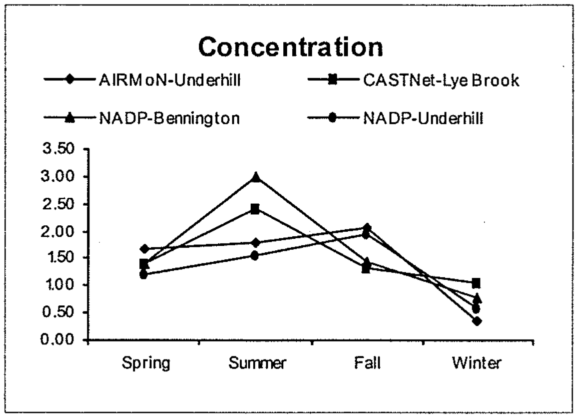
Chemical: pH-lab **Concentration Units:**

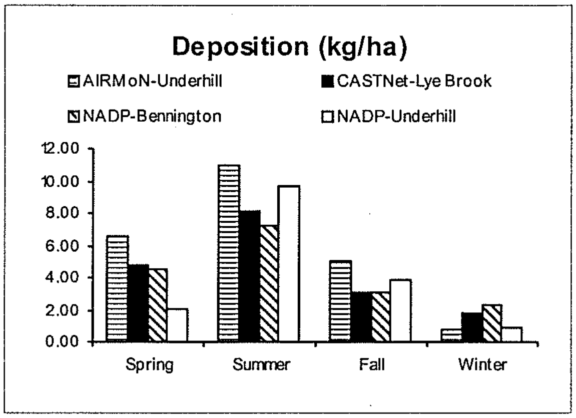


		Concentration		Deposition (kg/ha)		
Season	Location	Current Year	Period of Record Average	Current Year	Period of Record Average	Years of Data
Spring	AIRMoN-Underhill	4.48	4.48			4
Spring	CASTNet-Lye Brook	4.64	4.38			3
Spring	NADP-Bennington	4.58	4.40			13
Spring	NADP-Underhill	4.56	4.54			13
Summer	AIRMoN-Underhill	4.47	4.49			4
Summer	CASTNet-Lye Brook	4.30	4.41			3
Summer	NADP-Bennington	4.21	4.32			13
Summer	NADP-Underhill	4.55	4.44			13
Fall	AIRMoN-Underhill	4.44	4.67			4
Fall	CASTNet-Lye Brook	4.53	4.59			3
Fall	NADP-Bennington	4.51	4.60			13
Fall	NADP-Underhill	4.35	4.57			13
Winter	AIRMoN-Underhill	4.94	4.61			4
Winter	CASTNet-Lye Brook	4.57	4.51			3
Winter	NADP-Bennington	4.65	4.52			13
Winter	NADP-Underhill	4.68	4.51			13

Seasonal Wet Deposition by Chemical 1998

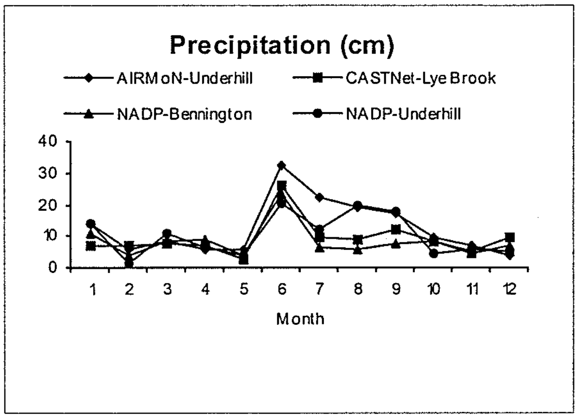
Chemical: SO4 **Concentration Units:** mg/l





		Concentration		Deposition (kg/ha)		
Season	**Location**	**Current Year**	**Period of Record Average**	**Current Year**	**Period of Record Average**	**Years of Data**
Spring	AIRMoN-Underhill	1.69	1.89	6.64	5.75	4
Spring	CASTNet-Lye Brook	1.38	2.29	4.72	4.51	3
Spring	NADP-Bennington	1.40	2.34	4.57	5.66	13
Spring	NADP-Underhill	1.20	1.83	2.05	4.84	13
Summer	AIRMoN-Underhill	1.80	2.01	10.98	8.43	4
Summer	CASTNet-Lye Brook	2.40	2.18	8.09	6.63	3
Summer	NADP-Bennington	2.99	2.81	7.21	7.16	13
Summer	NADP-Underhill	1.57	2.15	9.65	6.82	13
Fall	AIRMoN-Underhill	2.05	1.17	5.07	3.00	4
Fall	CASTNet-Lye Brook	1.32	1.07	3.16	2.94	3
Fall	NADP-Bennington	1.43	1.35	3.10	3.30	13
Fall	NADP-Underhill	1.95	1.37	3.92	3.38	13
Winter	AIRMoN-Underhill	0.34	0.86	0.71	1.36	4
Winter	CASTNet-Lye Brook	1.04	1.07	1.86	2.49	3
Winter	NADP-Bennington	0.77	1.26	2.35	2.26	13
Winter	NADP-Underhill	0.60	1.12	0.95	1.73	13

Monthly Wet Deposition: Precipitation 1998



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	13.72	8.86	4
February	5.94	4.74	4
March	8.18	7.65	3
April	5.75	8.73	3
May	5.50	7.95	4
June	32.31	16.02	4
July	21.95	15.82	4
August	18.95	15.37	4
September	17.32	11.58	4
October	9.80	9.59	4
November	7.12	9.01	4
December	3.67	7.25	4

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	7.16	5.25	2
February	6.76	7.07	2
March	7.65	9.21	2
April	7.19	9.86	2
May	2.39	7.33	2
June	25.96	12.13	3
July	9.50	14.05	3
August	8.84	6.99	3
September	11.91	10.64	3
October	8.33	9.80	3
November	5.08	7.93	3
December	9.25	11.73	3

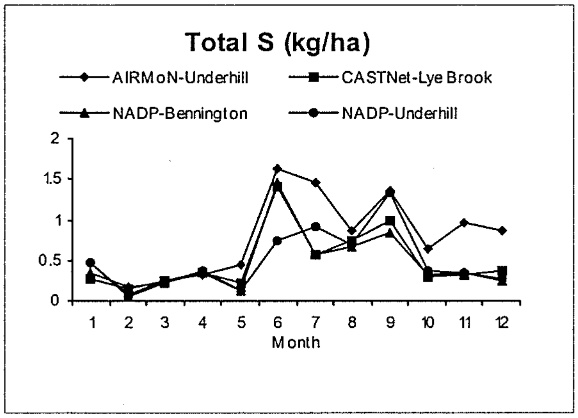
Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	10.72	7.05	13
February	4.11	3.91	13
March	8.13	6.97	13
April	8.61	8.49	13
May	3.90	7.46	13
June	23.32	9.13	13
July	6.12	8.84	13
August	5.91	10.10	12
September	7.32	7.59	12
October	8.53	9.02	13
November	4.50	8.66	13
December	7.14	7.26	12

Location NADP-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	14.15	7.16	13
February	1.40	3.85	13
March	10.72	6.98	13
April	6.07	8.47	13
May	3.53	8.38	13
June	20.55	9.86	13
July	11.86	9.66	13
August	19.89	12.66	13
September	17.73	10.69	13
October	4.60	10.84	13
November	5.65	7.03	13
December	4.94	5.89	13

Monthly Wet Deposition: Total Sulfur Deposition 1998



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.48	0.23	4
February	0.07	0.16	4
March	0.24	0.31	3
April	0.33	0.51	3
May	0.44	0.44	4
June	1.62	1.22	4
July	1.45	1.10	4
August	0.85	0.97	4
September	1.37	0.72	4
October	0.64	0.40	4
November	0.97	0.40	4
December	0.86	0.35	4

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.28	0.24	2
February	0.16	0.17	2
March	0.26	0.44	2
April	0.35	0.55	2
May	0.21	0.53	2
June	1.40	1.01	3
July	0.56	0.81	3
August	0.75	0.52	3
September	0.98	0.67	3
October	0.29	0.39	3
November	0.31	0.23	3
December	0.36	0.40	3

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.36	0.24	13
February	0.16	0.26	13
March	0.22	0.37	13
April	0.33	0.58	13
May	0.11	0.56	13
June	1.47	0.90	13
July	0.58	0.78	13
August	0.66	1.06	12
September	0.83	0.53	12
October	0.31	0.45	13
November	0.34	0.31	13
December	0.26	0.28	12

Location NADP-Underhill

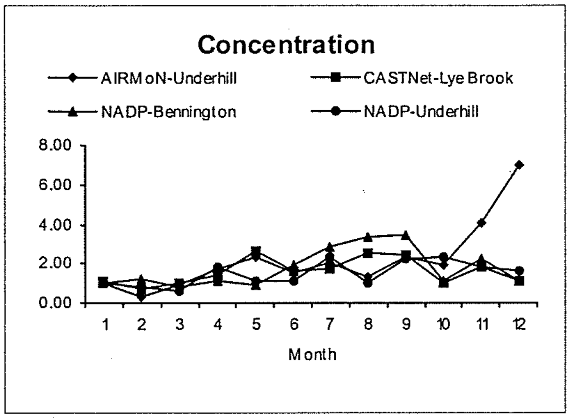
Month	Current Year	Period of Record Average	Years of Data
January	0.46	0.22	13
February	0.04	0.16	13
March	0.23	0.28	13
April	0.38	0.50	13
May	0.13	0.49	13
June	0.73	0.71	13
July	0.91	0.69	13
August	0.68	0.80	13
September	1.34	0.78	13
October	0.36	0.51	13
November	0.34	0.25	13
December	0.27	0.22	13

Monthly Wet Deposition by Chemical 1998

Chemical: Ca

Concentration

Units: mg/l



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.01	0.04	4
February	0.02	0.14	4
March	0.06	0.06	3
April	0.10	0.09	3
May	0.11	0.18	4
June	0.07	0.07	4
July	0.07	0.08	4
August	0.03	0.04	4
September	0.08	0.09	4
October	0.04	0.05	4
November	0.17	0.07	4
December	0.28	0.08	4

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.04	0.22	2
February	0.03	0.04	2
March	0.06	0.06	2
April	0.18	0.15	2
May	0.14	0.15	2
June	0.07	0.16	3
July	0.05	0.07	3
August	0.06	0.09	3
September	0.11	0.07	3
October	0.05	0.06	3
November	0.07	0.03	3
December	0.07	0.04	3

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.03	0.07	13
February	0.10	0.11	13
March	0.08	0.12	13
April	0.13	0.14	13
May	0.09	0.16	13
June	0.10	0.13	13
July	0.10	0.11	13
August	0.18	0.09	12
September	0.23	0.09	12
October	0.07	0.16	13
November	0.09	0.07	13
December	0.04	0.20	12

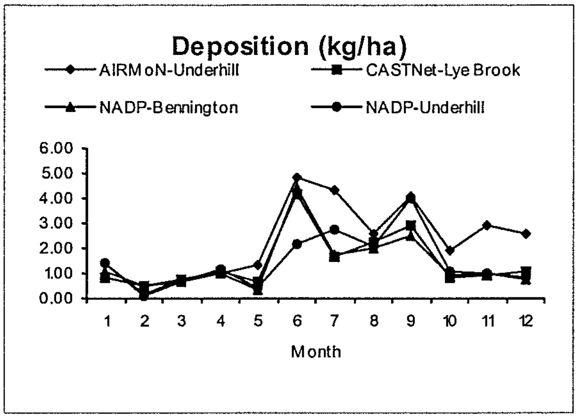
Location NADP-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.03	0.05	13
February	0.11	0.07	13
March	0.04	0.10	13
April	0.13	0.14	13
May	0.12	0.11	13
June	0.04	0.12	13
July	0.11	0.10	13
August	0.06	0.06	13
September	0.08	0.07	13
October	0.15	0.08	13
November	0.08	0.04	13
December	0.08	0.07	13

Monthly Wet Deposition by Chemical 1998

Chemical: Ca

Deposition



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.02	0.03	4
February	0.01	0.07	4
March	0.05	0.04	3
April	0.06	0.08	3
May	0.06	0.12	4
June	0.22	0.12	4
July	0.15	0.12	4
August	0.07	0.06	4
September	0.13	0.10	4
October	0.04	0.04	4
November	0.12	0.05	4
December	0.10	0.04	4

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.03	0.08	2
February	0.02	0.03	2
March	0.04	0.06	2
April	0.13	0.14	2
May	0.03	0.12	2
June	0.18	0.12	3
July	0.05	0.09	3
August	0.05	0.06	3
September	0.14	0.07	3
October	0.04	0.05	3
November	0.04	0.02	3
December	0.06	0.04	3

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.04	0.05	13
February	0.04	0.05	13
March	0.07	0.09	13
April	0.12	0.10	13
May	0.04	0.10	13
June	0.23	0.11	13
July	0.06	0.08	13
August	0.10	0.08	12
September	0.17	0.05	12
October	0.06	0.11	13
November	0.04	0.06	13
December	0.03	0.06	12

Location NADP-Underhill

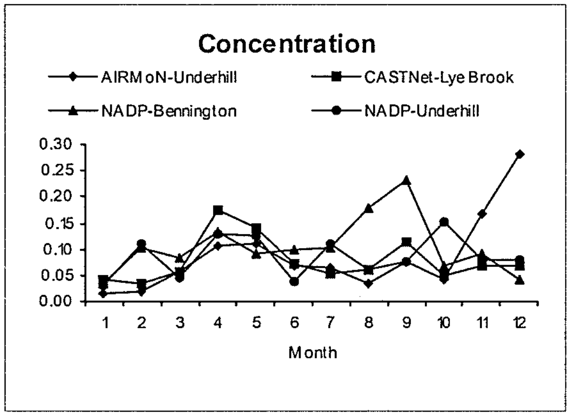
Month	Current Year	Period of Record Average	Years of Data
January	0.04	0.03	13
February	0.02	0.02	13
March	0.05	0.06	13
April	0.08	0.10	13
May	0.04	0.09	13
June	0.08	0.10	13
July	0.13	0.09	13
August	0.12	0.07	13
September	0.13	0.08	13
October	0.07	0.08	13
November	0.05	0.03	13
December	0.04	0.04	13

Monthly Wet Deposition by Chemical 1998

Chemical: Cl

Concentration

Units: mg/l



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.14	0.09	4
February	0.03	0.11	4
March	0.07	0.08	3
April	0.10	0.08	3
May	0.09	0.06	4
June	0.04	0.07	4
July	0.05	0.07	4
August	0.03	0.04	4
September	0.05	0.05	4
October	0.08	0.05	4
November	0.30	0.11	4
December	0.86	0.25	4

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.11	0.44	2
February	0.02	0.06	2
March	0.10	0.10	2
April	0.87	0.50	2
May	0.15	0.11	2
June	0.06	0.15	3
July	0.05	0.06	3
August	0.08	0.07	3
September	0.06	0.06	3
October	0.05	0.08	3
November	0.08	0.08	3
December	0.08	0.06	3

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.13	0.18	13
February	0.12	0.23	13
March	0.11	0.18	13
April	0.09	0.16	13
May	0.21	0.12	13
June	0.06	0.16	13
July	0.09	0.09	13
August	0.12	0.10	12
September	0.08	0.10	12
October	0.04	0.14	13
November	0.12	0.12	13
December	0.10	0.56	12

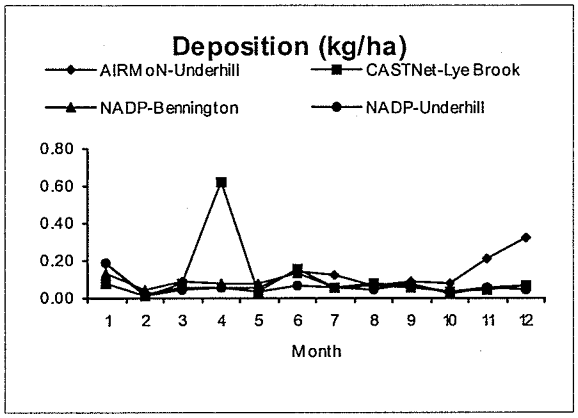
Location NADP-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.14	0.11	13
February	0.06	0.12	13
March	0.04	0.11	13
April	0.10	0.10	13
May	0.08	0.08	13
June	0.03	0.07	13
July	0.05	0.07	13
August	0.02	0.05	13
September	0.05	0.06	13
October	0.05	0.07	13
November	0.09	0.09	13
December	0.10	0.11	13

Monthly Wet Deposition by Chemical 1998

Chemical: Cl

Deposition



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.19	0.09	4
February	0.02	0.04	4
March	0.06	0.06	3
April	0.06	0.07	3
May	0.05	0.05	4
June	0.14	0.10	4
July	0.12	0.10	4
August	0.06	0.06	4
September	0.09	0.06	4
October	0.08	0.05	4
November	0.21	0.09	4
December	0.32	0.10	4

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.08	0.17	2
February	0.02	0.04	2
March	0.08	0.09	2
April	0.63	0.39	2
May	0.04	0.06	2
June	0.15	0.11	3
July	0.05	0.08	3
August	0.07	0.05	3
September	0.07	0.06	3
October	0.04	0.09	3
November	0.04	0.06	3
December	0.07	0.07	3

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.13	0.13	13
February	0.05	0.09	13
March	0.09	0.13	13
April	0.08	0.10	13
May	0.08	0.08	13
June	0.13	0.10	13
July	0.06	0.07	13
August	0.07	0.09	12
September	0.06	0.07	12
October	0.04	0.12	13
November	0.05	0.10	13
December	0.07	0.14	12

Location NADP-Underhill

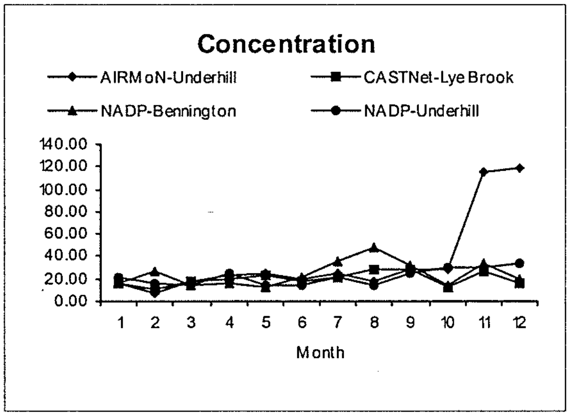
Month	Current Year	Period of Record Average	Years of Data
January	0.19	0.08	13
February	0.01	0.04	13
March	0.05	0.07	13
April	0.06	0.08	13
May	0.03	0.06	13
June	0.07	0.07	13
July	0.05	0.06	13
August	0.04	0.06	13
September	0.08	0.07	13
October	0.03	0.08	13
November	0.05	0.05	13
December	0.05	0.05	13

Monthly Wet Deposition by Chemical 1998

Chemical: Cond-field

Concentration

Units: uS/cm



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	16.15	12.73	4
February	6.39	16.29	4
March	18.43	24.26	3
April	22.81	22.25	3
May	24.89	18.00	4
June	19.45	29.18	4
July	24.68	27.16	4
August	18.07	21.23	4
September	27.47	20.58	4
October	29.09	20.25	4
November	115.70	36.61	4
December	118.20	40.27	4

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	16.28	24.05	2
February	10.45	10.41	2
March	17.01	21.75	2
April	19.41	19.62	2
May	23.87	24.84	2
June	16.86	42.32	3
July	21.89	21.37	3
August	28.04	24.05	3
September	28.53	21.90	3
October	13.27	17.05	3
November	27.03	15.98	3
December	15.65	15.61	3

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	16.15	18.51	13
February	25.98	32.07	13
March	14.38	22.24	13
April	16.71	30.26	13
May	11.67	27.78	13
June	20.88	33.94	13
July	36.28	34.07	13
August	47.53	35.99	12
September	32.58	26.33	12
October	14.67	21.84	13
November	34.50	17.45	13
December	19.26	24.63	12

Location NADP-Underhill

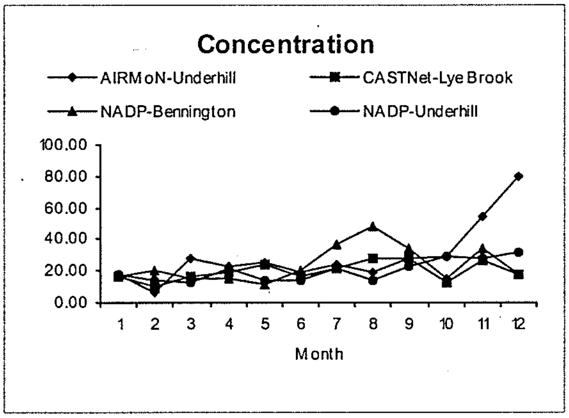
Month	Current Year	Period of Record Average	Years of Data
January	21.59	19.77	13
February	16.40	25.91	13
March	13.80	21.23	13
April	24.52	23.59	13
May	14.23	20.00	13
June	13.65	23.72	13
July	21.38	20.55	13
August	14.27	21.54	13
September	23.93	19.88	13
October	30.58	21.24	13
November	30.26	18.72	13
December	34.06	25.26	13

Monthly Wet Deposition by Chemical 1998

Chemical: Cond-lab

Concentration

Units: uS/cm



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	17.22	15.38	4
February	6.62	18.56	4
March	28.46	28.05	3
April	22.91	22.22	3
May	24.89	18.80	4
June	18.83	29.03	4
July	24.41	26.15	4
August	18.36	21.51	4
September	27.38	20.85	4
October	28.71	21.27	4
November	54.54	22.47	4
December	80.03	31.83	4

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	16.28	24.01	2
February	10.59	8.86	2
March	17.08	21.94	2
April	19.29	19.48	2
May	23.82	24.53	2
June	16.88	42.09	3
July	21.57	21.68	3
August	27.90	23.90	3
September	28.21	21.22	3
October	12.68	16.17	3
November	26.75	15.87	3
December	17.35	16.28	3

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	16.16	17.41	13
February	19.89	27.63	13
March	15.04	21.32	13
April	15.43	28.60	13
May	11.69	26.65	13
June	20.04	32.08	13
July	36.71	30.87	13
August	47.88	38.31	12
September	33.66	25.55	12
October	15.68	20.84	13
November	34.10	16.09	13
December	17.51	21.92	12

Location NADP-Underhill

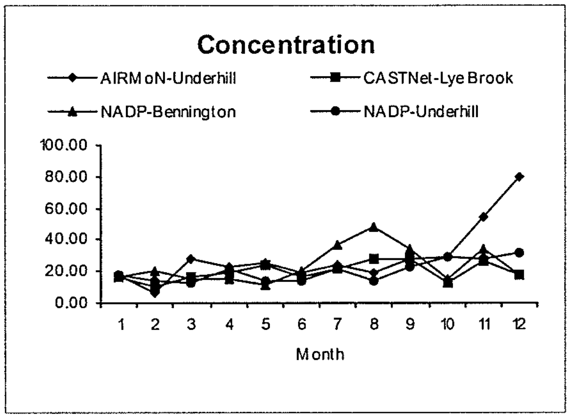
Month	Current Year	Period of Record Average	Years of Data
January	17.80	17.36	13
February	14.50	24.44	13
March	13.04	19.22	13
April	21.11	21.61	13
May	13.70	19.04	13
June	13.54	21.92	13
July	21.93	22.44	13
August	14.50	21.12	13
September	22.81	21.44	13
October	29.06	19.64	13
November	28.11	17.92	13
December	31.87	22.64	13

Monthly Wet Deposition by Chemical 1998

Chemical: H

Concentration

Units: ueq/l



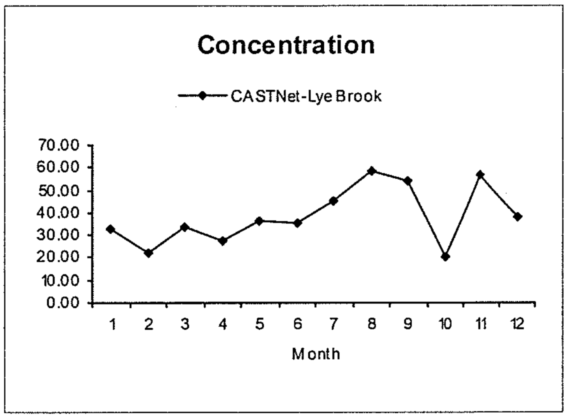
Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	32.67	48.39	2
February	22.01	21.79	2
March	33.59	49.54	2
April	27.71	32.19	2
May	35.97	42.49	2
June	35.37	85.35	3
July	45.24	42.25	3
August	58.34	48.82	3
September	53.92	42.94	3
October	20.62	30.89	3
November	56.69	34.95	3
December	38.13	36.07	3

Chemical: H unfiltered

Concentration

Units: ueq/l



Location CASTNet-Lye Brook

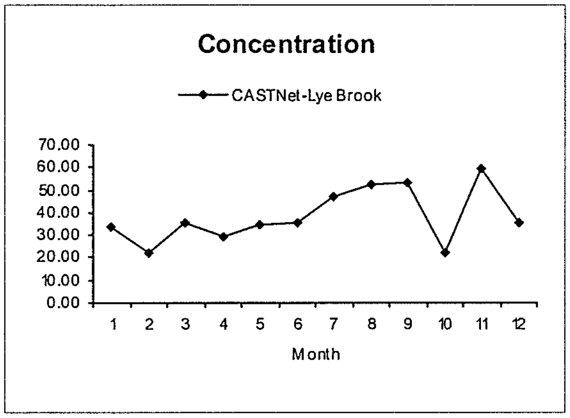
Month	Current Year	Period of Record Average	Years of Data
January	33.85	48.99	2
February	22.51	24.47	2
March	35.46	50.47	2
April	28.85	32.76	2
May	34.36	42.16	2
June	35.42	85.45	3
July	46.96	42.61	3
August	52.68	47.71	3
September	53.20	43.55	3
October	22.33	32.26	3
November	59.37	35.79	3
December	35.06	35.63	3

Monthly Wet Deposition by Chemical 1998

Chemical: K

Concentration

Units: mg/l



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.01	0.01	4
February	0.01	0.02	4
March	0.01	0.01	3
April	0.02	0.02	3
May	0.04	0.04	4
June	0.01	0.02	4
July	0.01	0.01	4
August	0.01	0.01	4
September	0.02	0.02	4
October	0.02	0.01	4
November	0.04	0.02	4
December	0.06	0.02	4

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.01	0.02	2
February	0.00	0.00	2
March	0.01	0.01	2
April	0.28	0.15	2
May	0.11	0.07	2
June	0.03	0.12	3
July	0.02	0.01	3
August	0.02	0.02	3
September	0.02	0.01	3
October	0.05	0.06	3
November	0.03	0.01	3
December	0.02	0.01	3

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.01	0.01	13
February	0.02	0.02	13
March	0.01	0.02	13
April	0.02	0.02	13
May	0.04	0.03	13
June	0.02	0.04	13
July	0.02	0.02	13
August	0.01	0.01	12
September	0.03	0.01	12
October	0.01	0.05	13
November	0.03	0.02	13
December	0.01	0.01	12

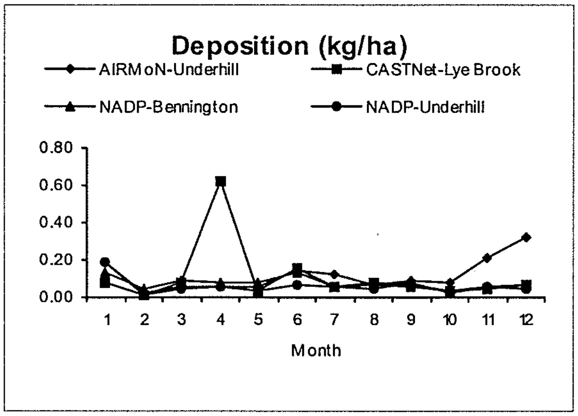
Location NADP-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.01	0.01	13
February	0.02	0.01	13
March	0.01	0.01	13
April	0.02	0.02	13
May	0.10	0.03	13
June	0.00	0.03	13
July	0.01	0.02	13
August	0.01	0.01	13
September	0.01	0.01	13
October	0.11	0.03	13
November	0.05	0.02	13
December	0.01	0.01	13

Monthly Wetly Deposition by Chemical 1998

Chemical: K

Deposition



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.01	0.01	4
February	0.00	0.01	4
March	0.01	0.01	3
April	0.01	0.01	3
May	0.02	0.03	4
June	0.04	0.03	4
July	0.02	0.02	4
August	0.02	0.01	4
September	0.03	0.02	4
October	0.02	0.01	4
November	0.03	0.01	4
December	0.02	0.01	4

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.01	0.01	2
February	0.00	0.00	2
March	0.01	0.01	2
April	0.20	0.11	2
May	0.03	0.03	2
June	0.08	0.07	3
July	0.02	0.02	3
August	0.01	0.02	3
September	0.02	0.01	3
October	0.04	0.08	3
November	0.01	0.01	3
December	0.02	0.01	3

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.01	0.01	13
February	0.01	0.01	13
March	0.01	0.01	13
April	0.02	0.01	13
May	0.01	0.02	13
June	0.05	0.03	13
July	0.01	0.01	13
August	0.01	0.01	12
September	0.02	0.01	12
October	0.01	0.03	13
November	0.02	0.01	13
December	0.01	0.01	12

Location NADP-Underhill

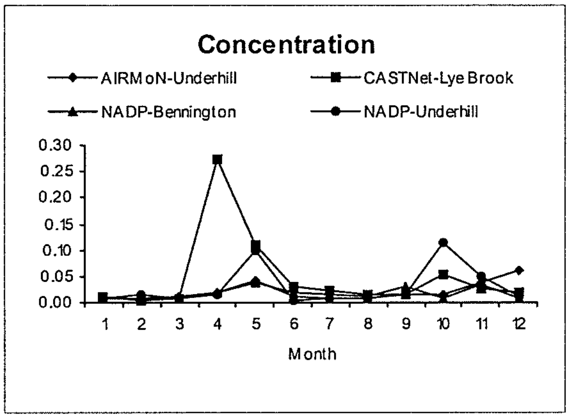
Month	Current Year	Period of Record Average	Years of Data
January	0.01	0.01	13
February	0.00	0.00	13
March	0.01	0.01	13
April	0.01	0.01	13
May	0.04	0.02	13
June	0.01	0.02	13
July	0.01	0.02	13
August	0.02	0.01	13
September	0.03	0.01	13
October	0.05	0.04	13
November	0.03	0.01	13
December	0.01	0.01	13

Monthly Wet Deposition by Chemical 1998

Chemical: Mg

Concentration

Units: mg/l



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.01	0.00	4
February	0.00	0.01	4
March	0.01	0.01	3
April	0.02	0.01	3
May	0.02	0.02	4
June	0.01	0.01	4
July	0.01	0.01	4
August	0.00	0.00	4
September	0.01	0.01	4
October	0.01	0.01	4
November	0.04	0.01	4
December	0.07	0.02	4

Location CASTNet-Lye Brook

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

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.01	0.02	13
February	0.02	0.02	13
March	0.02	0.03	13
April	0.02	0.03	13
May	0.02	0.04	13
June	0.02	0.03	13
July	0.01	0.02	13
August	0.02	0.02	12
September	0.03	0.02	12
October	0.01	0.04	13
November	0.02	0.01	13
December	0.01	0.04	12

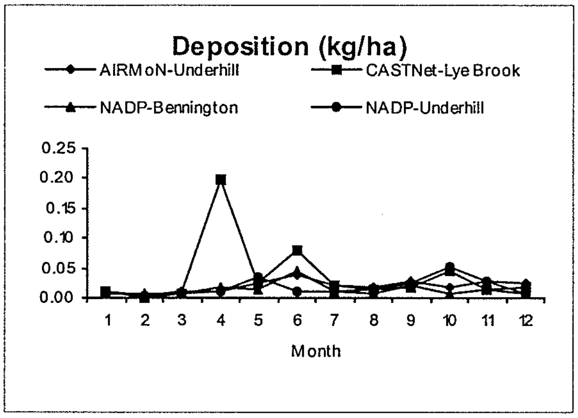
Location NADP-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.01	0.01	13
February	0.01	0.01	13
March	0.01	0.01	13
April	0.02	0.02	13
May	0.02	0.02	13
June	0.01	0.02	13
July	0.02	0.02	13
August	0.01	0.01	13
September	0.01	0.01	13
October	0.02	0.02	13
November	0.01	0.01	13
December	0.01	0.01	13

Monthly Wet Deposition by Chemical 1998

Chemical: Mg

Deposition



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.01	0.00	4
February	0.00	0.00	4
March	0.01	0.01	3
April	0.01	0.01	3
May	0.01	0.02	4
June	0.03	0.02	4
July	0.02	0.02	4
August	0.01	0.01	4
September	0.02	0.01	4
October	0.01	0.01	4
November	0.03	0.01	4
December	0.02	0.01	4

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.01	0.02	2
February	0.00	0.01	2
March	0.01	0.01	2
April	0.02	0.04	2
May	0.01	0.02	2
June	0.04	0.03	3
July	0.01	0.02	3
August	0.01	0.01	3
September	0.02	0.01	3
October	0.01	0.02	3
November	0.01	0.01	3
December	0.01	0.01	3

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.01	0.01	13
February	0.01	0.01	13
March	0.02	0.02	13
April	0.02	0.02	13
May	0.01	0.02	13
June	0.04	0.02	13
July	0.01	0.02	13
August	0.01	0.02	12
September	0.02	0.01	12
October	0.01	0.03	13
November	0.01	0.01	13
December	0.01	0.01	12

Location NADP-Underhill

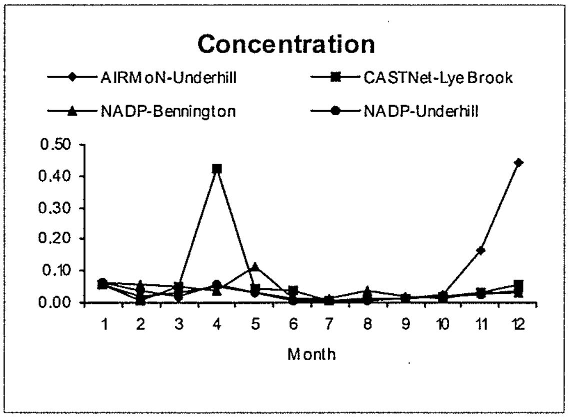
Month	Current Year	Period of Record Average	Years of Data
January	0.02	0.01	13
February	0.00	0.00	13
March	0.01	0.01	13
April	0.01	0.02	13
May	0.01	0.02	13
June	0.01	0.02	13
July	0.02	0.02	13
August	0.02	0.01	13
September	0.02	0.01	13
October	0.01	0.02	13
November	0.01	0.01	13
December	0.01	0.01	13

Monthly Wet Deposition by Chemical 1998

Chemical: Na

Concentration

Units: mg/l



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.06	0.03	4
February	0.02	0.05	4
March	0.03	0.03	3
April	0.05	0.04	3
May	0.03	0.02	4
June	0.01	0.02	4
July	0.01	0.02	4
August	0.01	0.01	4
September	0.01	0.02	4
October	0.02	0.02	4
November	0.17	0.06	4
December	0.44	0.12	4

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.06	0.26	2
February	0.01	0.04	2
March	0.05	0.05	2
April	0.42	0.24	2
May	0.05	0.03	2
June	0.04	0.04	3
July	0.00	0.01	3
August	0.02	0.02	3
September	0.01	0.02	3
October	0.02	0.03	3
November	0.03	0.03	3
December	0.06	0.03	3

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.07	0.11	13
February	0.06	0.14	13
March	0.05	0.11	13
April	0.04	0.09	13
May	0.11	0.06	13
June	0.01	0.08	13
July	0.01	0.04	13
August	0.04	0.04	12
September	0.02	0.04	12
October	0.01	0.09	13
November	0.03	0.07	13
December	0.03	0.37	12

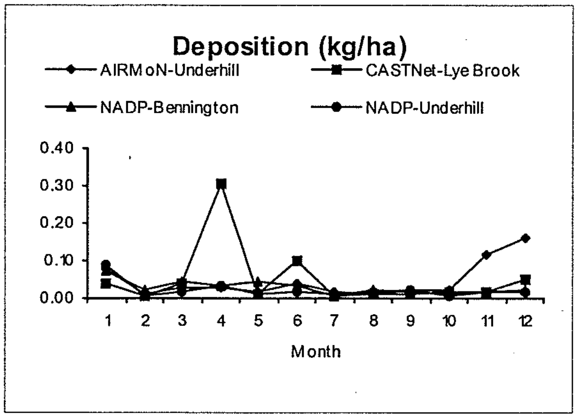
Location NADP-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.06	0.06	13
February	0.04	0.06	13
March	0.02	0.06	13
April	0.06	0.06	13
May	0.03	0.04	13
June	0.01	0.04	13
July	0.01	0.03	13
August	0.01	0.02	13
September	0.01	0.03	13
October	0.02	0.04	13
November	0.03	0.04	13
December	0.04	0.06	13

Monthly Wet Deposition by Chemical 1998

Chemical: Na

Deposition



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.08	0.03	4
February	0.01	0.02	4
March	0.03	0.02	3
April	0.03	0.03	3
May	0.02	0.01	4
June	0.04	0.03	4
July	0.02	0.02	4
August	0.01	0.01	4
September	0.02	0.02	4
October	0.02	0.01	4
November	0.12	0.05	4
December	0.16	0.05	4

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.04	0.10	2
February	0.01	0.03	2
March	0.04	0.04	2
April	0.30	0.18	2
May	0.01	0.02	2
June	0.10	0.05	3
July	0.00	0.02	3
August	0.01	0.01	3
September	0.01	0.02	3
October	0.02	0.04	3
November	0.02	0.03	3
December	0.05	0.03	3

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.07	0.08	13
February	0.02	0.06	13
March	0.04	0.08	13
April	0.03	0.05	13
May	0.04	0.04	13
June	0.03	0.04	13
July	0.01	0.03	13
August	0.02	0.04	12
September	0.02	0.03	12
October	0.01	0.08	13
November	0.01	0.06	13
December	0.02	0.08	12

Location NADP-Underhill

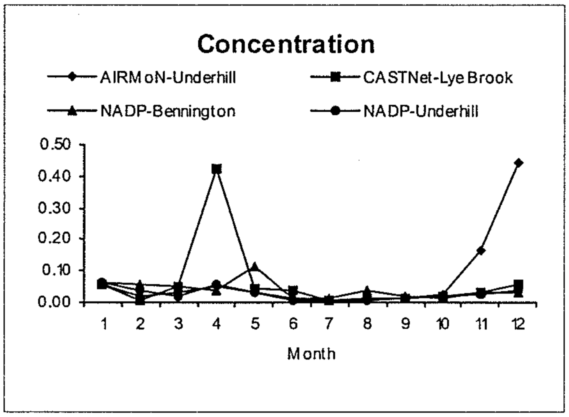
Month	Current Year	Period of Record Average	Years of Data
January	0.09	0.04	13
February	0.01	0.02	13
March	0.02	0.04	13
April	0.03	0.05	13
May	0.01	0.03	13
June	0.02	0.03	13
July	0.01	0.03	13
August	0.02	0.03	13
September	0.02	0.03	13
October	0.01	0.04	13
November	0.02	0.03	13
December	0.02	0.03	13

Monthly Wet Deposition by Chemical 1998

Chemical: NH4

Concentration

Units: mg/l



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.13	0.11	4
February	0.07	0.21	4
March	0.33	0.28	3
April	0.35	0.35	3
May	0.65	0.48	4
June	0.31	0.42	4
July	0.39	0.39	4
August	0.30	0.29	4
September	0.44	0.33	4
October	0.37	0.25	4
November	0.63	0.26	4
December	0.91	0.32	4

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.16	0.20	2
February	0.10	0.08	2
March	0.19	0.24	2
April	0.32	0.29	2
May	0.89	0.65	2
June	0.29	0.75	3
July	0.22	0.27	3
August	0.36	0.29	3
September	0.39	0.27	3
October	0.26	0.21	3
November	0.42	0.21	3
December	0.16	0.14	3

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.09	0.11	13
February	0.15	0.22	13
March	0.12	0.18	13
April	0.19	0.32	13
May	0.11	0.34	13
June	0.31	0.39	13
July	0.21	0.35	13
August	0.34	0.32	12
September	0.55	0.22	12
October	0.14	0.19	13
November	0.37	0.12	13
December	0.11	0.15	12

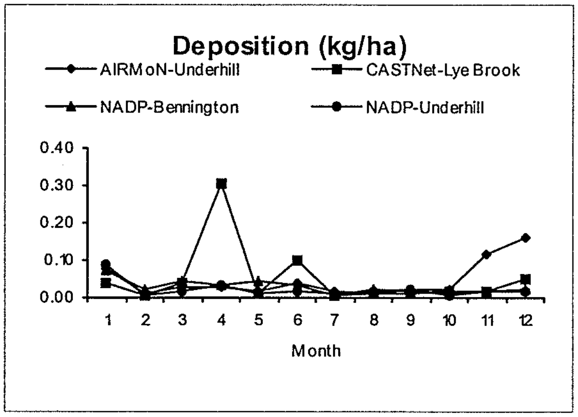
Location NADP-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.07	0.12	13
February	0.07	0.20	13
March	0.07	0.18	13
April	0.32	0.32	13
May	0.15	0.29	13
June	0.14	0.33	13
July	0.41	0.29	13
August	0.26	0.22	13
September	0.35	0.26	13
October	0.41	0.22	13
November	0.34	0.20	13
December	0.34	0.20	13

Monthly Wet Deposition by Chemical 1998

Chemical: NH4

Deposition



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.18	0.10	4
February	0.04	0.10	4
March	0.27	0.21	3
April	0.20	0.31	3
May	0.36	0.33	4
June	1.00	0.63	4
July	0.85	0.60	4
August	0.57	0.44	4
September	0.76	0.41	4
October	0.36	0.21	4
November	0.45	0.21	4
December	0.34	0.16	4

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.12	0.10	2
February	0.07	0.06	2
March	0.14	0.23	2
April	0.23	0.28	2
May	0.21	0.36	2
June	0.76	0.55	3
July	0.21	0.34	3
August	0.32	0.21	3
September	0.47	0.29	3
October	0.21	0.19	3
November	0.22	0.14	3
December	0.15	0.14	3

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	0.10	0.07	13
February	0.06	0.09	13
March	0.09	0.13	13
April	0.16	0.24	13
May	0.04	0.22	13
June	0.72	0.36	13
July	0.13	0.26	13
August	0.20	0.32	12
September	0.40	0.16	12
October	0.12	0.15	13
November	0.17	0.09	13
December	0.08	0.07	12

Location NADP-Underhill

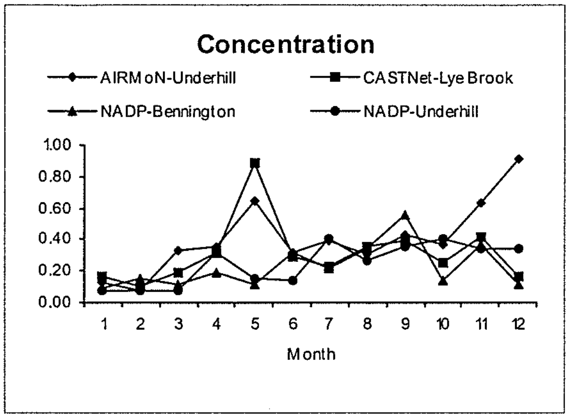
Month	Current Year	Period of Record Average	Years of Data
January	0.10	0.08	13
February	0.01	0.07	13
March	0.08	0.12	13
April	0.19	0.24	13
May	0.05	0.22	13
June	0.29	0.30	13
July	0.49	0.28	13
August	0.52	0.28	13
September	0.62	0.29	13
October	0.19	0.19	13
November	0.19	0.13	13
December	0.17	0.10	13

Monthly Wet Deposition by Chemical 1998

Chemical: NO3

Concentration

Units: mg/l



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	1.23	1.42	4
February	0.49	1.82	4
March	1.79	2.33	3
April	1.54	1.54	3
May	1.32	1.38	4
June	1.03	1.49	4
July	1.15	1.28	4
August	0.70	0.87	4
September	1.20	1.10	4
October	2.13	1.50	4
November	4.54	1.84	4
December	4.64	2.28	4

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	1.13	2.41	2
February	0.82	0.72	2
March	1.53	1.92	2
April	1.52	1.51	2
May	1.83	1.95	2
June	0.94	2.68	3
July	1.23	1.25	3
August	1.47	1.36	3
September	1.68	1.31	3
October	0.99	1.17	3
November	2.38	1.31	3
December	1.41	1.22	3

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	1.17	1.42	13
February	1.66	2.47	13
March	1.45	1.86	13
April	1.38	2.12	13
May	0.94	1.92	13
June	1.19	1.88	13
July	2.31	1.77	13
August	3.72	2.02	12
September	2.21	1.48	12
October	1.05	1.50	13
November	3.18	1.31	13
December	1.46	2.11	12

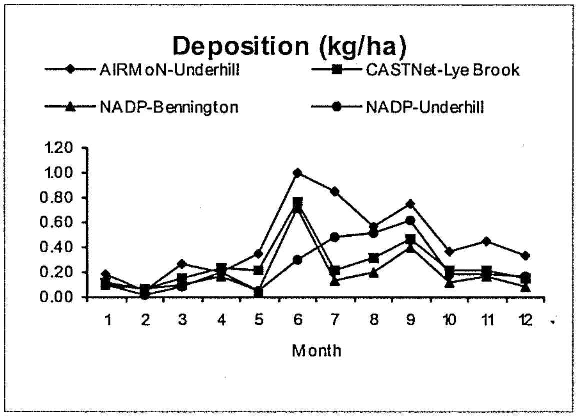
Location NADP-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	1.04	1.64	13
February	1.31	2.49	13
March	1.05	1.78	13
April	1.62	1.82	13
May	1.10	1.31	13
June	0.77	1.33	13
July	1.20	1.29	13
August	0.73	1.03	13
September	1.15	1.18	13
October	1.94	1.32	13
November	2.71	1.54	13
December	3.57	2.35	13

Monthly Wet Deposition by Chemical 1998

Chemical: NO3

Deposition



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	1.68	1.20	4
February	0.29	0.82	4
March	1.47	1.65	3
April	0.89	1.39	3
May	0.73	1.13	4
June	3.32	2.16	4
July	2.51	1.93	4
August	1.32	1.32	4
September	2.07	1.31	4
October	2.08	1.24	4
November	3.23	1.50	4
December	1.70	1.29	4

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.81	1.02	2
February	0.55	0.51	2
March	1.17	1.83	2
April	1.09	1.49	2
May	0.44	1.49	2
June	2.44	1.93	3
July	1.17	1.56	3
August	1.30	0.92	3
September	2.00	1.42	3
October	0.82	1.06	3
November	1.21	0.88	3
December	1.30	1.30	3

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	1.25	0.98	13
February	0.68	1.01	13
March	1.18	1.35	13
April	1.19	1.57	13
May	0.37	1.30	13
June	2.78	1.61	13
July	1.41	1.40	13
August	2.20	1.79	12
September	1.62	1.02	12
October	0.90	1.24	13
November	1.43	1.05	13
December	1.04	1.12	12

Location NADP-Underhill

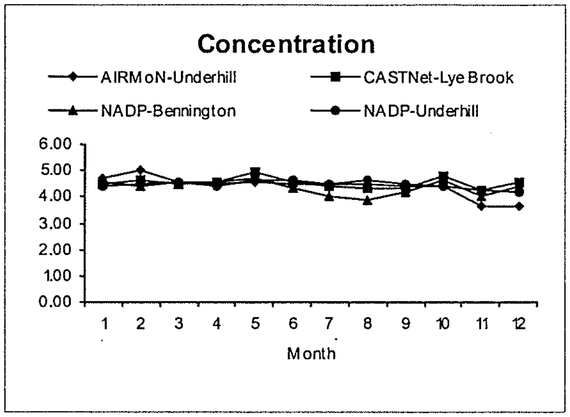
Month	Current Year	Period of Record Average	Years of Data
January	1.47	1.09	13
February	0.18	0.94	13
March	1.12	1.16	13
April	0.99	1.43	13
May	0.39	1.06	13
June	1.59	1.23	13
July	1.42	1.16	13
August	1.44	1.22	13
September	2.04	1.30	13
October	0.89	1.21	13
November	1.53	0.94	13
December	1.76	1.23	13

Monthly Wet Deposition by Chemical 1998

Chemical: pH-field

Concentration

Units:



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	4.69	4.59	4
February	4.97	4.54	4
March	4.54	4.45	3
April	4.47	4.46	3
May	4.54	4.72	4
June	4.50	4.32	4
July	4.49	4.40	4
August	4.51	4.45	4
September	4.43	4.55	4
October	4.42	4.59	4
November	3.66	4.51	4
December	3.67	4.37	4

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	4.47	4.34	2
February	4.66	4.64	2
March	4.46	4.33	2
April	4.59	4.53	2
May	4.94	4.62	2
June	4.53	4.19	3
July	4.39	4.44	3
August	4.32	4.42	3
September	4.33	4.43	3
October	4.79	4.61	3
November	4.26	4.54	3
December	4.55	4.54	3

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	4.54	4.48	13
February	4.43	4.29	13
March	4.52	4.38	13
April	4.52	4.29	13
May	4.68	4.41	13
June	4.34	4.28	13
July	4.05	4.18	13
August	3.89	4.16	12
September	4.17	4.35	12
October	4.60	4.50	13
November	4.06	4.54	13
December	4.41	4.43	12

Location NADP-Underhill

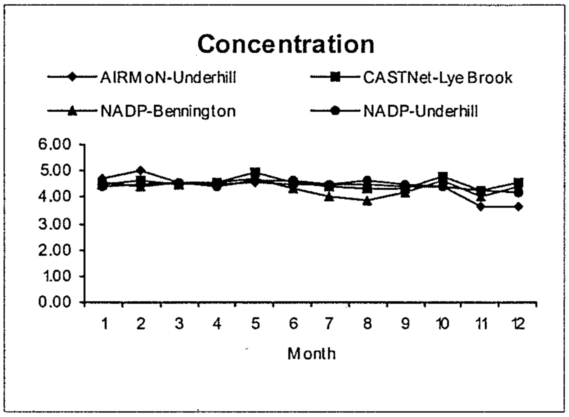
Month	Current Year	Period of Record Average	Years of Data
January	4.39	4.51	13
February	4.50	4.36	13
March	4.56	4.48	13
April	4.37	4.42	13
May	4.63	4.55	13
June	4.60	4.48	13
July	4.50	4.47	13
August	4.62	4.44	13
September	4.47	4.45	13
October	4.41	4.55	13
November	4.25	4.55	13
December	4.21	4.40	13

Monthly Wet Deposition by Chemical 1998

Chemical: pH-lab

Concentration

Units:



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	4.67	4.66	4
February	4.99	4.63	4
March	4.39	4.40	3
April	4.48	4.48	3
May	4.55	4.81	4
June	4.50	4.33	4
July	4.45	4.47	4
August	4.51	4.48	4
September	4.40	4.56	4
October	4.47	4.63	4
November	4.23	4.69	4
December	4.23	4.53	4

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	4.49	4.35	2
February	4.67	4.70	2
March	4.48	4.34	2
April	4.61	4.54	2
May	4.98	4.65	2
June	4.53	4.19	3
July	4.40	4.43	3
August	4.26	4.40	3
September	4.34	4.43	3
October	4.83	4.62	3
November	4.28	4.54	3
December	4.44	4.51	3

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	4.56	4.54	13
February	4.50	4.35	13
March	4.58	4.49	13
April	4.60	4.33	13
May	4.73	4.41	13
June	4.47	4.32	13
July	4.19	4.30	13
August	4.05	4.20	12
September	4.25	4.41	12
October	4.68	4.59	13
November	4.24	4.68	13
December	4.51	4.55	12

Location NADP-Underhill

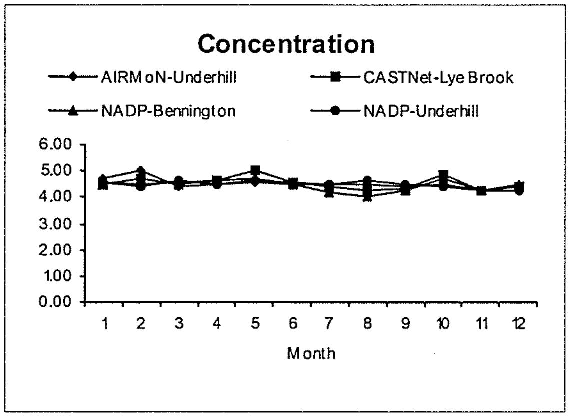
Month	Current Year	Period of Record Average	Years of Data
January	4.53	4.55	13
February	4.39	4.39	13
March	4.61	4.54	13
April	4.46	4.50	13
May	4.65	4.61	13
June	4.59	4.51	13
July	4.47	4.47	13
August	4.62	4.44	13
September	4.46	4.46	13
October	4.39	4.55	13
November	4.28	4.57	13
December	4.23	4.44	13

Monthly Wet Deposition by Chemical 1998

Chemical: SO4

Concentration

Units: mg/l



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	1.05	0.72	4
February	0.35	1.04	4
March	0.87	1.27	3
April	1.73	1.68	3
May	2.37	1.61	4
June	1.50	2.52	4
July	1.98	2.24	4
August	1.35	1.86	4
September	2.37	1.75	4
October	1.96	1.43	4
November	4.06	1.51	4
December	7.04	2.30	4

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	1.16	1.47	2
February	0.70	0.72	2
March	1.01	1.37	2
April	1.46	1.62	2
May	2.66	2.37	2
June	1.62	4.13	3
July	1.76	1.93	3
August	2.53	2.26	3
September	2.47	1.84	3
October	1.04	1.35	3
November	1.83	1.04	3
December	1.16	1.09	3

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	1.00	1.14	13
February	1.19	1.81	13
March	0.83	1.52	13
April	1.16	2.50	13
May	0.88	2.50	13
June	1.88	3.11	13
July	2.83	2.94	13
August	3.33	3.50	12
September	3.41	2.27	12
October	1.10	1.65	13
November	2.28	1.12	13
December	1.07	1.34	12

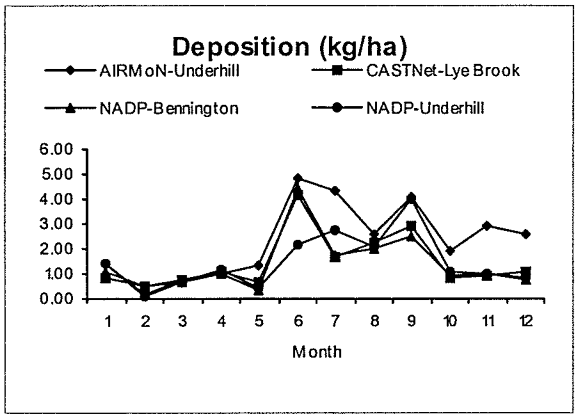
Location NADP-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	0.97	0.95	13
February	0.82	1.31	13
March	0.65	1.27	13
April	1.87	1.93	13
May	1.13	1.81	13
June	1.07	2.22	13
July	2.29	2.24	13
August	1.03	2.02	13
September	2.26	2.05	13
October	2.37	1.62	13
November	1.81	1.24	13
December	1.66	1.27	13

Monthly Wet Deposition by Chemical 1998

Chemical: SO4

Deposition



Location AIRMoN-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	1.43	0.68	4
February	0.21	0.49	4
March	0.71	0.91	3
April	0.99	1.52	3
May	1.31	1.32	4
June	4.85	3.65	4
July	4.34	3.30	4
August	2.56	2.89	4
September	4.10	2.17	4
October	1.92	1.20	4
November	2.90	1.20	4
December	2.58	1.06	4

Location CASTNet-Lye Brook

Month	Current Year	Period of Record Average	Years of Data
January	0.83	0.71	2
February	0.48	0.51	2
March	0.77	1.32	2
April	1.05	1.64	2
May	0.63	1.60	2
June	4.19	3.02	3
July	1.67	2.42	3
August	2.24	1.57	3
September	2.94	2.01	3
October	0.87	1.17	3
November	0.93	0.69	3
December	1.07	1.19	3

Location NADP-Bennington

Month	Current Year	Period of Record Average	Years of Data
January	1.07	0.73	13
February	0.49	0.78	13
March	0.67	1.11	13
April	1.00	1.73	13
May	0.34	1.67	13
June	4.39	2.70	13
July	1.73	2.34	13
August	1.96	3.16	12
September	2.49	1.60	12
October	0.94	1.36	13
November	1.02	0.92	13
December	0.77	0.83	12

Location NADP-Underhill

Month	Current Year	Period of Record Average	Years of Data
January	1.38	0.66	13
February	0.11	0.49	13
March	0.70	0.84	13
April	1.13	1.50	13
May	0.40	1.48	13
June	2.20	2.13	13
July	2.72	2.05	13
August	2.05	2.41	13
September	4.01	2.33	13
October	1.09	1.53	13
November	1.02	0.75	13
December	0.82	0.66	13