NEW HAMPSHIRE DEPARTMENT OF ENVIRONMENTAL SERVICES 2014 PAMS SUMMARY

Photochemical Assessment Monitoring Station (PAMS)

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NEW HAMPSHIRE DEPARTMENT OF ENVIRONMENTAL SERVICES 2014 PAMS SUMMARY

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Table of Contents

1. COMMONLY USED ACRONYMS

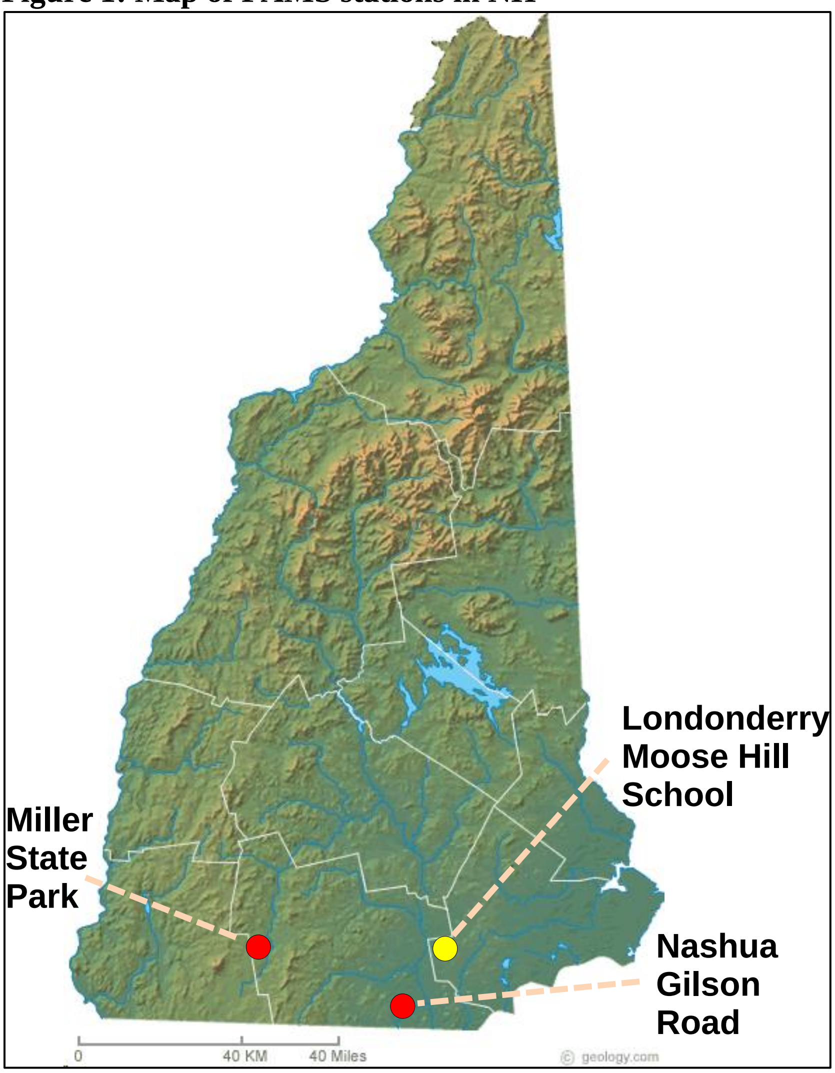
AAL	Ambient Air Limits, a health based air limit
AIRS	Aerometric Information Retrieval System, repository for air pollution information
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene (inherent to gasoline)
EPA	U.S. Environmental Protection Agency
ETP	External temperature, temperature outside of the monitoring station
HAPS	Hazardous Air Pollutants, substances that are defined as hazardous
NAAQS	National Ambient Air Quality Standard, health-based ambient air standard
NCORE	National Core, an air monitoring network
NHDES	New Hampshire Department of Environmental Services
NIST	National Institute of Standards & Technology
O_3	Ozone, a chemically reactive air pollutant
PAMS	Photochemical Assessment Monitoring Station
ppb	parts per billion, a measure of concentration
ppbc	parts per billion times carbon, a measure of concentration
QAPP	Quality Assurance Project Plan
SOAP	Secondary Organic Aerosol Precursors
TAD	Technical Assistance Document, Issued by EPA
TNMOC	Total Non-Methane Organic Compounds
UTC	Coordinated universal time, a worldwide time reference
UV	Ultra violet (radiation), a type of light from the sun
UVRAD	Ultra violet radiation, a type of light from the sun
VOCs	Volatile organic compounds

2. INTRODUCTION

In 2014, Photochemical Assessment Monitoring Station (PAMS) monitoring was completed for the tenth summer season at the Gilson Road site in Nashua, NH, and for the ninth summer at Miller State Park atop Pack Monadnock in Peterborough, NH. The combination of the two sites provides a unique high-low look (elevation 2290ft. vs. 368ft.) at ozone precursors in the skies above New Hampshire.

Upon completion of PAMS monitoring at the end of the 2014 season, PAMS instrumentation at the Gilson Road site was relocated to the National Core (NCORE) station at the Moose Hill School in Londonderry, NH (Figure 1). The recent move was driven by a desire to gather as many different air pollution measurements as possible in certain targeted locations within the state; this is the strategic goal of the NCORE network. In 2015, New Hampshire's two NCORE sites will both include PAMS stations. Also, Londonderry is relatively close to Miller State Park and continues to support comparisons between high and low elevations.

Figure 1: Map of PAMS stations in NH



PAMS monitoring is required under the Clean Air Act's provision for enhanced monitoring in certain regions that have measured ozone concentrations high enough to be designated as serious nonattainment or worse. Ozone in New Hampshire has improved significantly in recent years. However, the area in which the PAMS stations are located is still in a chemically complicated air region, and ozone nonattainment areas exist near the New Hampshire border. The high-low elevation combination of New Hampshire PAMS sites also provides unique scientifically interesting information and helps improve photochemical model performance in the Northeast United States.

PAMS monitoring stations collect information on a select group of Volatile Organic Compounds (VOCs) and certain nitrogen oxides. Table 1 lists PAMS VOC target compounds along with the chemical species' Aerometric Information Retrieval System (AIRS) codes. This report will summarize PAMS VOC concentration patterns, meteorological conditions, and a comparison of ozone values with PAMS compounds.

Table 1: List of PAMS organic compounds and their AIRS codes

Ethane (43202)	Ethylene (43203)	Propane (43204)	Propylene (43205)
Isobutane (43214)	n-Butane (43212)	Acetylene (43206)	trans-2-Butene (43216)
1-butene (43280)	cis-2-Butene (43217)	Cyclopentane (43242)	Isopentane (43221)
n-Pentane (43220)	trans-2-Pentene (43226)	1-Pentene (43224)	cis-2-Pentene (43227)
2,2-Dimethylbutane (43244)	2,3-Dimethylbutane (43284)	2-Methylpentane (43285)	3-Methylpentane (43230)
Isoprene (43243)	n-Hexane (43231)	Methylcyclohexane (43262)	2,4-Dimethylpentane (43247)
Benzene (45201)	Cyclohexane (43248)	2-Methylhexane (43263)	2,3-Dimethylpentane (43291)
3-Methylhexane (43249)	2,2,4-Trimethylpentane (43250)	n-Heptane (43232)	Methylcyclohexane (43261)
2,3,4-Trimethylpentane (43252)	Toluene (45202)	2-Methylheptane (43960)	3-Methylheptane (43253)
n-Octane (43233)	Ethylbenzene (45203)	m&p-Xylene (45109)	Styrene (45220)
o-Xylene (45204)	n-Nonane (43235)	Isopropylbenzene (45210)	n-Propylbenzene (45209)
m-Ethyltoluene (45212)	p-Ethyltoluene (45213)	1,3,5-Trimethylbenzene (45207)	o-Ethyltoluene (45211)
1,2,4-Trimethylbenzene (45208)	n-Decane (43238)	1,2,3-Trimethylbenzene (45225)	m-Diethylbenzene (45218)
p-Diethylbenzene (45219)	n-Undecane (43954)	Total Non-Methane Organic Compounds (43102)	Sum PAMS Target Species (43000)

3. QUALITY CONTROL ANALYSIS

New Hampshire Department of Environmental Services (NHDES) performs PAMS monitoring in accordance with the Environmental Protection Agency's (EPA) PAMS Technical Assistance Document (TAD). Quality control procedures are documented in the EPA-approved New Hampshire PAMS Quality Assurance Project Plan (QAPP), which ensures certain quality control implements are in place to maintain high quality PAMS data.

In addition to calibration and blank samples run on a bi-weekly basis at each PAMS site, NHDES coordinates with the EPA Region One Lab and runs a National Institute of Standards & Technology (NIST) standard once per month during the PAMS season. NHDES supplies the EPA lab with a summa canister, which they fill with the NIST standard. Results are compared to the known results and submitted to EPA. Acceptance criteria are considered ≤ 20 percent difference for each compound.

Tables 2 and 3 below provide example NIST canister results from each site in 2014. In summary, NHDES saw excellent results for the 2014 season with no corrective actions necessary. Compounds highlighted in green are calibration compounds used for quantification in the calibration curve for Gilson Road and Miller State Park, respectively.

Table 2: NIST Quality Control Results for Gilson Road (parts per billion - ppbc)

EPA QC Can Run #1 6/4/14
@ 7:05 Gilson Rd.

Compound	Reference Concentration (ppbc)	NH Test Results (ppbc)	Difference (ppbc)	Difference (%)
Ethane	10.76	10.37	0.39	3.62
Propane	17.01	16.08	0.93	5.47
Propylene	16.26	13.58	2.68	16.48
Iso-butane	22.84	23.67	-0.83	-3.63
n-Butane	22.28	24.15	-1.87	-8.39
Iso-Pentane	26.30	28.06	-1.76	-6.69
n-Pentane	26.60	28.49	-1.89	-7.11
1-Pentene	25.70	22.11	3.59	13.97
n-Hexane	31.68	30.53	1.15	3.63
Heptane	37.87	34.67	3.2	8.45
Benzene	33.24	29.97	3.27	9.84
Iso-octane(2,2,4-TMB)	42.48	38.63	3.85	9.06
n-Octane	41.84	39.32	2.52	6.02
Toluene	37.80	30.24	7.56	20.00
nonane	46.53	46.19	0.34	0.73
o-Xylene	43.44	33.43	10.01	23.04
n-Decane	53.70	49.38	4.32	8.04

Table 3: NIST Quality Control Results for Miller State Park (parts per billion - ppbc)

EPA QC Can Run #1 6/5/14
@ 8:40 Miller State Park

Compound	Reference Concentration (ppbc)	NH Test Results (ppbc)	Difference (ppbc)	Difference (%)
Ethane	10.76	10.46	0.3	2.79
Propane	17.01	16.95	0.06	0.35
Propylene	16.26	14.52	1.74	10.70
Iso-butane	22.84	25.7	-2.86	-12.52
n-Butane	22.28	26.42	-4.14	-18.58
Iso-Pentane	26.30	29.21	-2.91	-11.06
n-Pentane	26.60	30.03	-3.43	-12.89
1-Pentene	25.70	23.57	2.13	8.29
n-Hexane	31.68	33.13	-1.45	-4.58
Heptane	37.87	39.78	-1.91	-5.04
Benzene	33.24	31.97	1.27	3.82
Iso-octane(2,2,4-TMB)	42.48	45.22	-2.74	-6.45
n-Octane	41.84	46.39	-4.55	-10.87
Toluene	37.80	35.77	2.03	5.37
nonane	46.53	48.24	-1.71	-3.68
o-Xylene	43.44	38.21	5.23	12.04
n-Decane	53.70	48.08	5.62	10.47

New Hampshire PAMS sites also collect and run a 24-hour ambient canister sample every six days. To incorporate precision data in the quality check routine, one sample can is analyzed per month as a duplicate per site. Acceptance criteria is defined as ± 20 percent for compounds greater than five parts per billion times carbon (ppbc) and ± 25 percent for compounds between one and five ppbc. Tables 4 and 5 below provide examples from each site. Compounds highlighted in blue are eligible to meet precision requirements. Again, no quality control concerns were reported for the 2014 PAMS season.

Table 4: Canister Samples for Gilson Road

AIRS	COMPOUND Gilson Rd.	Run #1 6/16/14 (ppbc)	Run #2 6/23/14 (ppbc)	DIFFERENCE (ppbc)	DIFFERENCE (%)
43202	Ethane	2.23	2.43	-0.20	-8.97
43203	Ethylene	0.62	0.63	-0.01	-1.61
43204	Propane	3.51	3.82	-0.31	-8.83
43205	Propylene	0.29	0.44	-0.15	-51.72
43214	Isobutane	0.31	0.36	-0.05	-16.13
43212	n-Butane	0.64	0.66	-0.02	-3.13
43206	Acetylene	0.24	0.27	-0.03	-12.50
43242	Cyclopentane	0.12	0.13	-0.01	-8.33
43221	Isopentane	0.82	0.87	-0.05	-6.10
43220	n-Pentane	0.57	0.56	0.01	1.75
43243	Isoprene	2.83	3.23	-0.40	-14.13
43231	n-Hexane	0.18	0.21	-0.03	-16.67
43262	Methylcyclopentane	0.13	0.17	-0.04	-30.77
45201	Benzene	0.76	0.76	0.00	0.00
43263	2-Methylhexane	0.10	0.12	-0.02	-20.00
43249	3-Methylhexane	0.15	0.17	-0.02	-13.33
43250	2,2,4-Trimethylpentane	0.31	0.34	-0.03	-9.68
43232	n-Heptane	0.15	0.16	-0.01	-6.67
43252	2,3,4-Trimethylpentane	0.11	0.14	-0.03	-27.27
45202	Toluene	0.83	0.89	-0.06	-7.23
43960	2-Methylheptane	0.07	0.09	-0.02	-28.57
43233	n-Octane	0.14	0.16	-0.02	-14.29
45203	Ethylbenzene	0.13	0.12	0.01	7.69
45109	m&p-Xylene	0.33	0.38	-0.05	-15.15
45204	o-Xylene	0.12	0.12	0.00	0.00
43235	n-Nonane	0.12	0.11	0.01	8.33
45212	m-Ethyltoluene	1.90	2.13	-0.23	-12.11
45207	1,3,5-Trimethylbenzene	0.12	0.09	0.03	25.00
45211	o-Ethyltoluene	0.18	0.28	-0.10	-55.56
45208	1,2,4-Trimethylbenzene	1.10	1.16	-0.06	-5.45
43238	n-Decane	0.15	0.14	0.01	6.67
45225	1,2,3-Trimethylbenzene	5.20	4.97	0.23	4.42
43102	Total Non-Methane Organic Compounds	30.33	31.53	-1.20	-3.96
43000	Sum PAMS Target Species	24.46	26.11	-1.65	-6.75
43131	Unidentified	5.87	5.42	0.45	7.67

* All PAMS target species that are not listed above were below detection limits.

Table 5: Canister Samples for Miller State Park

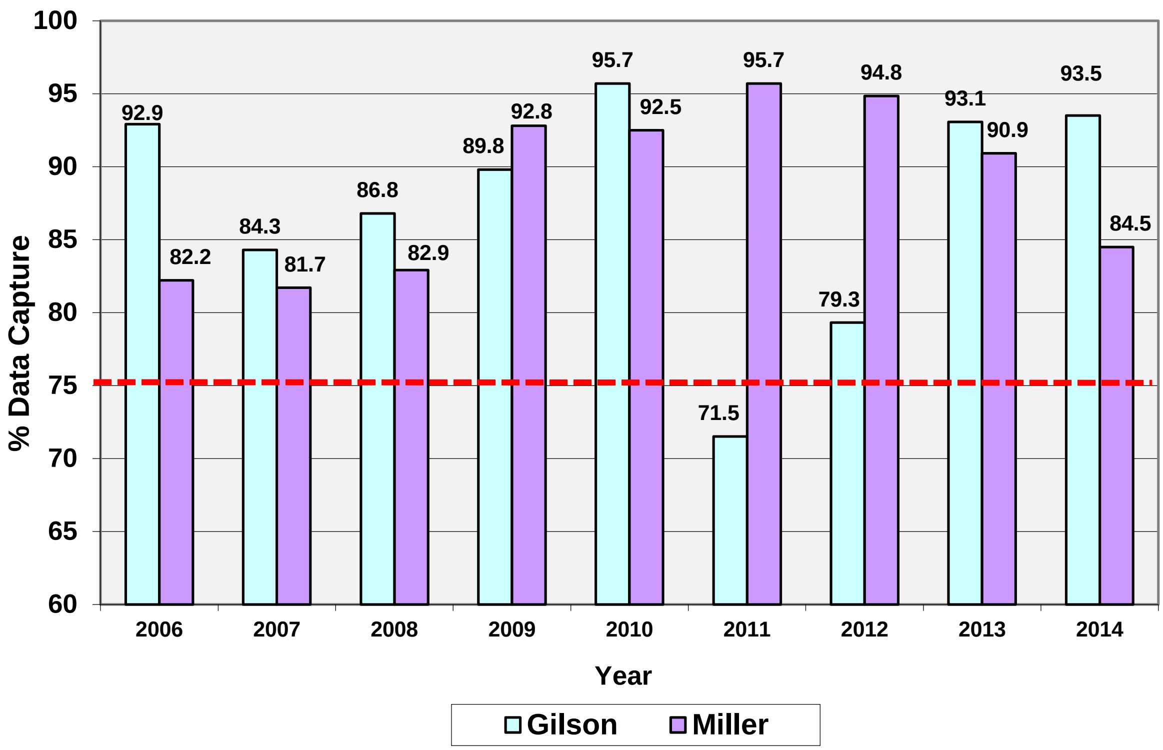
AIRS	COMPOUND MSP	Run #1 7/24/14 (ppbc)	Run #2 8/5/14 (ppbc)	DIFFERENCE (ppbc)	DIFFERENCE (%)
43202	Ethane	3.16	3.24	-0.08	-2.53
43203	Ethylene	0.55	0.53	0.02	3.64
43204	Propane	2.12	2.28	-0.16	-7.55
43205	Propylene	0.41	0.53	-0.12	-29.27
43214	Isobutane	0.46	0.78	-0.32	-69.57
43212	n-Butane	0.89	1.24	-0.35	-39.33
43206	Acetylene	0.39	0.42	-0.03	-7.69
43242	Cyclopentane	0.18	0.19	-0.01	-5.56
43221	Isopentane	1.69	1.96	-0.27	-15.98
43220	n-Pentane	0.86	1.29	-0.43	-50.00
43224	1-Pentene	0.20	0.20	0.00	0.00
43284	2,3-Dimethylbutane	0.15	0.11	0.04	26.67
43285	2-Methylpentane	0.39	0.38	0.01	2.56
43230	3-Methylpentane	0.22	0.20	0.02	9.09
43243	Isoprene	5.63	4.43	1.20	21.31
43231	n-Hexane	0.46	0.73	-0.27	-58.70
43262	Methylcyclohexane	0.20	0.65	-0.45	-225.00
45201	Benzene	0.45	1.05	-0.60	-133.33
43250	2,2,4-Trimethylpentane	0.41	0.93	-0.52	-126.83
43252	2,3,4-Trimethylpentane	0.17	0.14	0.03	17.65
45202	Toluene	0.83	1.43	-0.60	-72.29
43233	n-Octane	0.14	0.14	0.00	0.00
45203	Ethylbenzene	0.20	0.15	0.05	25.00
45109	m&p-Xylene	0.29	0.27	0.02	6.90
45204	o-Xylene	0.14	0.18	-0.04	-28.57
43235	n-Nonane	0.15	0.68	-0.53	-353.33
45213	p-Ethyltoluene	1.03	1.13	-0.10	-9.71
45208	1,2,4-Trimethylbenzene	0.19	0.15	0.04	21.05
43238	n-Decane	0.11	0.89	-0.78	-709.09
45225	1,2,3-Trimethylbenzene	2.29	2.15	0.14	6.11
43954	n-Undecane	0.16	0.14	0.02	12.50
43102	Total Non-Methane Organic Compounds	30.60	39.41	-8.81	-28.79
43000	Sum PAMS Target Species	55.12	68.00	-12.88	-23.37
43131	Unidentified	-24.52	-28.59	4.07	-16.60

* All PAMS target species that are not listed above were below detection limits.

Data capture rates met the EPA acceptance criteria of 75 percent at both sites for 2014 (red dotted line in Figure 2). The majority of data loss at the Miller State Park site resulted from software issues that shut down sampling prior to long weekends when the station was unattended. Restarting the equipment corrected this issue, but multiple samples were lost due to the inadvertent timing.

Gilson Road site had an instrument issue during the middle of September. Since the official New Hampshire PAMS season runs from June 1 through August 30, no seasonally required data was lost and, rather than working to rectify operations, the equipment was shut down in preparation of its move to Londonderry. Data capture rates for the season do not reflect this lack of data.

Figure 2: Data Capture Rates 2006-2014



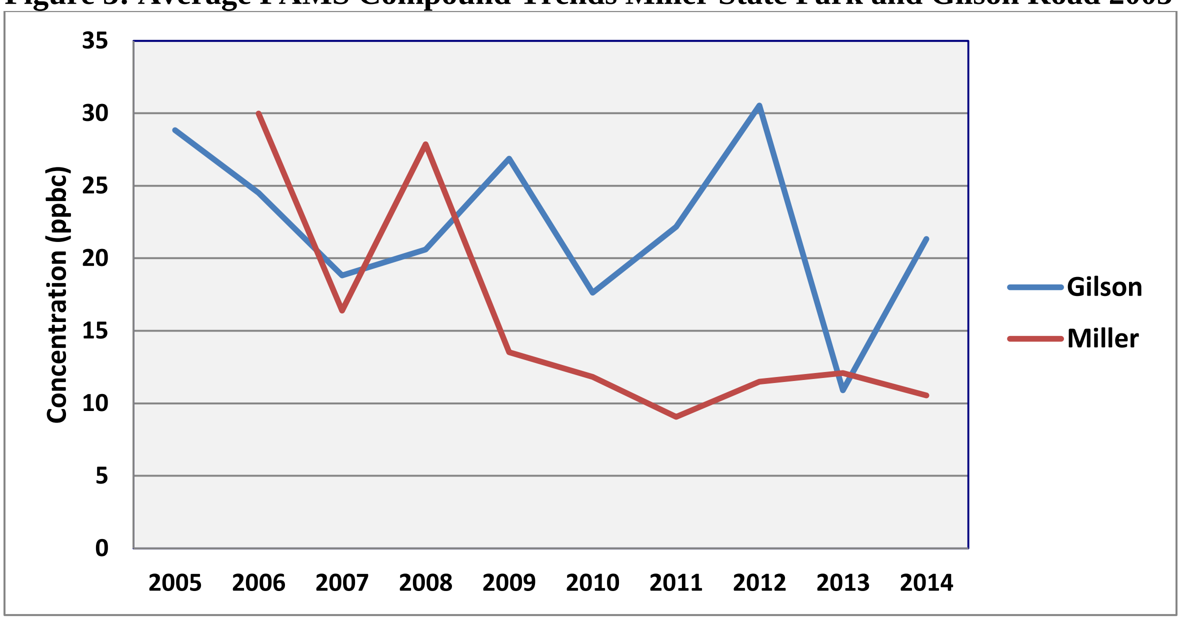
4. DATA ANAYLSIS

Figure 3 below shows average PAMS compound concentrations at the Gilson Road and Miller State Park sites since 2005. September 2014 data included in the chart only captures up to September 10, 2014, due to an instrument issue described in section three.

As seen in Figure 3, average PAMS compound concentrations at the Gilson Road site have been variable, but have generally declined in the last ten years. However, between 2013 and 2014, this site saw a nearly a 50 percent increase average concentrations. No exceptional events were noted during 2014, and 2014 concentrations are more in line with previous years, except that 2009 data was biased high due to a local paving event that summer.

At the Miller State Park site, concentrations have remained relatively stable, with the exception of 2006 and 2008. The 2008 data was skewed due to the installation of new instrumentation as footnoted below.

Figure 3: Average PAMS Compound Trends Miller State Park and Gilson Road 2005-2014



*2005 Gilson Road data do not include September.
*****2008 Miller data are biased high due to the installation of new instrumentation and subsequent contamination of high molecular weight compounds.
*****2009 Gilson Road data are biased high due to influence from a local paving project that took place that year.
*2014 Gilson Road data only includes September data up until September 10.

Figures 4 and 5 below provide another illustration of yearly trends, depicting Total Non-Methane Organic Compounds (TNMOC) and total PAMS concentrations compared to concentration trend lines (red line). The declines in concentration are much more gradual at Gilson Road than at Miller State Park. Miller State Park's decline is steeper primarily due to the high concentrations of 2006 and 2008; the years 2009 through 2014 show little change.

Figure 4: TNMOC and PAMS Averages for Gilson Road 2005-2014

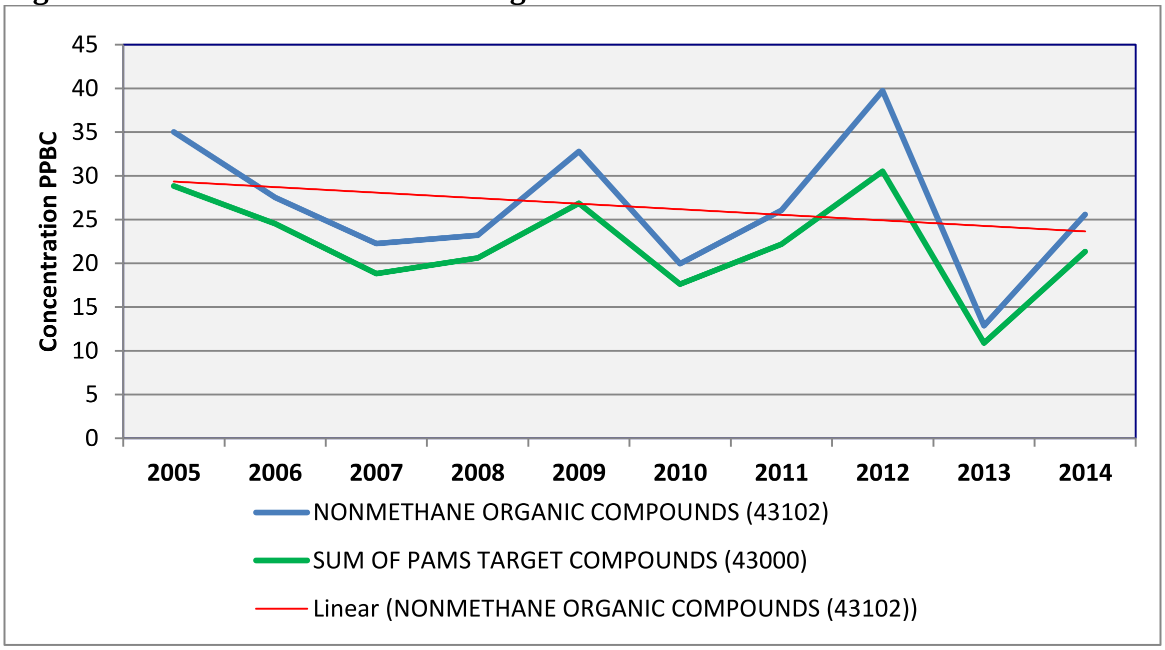
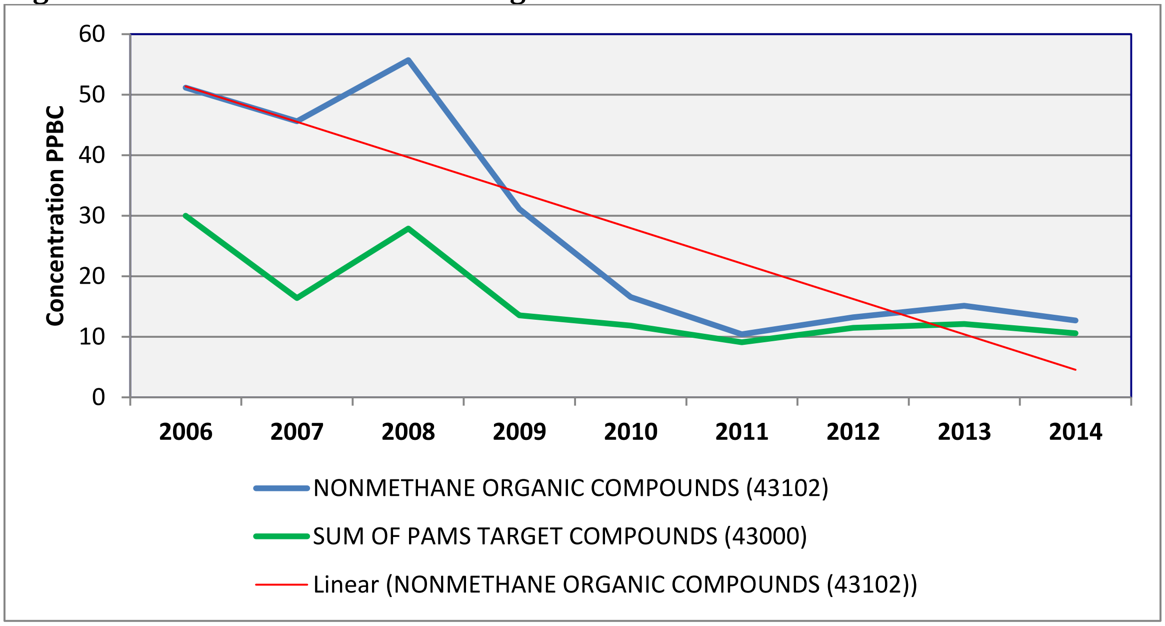


Figure 5: TNMOC and PAMS Averages for Miller State Park 2006-2014



*2005 Gilson Road data do not include September.
*****2008 Miller data are biased high due to the installation of new instrumentation and subsequent contamination of high molecular weight compounds.
*****2009 Gilson Road data are biased high due to influence from a local paving project that took place that year.
*2014 Gilson Road data only includes September data up until September 10.

Tables 6 and 7 summarize the most abundant organic compounds for each site. Compounds highlighted in green are most abundant at both sites, while ones in red are unique to that site. The pollutants in greatest abundance at each are very similar in 2014, though Gilson Road experienced higher concentrations.

Table 6: Top 10 Most Abundant Compounds Gilson Road 2014

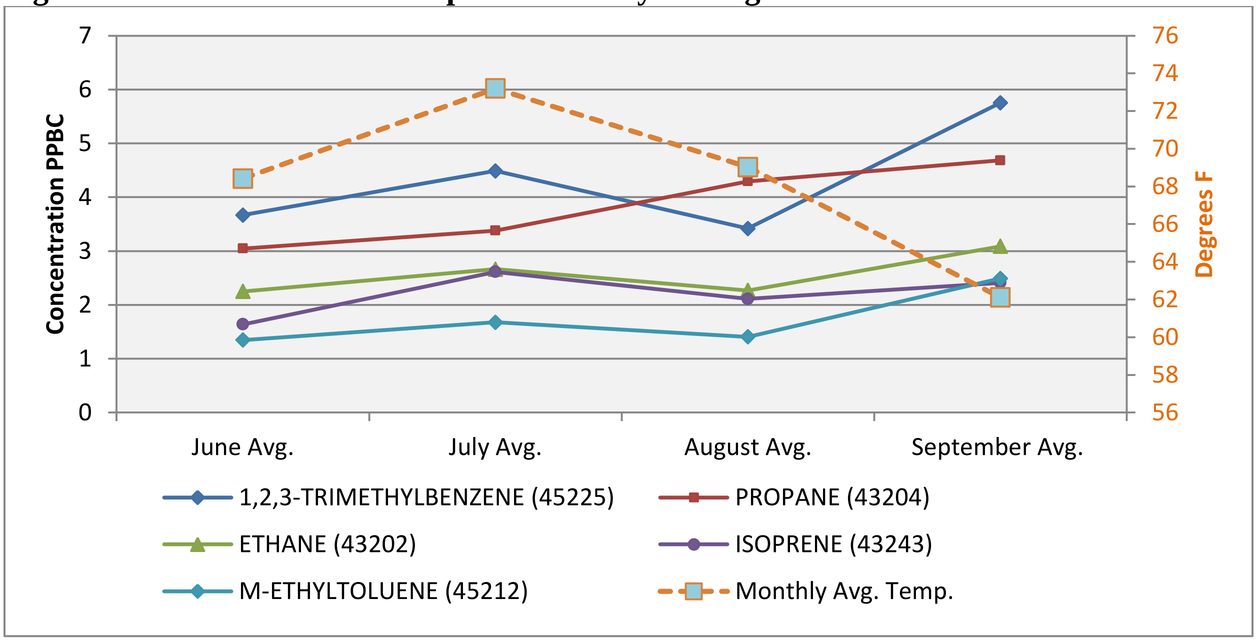
Gilson Road	Average Concentration (ppbc)	Max Concentration (ppbc)
1,2,3-TRIMETHYLBENZENE	3.99	28.82
PROPANE	3.66	37.54
ETHANE	2.44	13.4
ISOPRENE	2.15	19.43
M-ETHYLTOLUENE	1.55	14.24
ISOPENTANE	0.92	7.92
TOLUENE	0.84	57.21
BUTANE	0.67	4.43
PENTANE	0.59	3.31
ETHYLENE	0.46	3.06

Table 7: Top 10 Most Abundant Compounds Miller State Park 2014

Miller State Park	Average Concentration (ppbc)	Max Concentration (ppbc)
ETHANE	2.41	6.99
ISOPRENE	1.81	16.44
PROPANE	1.28	10.76
1,2,3-TRIMETHYLBENZENE	0.89	5.2
P-ETHYLTOLUENE	0.49	2.11
TOLUENE	0.46	2.63
ISOPENTANE	0.46	8.1
BUTANE	0.43	9.65
ACETYLENE	0.28	1.55
BENZENE	0.27	1.2

The five most abundant compounds are the same at both sites. Generally July and August are the months with the highest averages. Gilson Road's September data are likely biased high due to low data capture that month, since the end of September usually results in cooler weather and lower PAMS results.

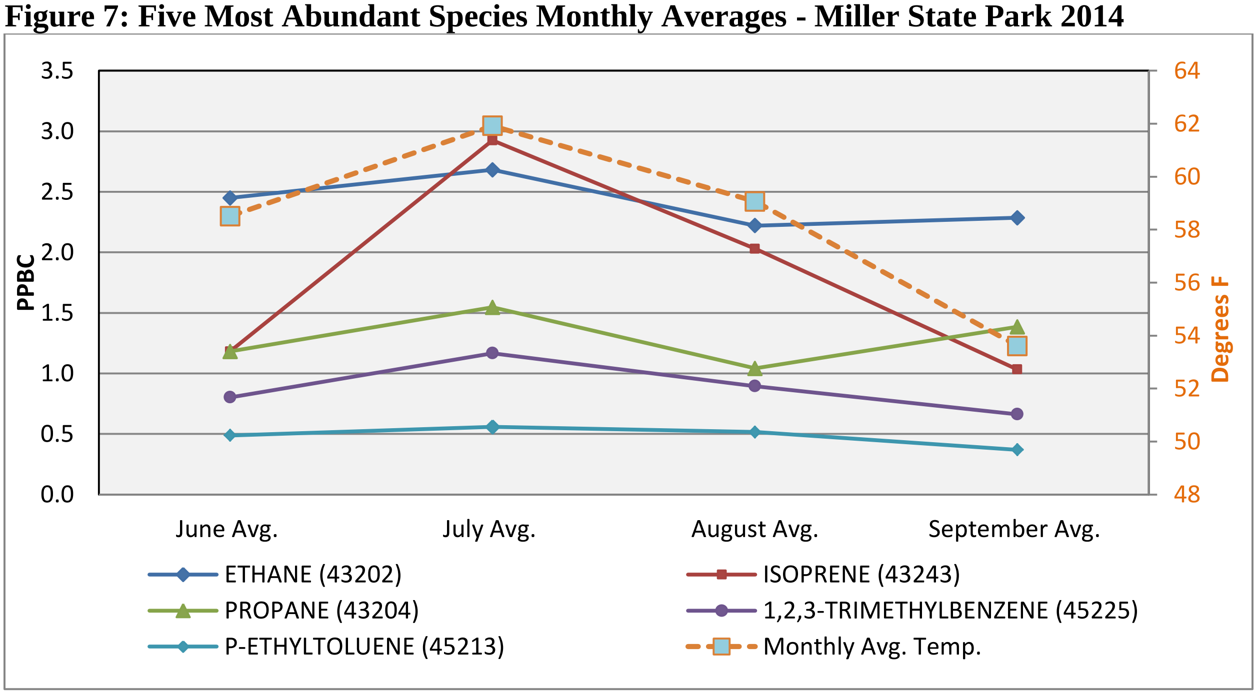
Figure 6: Five Most Abundant Species Monthly Averages - Gilson Road 2014



*2014 Gilson Road data only include September data up until September 10.

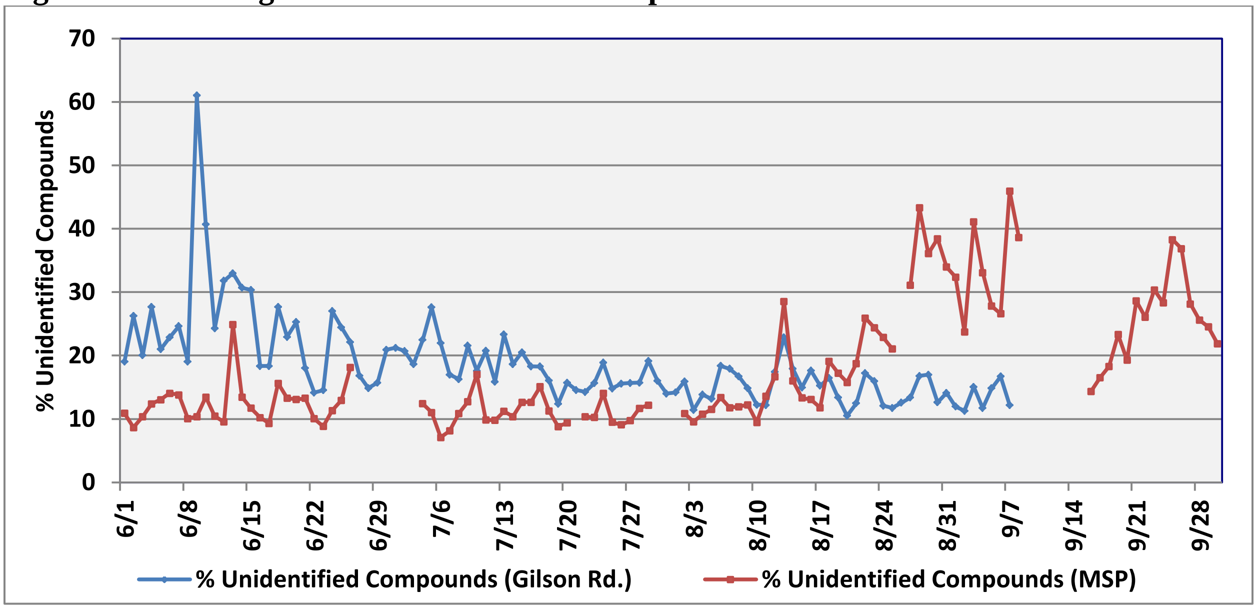
The highest concentrations of the most abundant species at Miller State Park occur in July. This pattern mirrors average monthly temperature at that site.

Figure 7: Five Most Abundant Species Monthly Averages - Miller State Park 2014



In addition to TNMOC and total PAMS compounds, unidentified PAMS compounds can be estimated by taking the difference between total PAMS and TNMOC concentrations. As seen in Figure 8 below, these unidentified compounds can sometimes add up to a large percentage of TNMOC. The Gilson Road site appears to see more unidentified compounds in the beginning of the season, whereas unidentified compounds increase toward the end of the season at Miller State Park. The reason for this is uncertain.

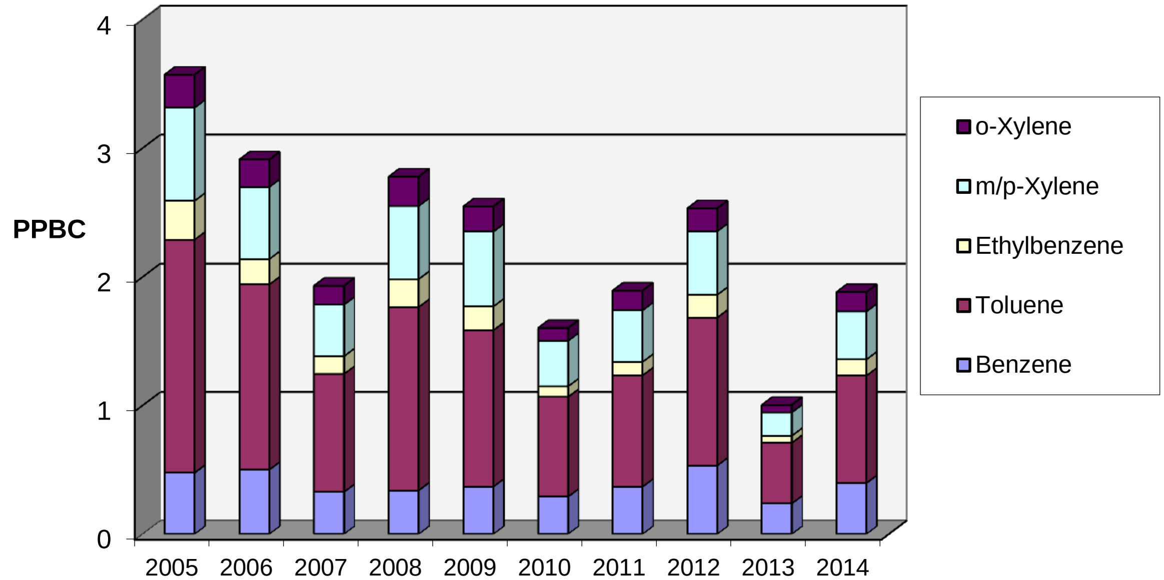
Figure 8: Percentage of 2014 Unidentified Compounds



Trending of select compound groups is a useful way to analyze PAMS data. The concept is to group compounds associated with certain types of emission sources to determine how those emissions trend over time and how they appear to affect ozone forming potential. One such grouping includes benzene, toluene, ethylbenzene, and xylene (or BTEX), which are emitted from petroleum derivatives such as gasoline. Another group representing fuel oils consists of butane, butane, propane, and propylene.

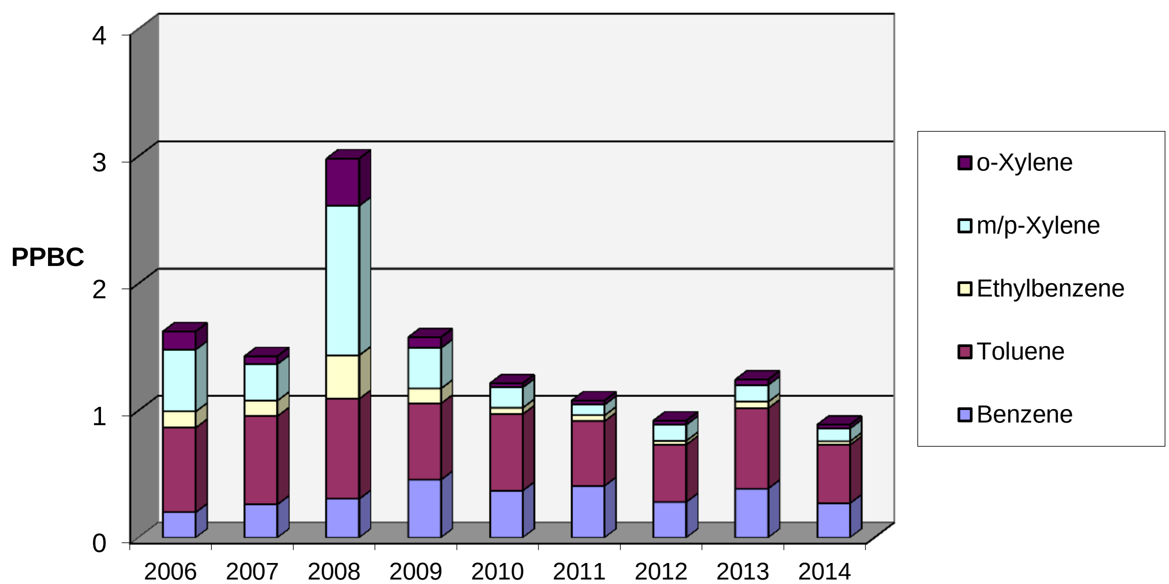
As expected, the Gilson Road location sees higher values for the BTEX compounds due in part to its location in a more urban area and near heavily traveled roadways. The Miller State Park site is much more remote from emission sources and at a higher elevation; as a result this site sees lower BTEX concentrations than those at Gilson Road. Despite some year-to-year variability, BTEX compound concentrations have clearly trended downward since 2005.

Figure 9: Yearly Averages of BTEX Compounds Gilson Road PAMS



*2005 Gilson Road data do not include September.
*2009 Gilson Road data are biased high due to influence from a local paving project that took place that year.
*2014 Gilson Road data only include September data up until September 10.

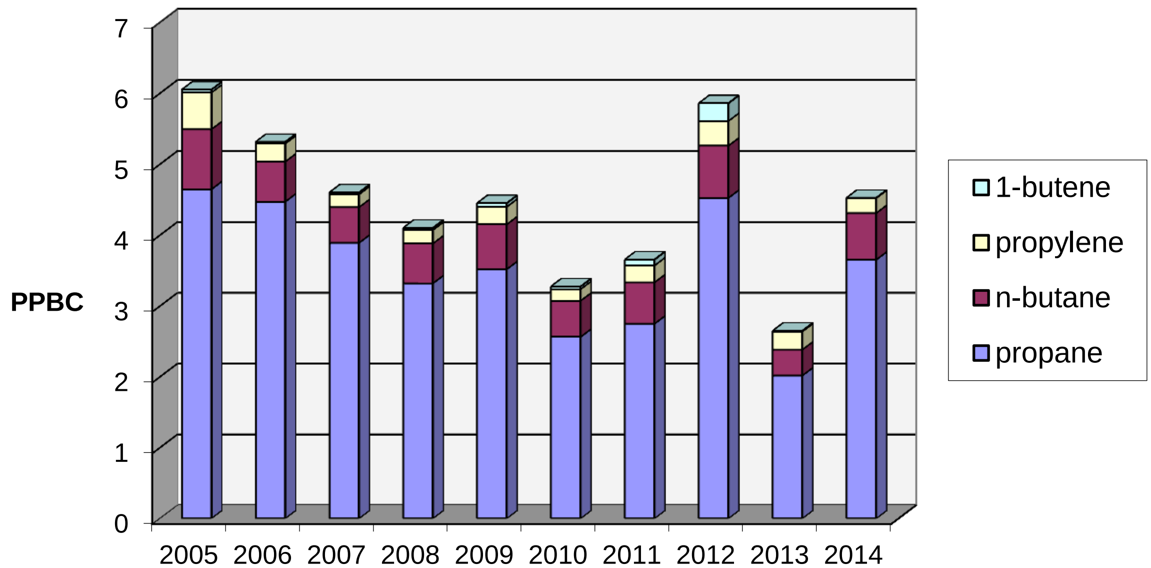
Figure 10: Yearly Averages of BTEX Compounds Miller State Park PAMS



*2008 Miller State Park data are biased high due to the installation of new instrumentation and subsequent contamination of high molecular weight compounds.

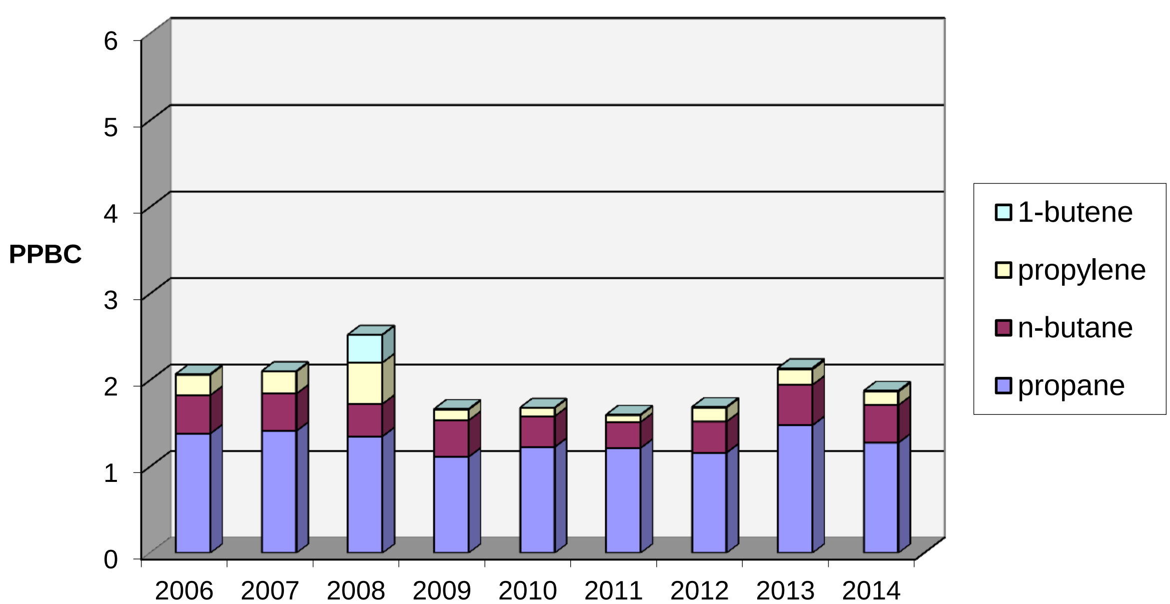
Figures 11 and 12 summarize Gilson Road and Miller State Park trends for compounds associated fuel oils (heating appliances and vehicles). Fuel oil group concentration trends at Miller State Park are generally steady while Gilson Road sees a downward trend with more yearly fluctuation.

Figure 11: Yearly Fuel Oil Compound Averages for Gilson Road PAMS



*2005 Gilson Road data do not include September.
*2009 Gilson Road data are biased high due to influence from a local paving project that took place that year.
*2014 Gilson Road data only include September data up until September 10.

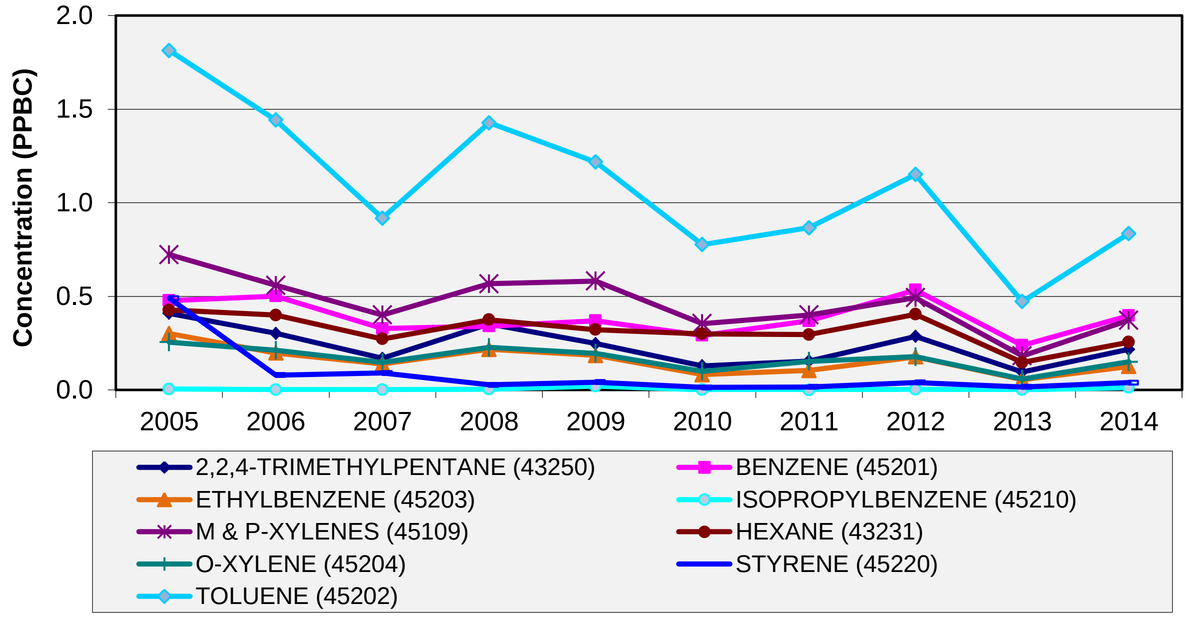
Figure 12: Yearly Fuel Oil Compound Averages for Miller State Park PAMS



*2008 Miller data are biased high due to the installation of new instrumentation and subsequent contamination of high molecular weight compounds.

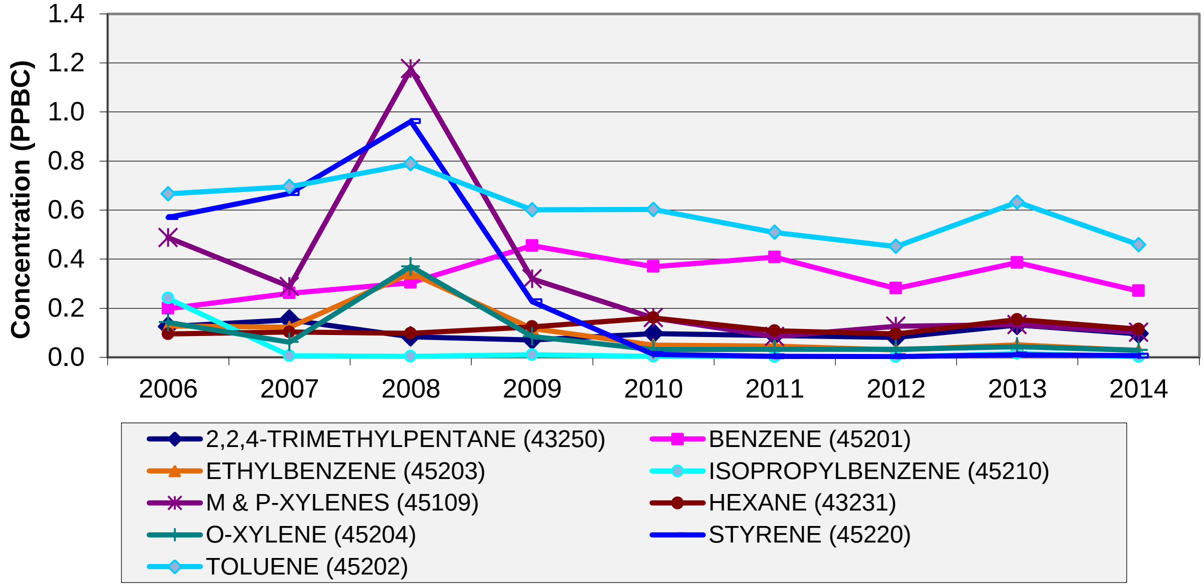
Hazardous Air Pollutants (HAPs) are chemicals which can cause adverse effects to human health or the environment. About 188 compounds have been identified in this group including substances that cause cancer, neurological, respiratory, and reproductive effects. A number of the PAMS compounds have been identified as HAPs. PAMS monitoring is currently the only consistent method to measure these concentrations in ambient air in New Hampshire. HAPs at Gilson Road show a slight increase in 2014 while Miller sees a slight decrease in 2014.

Figure 13: Trends of HAPs Gilson Road 2005-2014



*2005 Gilson Road data do not include September.
*2009 Gilson Road data are biased high due to influence from a local paving project that took place that year.
*2014 Gilson Road data only include September data up until September 10.

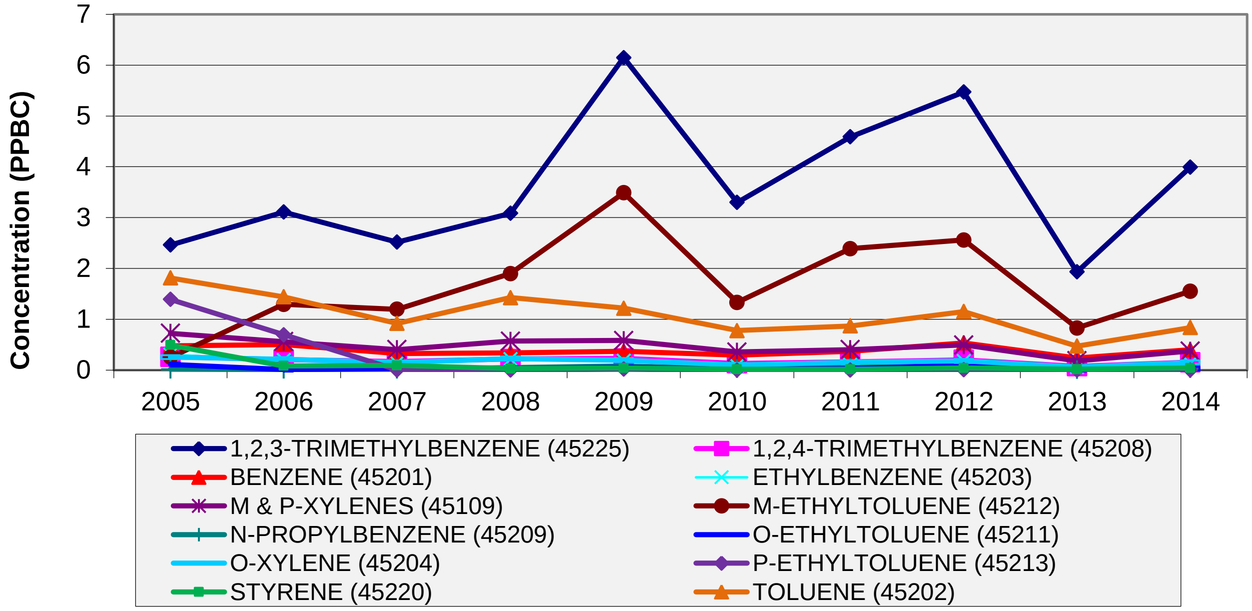
Figure 14: Trends of HAPs Miller State Park 2006-2014



*2008 Miller data are biased high due to the installation of new instrumentation and subsequent contamination of high molecular weight compounds.

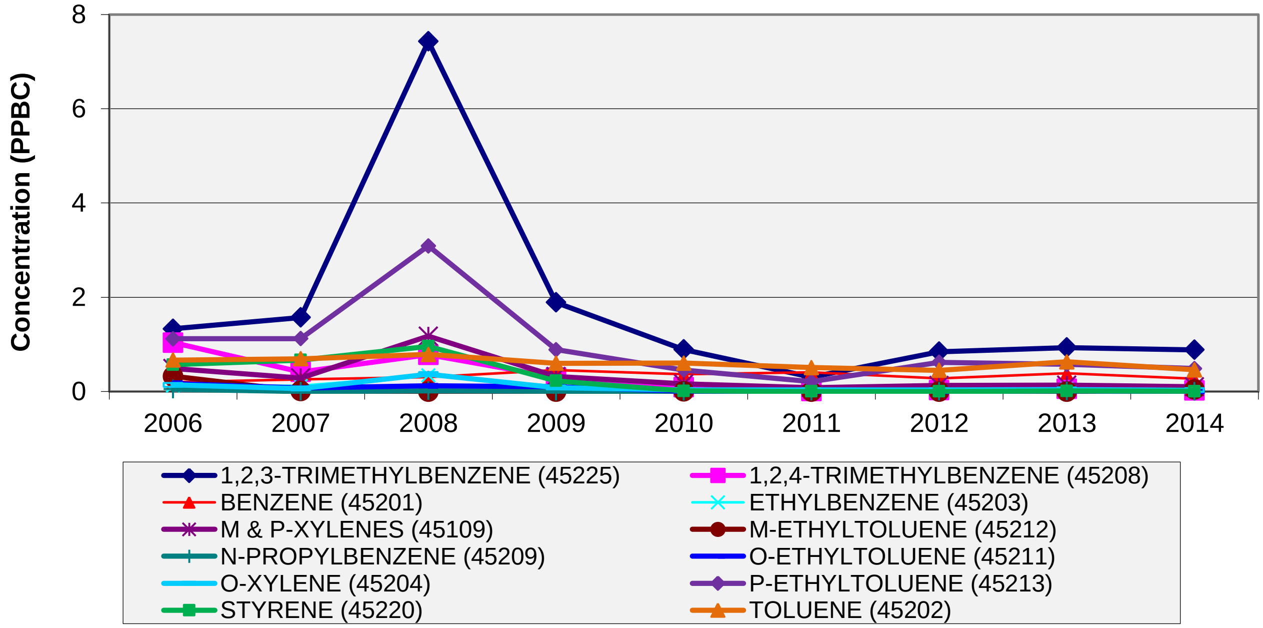
Several PAMS compounds are also categorized as Secondary Organic Aerosol Precursors (SOAP). These are organic compounds that reside in the aerosol phase as a function of atmospheric reactions that occur in either the gas or particle phases. The full list of SOAP compounds has been cross referenced with the PAMS list, and the following graphs depict level or slightly increasing trends for SOAP compounds identified within the PAMS reporting list.

Figure 15: Trends of SOAP Compounds Gilson Road 2005-2014



*2005 Gilson Road data do not include September.
*2009 Gilson Road data are biased high due to influence from a local paving project that took place that year.
*2014 Gilson Road data only include September data up until September 10.

Figure 16: Trends of SOAP Compounds Miller State Park 2006-2014

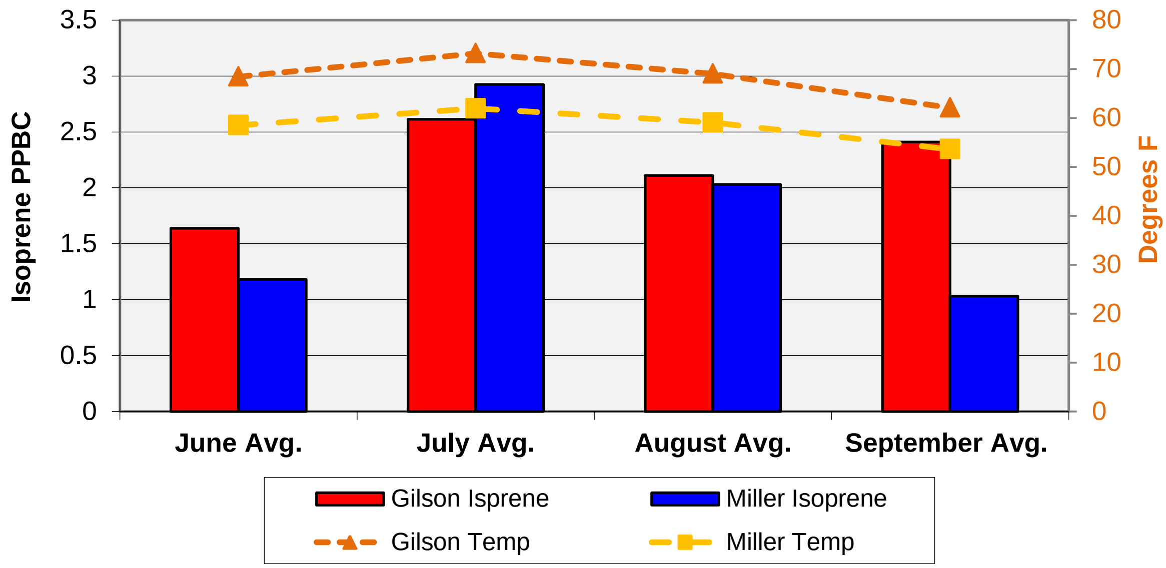


*2008 Miller data are biased high due to the installation of new instrumentation and subsequent contamination of high molecular weight compounds.

Differences in ozone-producing photochemical reactivity provide evidence that not all VOCs are equal in their contribution to ozone formation. While isoprene concentrations can be lower than other VOCs, it can account for a significant amount of the ozone-forming potential, especially in non-urban areas. Isoprene concentrations are usually highest during the middle of the day when solar ultraviolet (UV) radiation and air temperatures are highest and most conductive to ozone formation.

Isoprene emissions are largely natural and emitted by varying types of vegetation. Its emissions are thought to be influenced by factors that affect tree health and growth such as rainfall and severe temperatures. The majority of isoprene emissions in the Northeast come largely from oak and spruce trees. Figure 17 shows how Gilson Road and Miller State Park average monthly isoprene concentrations compare in 2014. Figure 18 depicts isoprene concentration trends since 2005. The higher temperatures at Gilson Road likely contribute to the increase in isoprene concentrations at that site.

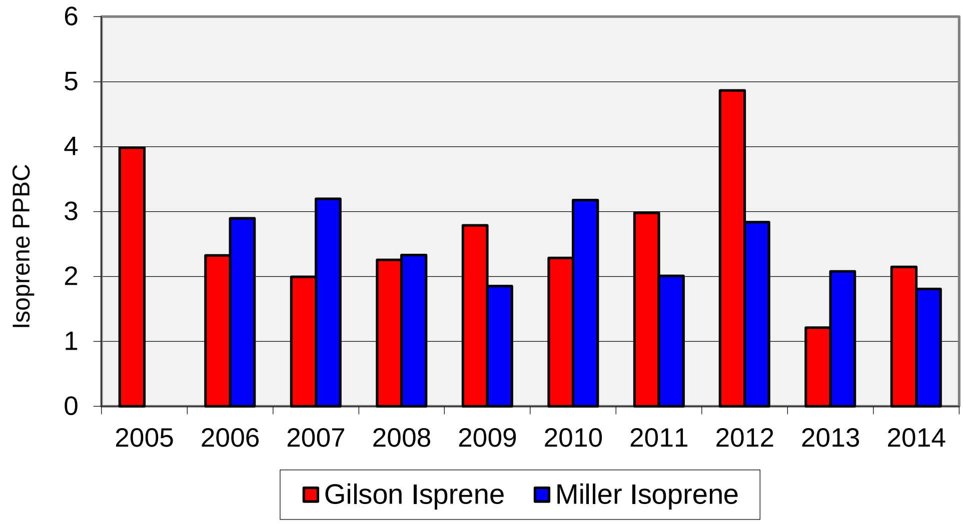
Figure 17: Isoprene Monthly Averages Miller State Park and Gilson Road 2014



*2014 Gilson Road data only include September data up until September 10.

The graph below provides a good visual of how isoprene concentrations were lower during 2013 and 2014, which had cooler and wetter summers.

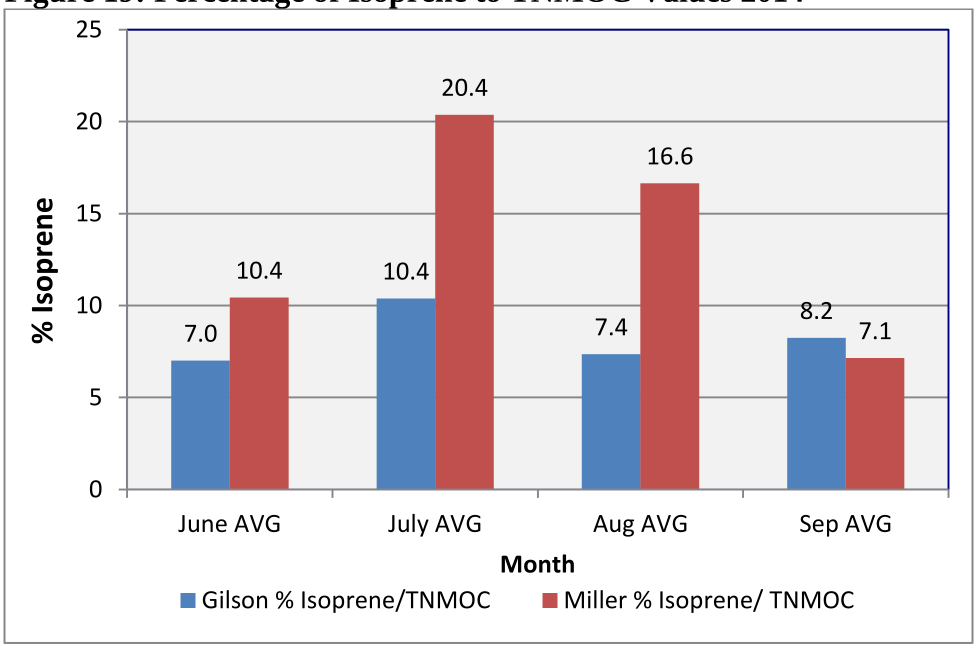
Figure 18: Yearly Isoprene Averages Miller State Park and Gilson Road



*2005 Gilson Road data do not include September.
*2014 Gilson Road data only include September data up until September 10.

Although isoprene concentrations are generally higher at Gilson Road, isoprene makes up a higher percentage of TNMOC at Miller State Park, especially during the two hottest months of the season. Gilson Road concentrations are a bit skewed downward for September as they do not represent the entire month as mentioned in section 3 (see footnote).

Figure 19: Percentage of Isoprene to TNMOC Values 2014



*2014 Gilson Road data only include September data up until September 10.

Figure 20 demonstrates how isoprene concentrations vary with temperature at Gilson Road. Figure 21 shows the relationship between isoprene, temperature, and UV radiation at Miller State Park. Generally, ozone increases with higher daytime temperatures.

Figure 20: 24 Hour Averages Temperature, and Isoprene at Gilson Road 2014

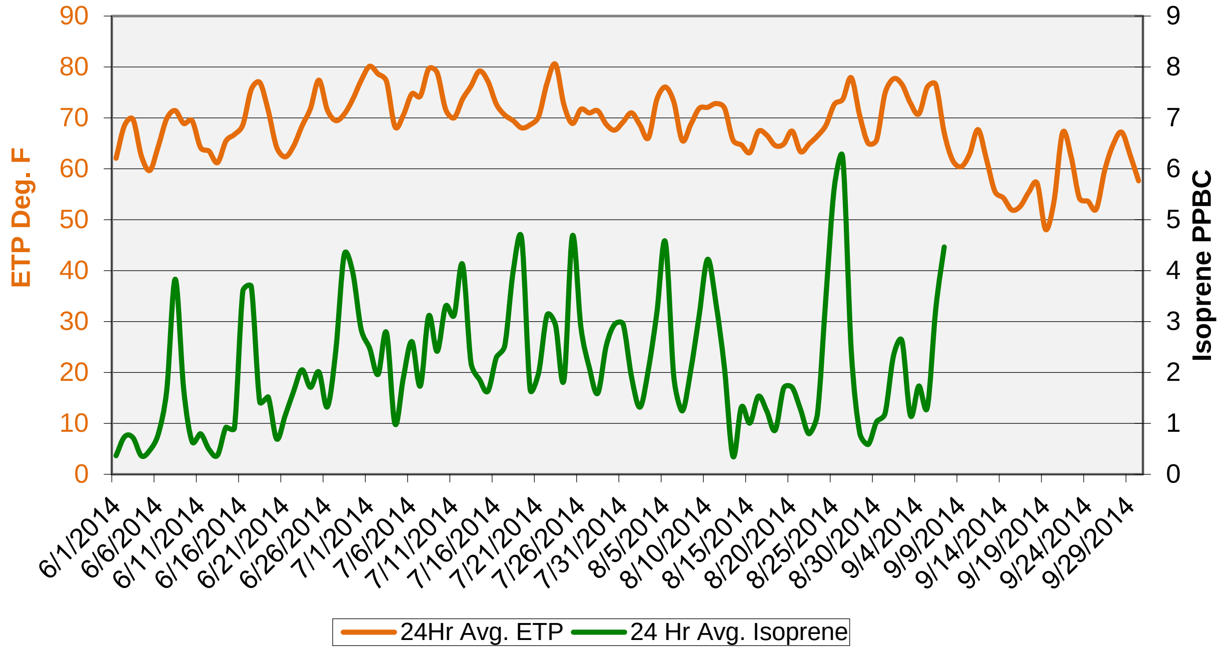


Figure 21: 24 Hour Averages Temperature, UV Radiation, and Isoprene at Miller State Park 2014

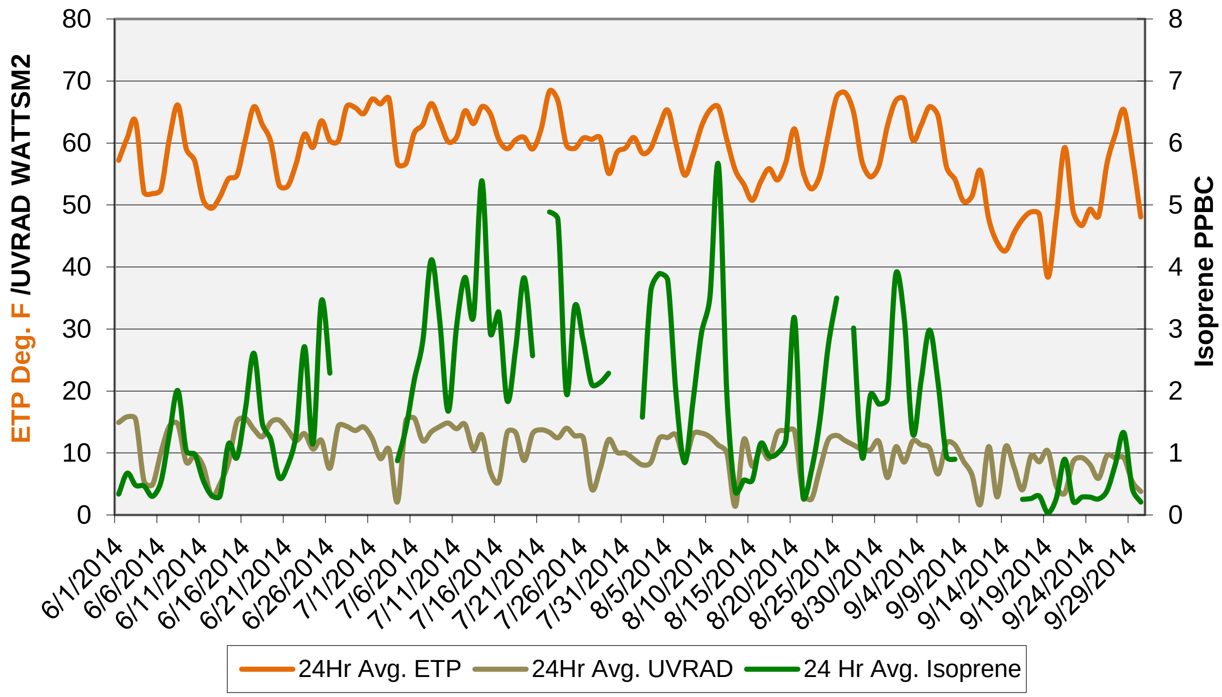
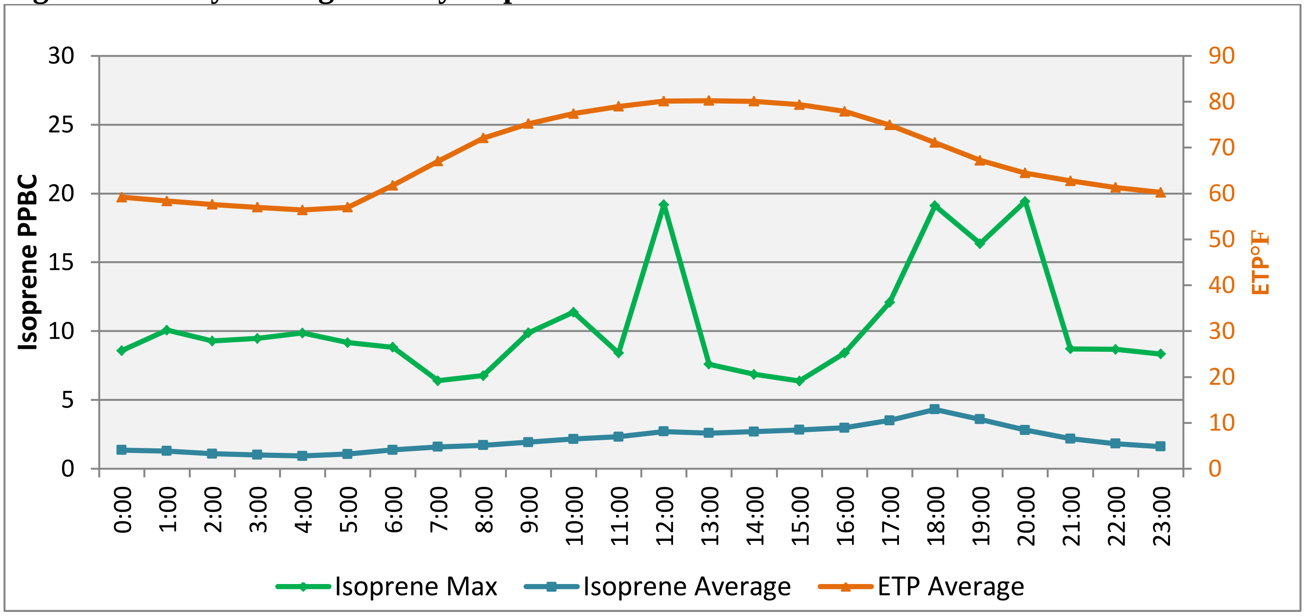


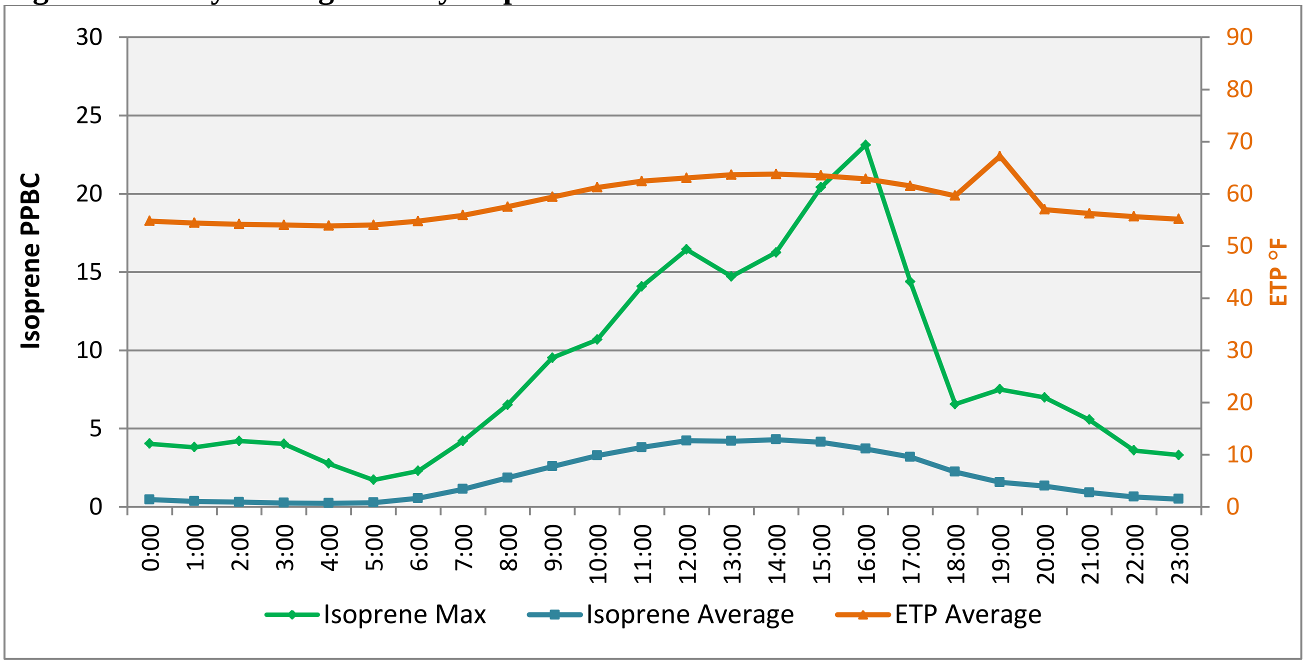
Figure 22 shows average diurnal isoprene concentrations and how they changed with temperature during the 2014 summer season. Generally, isoprene concentrations peak shortly after temperatures peak and into the early evening hours. On an individual day, hourly isoprene patterns are not as smooth as the average values over a season because peak concentrations often result from brief, isolated events.

Figure 22: Daily Average Hourly Isoprene Gilson Road 2014



Contradictory to isoprene averages at Gilson Road, values at Miller State Park peak between midday and early afternoon, correlating with peak temperature values.

Figure 23: Daily Average Hourly Isoprene Miller State Park 2014



Tables 8 and 9 (next two pages) summarize the Ambient Allowable Limits (AAL's) for the toxic PAMS parameters at each site. The AALs are a health-based ambient air guideline used to evaluate potential human health risks from exposures to chemicals in ambient air. Measured benzene concentrations at Gilson Road and Miller State Park are about 20 percent of the AAL. Apparently, benzene is widespread horizontally and vertically in the lower atmosphere in the Northeast. All other PAMS compounds with an assigned AAL consistently measure less than 1 percent of their AAL.

Table 8: Seasonal 24-hour Values at Gilson Road for Toxic Species vs. AAL

Seasonal 24-hour Max Values at Gilson Rd. for Toxic PAMS Species Compared to the Ambient Allowable Limit

PAMS Parameter	AAL ug/m3	Max 24 Hour Avg. (ug/m3)										Max as % of AAL
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	
PROPYLENE (43205)	35,833	0.55	0.34	0.30	0.33	0.35	0.20	1.29	1.49	0.28	0.33	0.00%
CYCLOPENTANE (43242)	25,595	0.23	0.23	0.16	0.13	0.15	0.10	0.30	1.12	0.07	0.18	0.00%
ISOPENTANE (43221)	36,875	2.04	2.50	1.56	1.41	1.23	1.13	4.58	11.95	0.75	1.30	0.03%
PENTANE (43220)	36,875	3.13	1.39	0.85	0.74	0.76	0.61	1.99	6.05	0.47	0.84	0.02%
2-METHYLPENTANE (43285)	36,875	0.60	0.78	0.21	0.35	0.25	0.18	0.45	2.26	0.09	0.15	0.01%
3-METHYLPENTANE (43230)	36,875	0.41	0.48	0.20	0.30	0.20	0.25	0.44	1.65	0.09	0.13	0.00%
HEXANE (43231)	885	0.59	0.58	0.47	0.74	0.51	1.18	1.17	1.89	0.21	0.54	0.21%
BENZENE (45201)	6	0.51	0.74	0.36	0.42	0.37	0.29	1.11	1.23	0.21	0.86	21.65%
CYCLOHEXANE (43248)	6,000	0.25	0.21	0.21	0.48	0.19	0.29	0.41	0.47	0.06	0.16	0.01%
HEPTANE (43232)	8,249	0.56	0.34	0.18	0.32	0.25	0.12	0.43	1.37	0.07	0.21	0.02%
METHYLCYCLOHEXANE (43261)	23,958	0.21	0.21	0.11	0.16	0.10	0.06	0.30	0.85	0.03	0.15	0.00%
TOLUENE (45202)	5,000	2.37	2.67	1.39	1.97	1.60	1.77	2.18	5.10	0.67	1.75	0.10%
OCTANE (43233)	7,000	0.32	0.13	0.10	0.13	0.09	0.07	0.25	2.04	0.03	1.88	0.03%
ETHYLBENZENE (45203)	1,000	0.36	0.36	0.18	0.39	0.57	0.14	0.47	1.14	0.09	0.56	0.11%
M & P-XYLENES (45109)	1,550	0.88	0.96	0.68	1.15	2.04	0.45	1.22	3.49	0.24	1.07	0.22%
STYRENE (45220)	1,000	0.88	0.13	0.22	0.07	0.06	0.13	0.19	0.89	0.06	0.07	0.09%
O-XYLENE (45204)	1,550	0.32	0.36	0.26	0.40	0.40	0.16	0.56	1.26	0.10	0.51	0.08%
NONANE (43235)	15,625	0.21	0.13	0.21	0.10	0.11	0.07	0.33	0.35	0.04	2.08	0.00%
1,3,5-TRIMETHYLBENZENE (45207)	619	0.11	0.12	0.09	0.32	0.17	0.09	0.44	0.61	0.08	0.30	0.10%
1,2,4-TRIMETHYLBENZENE (45208)	619	0.32	0.39	0.32	0.39	0.31	0.18	0.47	1.25	0.19	0.21	0.20%

* All data in ug/m3

Table 9: Seasonal 24-hour Values at Miller State Park for Toxic Species vs. AAL

Seasonal 24-hour Max Values at Miller State Park for Toxic PAMS Species Compared to the Ambient Allowable Limit

PAMS Parameter	AAL ug/m3	Max 24 Hour Avg. (ug/m3)									Max as % of AAL
		2006	2007	2008	2009	2010	2011	2012	2013	2014	
PROPYLENE (43205)	35,833	0.28	0.25	0.46	0.15	0.20	0.59	0.38	0.17	0.16	0.00%
CYCLOPENTANE (43242)	25,595	0.42	0.53	1.63	0.29	0.09	0.17	0.21	0.13	0.13	0.01%
ISOPENTANE (43221)	36,875	1.03	1.09	0.70	0.89	0.75	1.84	2.32	0.95	0.73	0.01%
PENTANE (43220)	36,875	45.41	7.63	0.55	0.45	0.38	0.86	0.76	0.48	0.40	0.12%
2-METHYLPENTANE (43285)	36,875	0.19	0.27	0.04	0.06	0.04	0.30	0.25	0.06	0.07	0.00%
3-METHYLPENTANE (43230)	36,875	0.13	0.17	0.01	0.04	0.03	0.21	0.19	0.03	0.02	0.00%
HEXANE (43231)	885	0.21	0.27	0.19	0.32	1.36	1.01	0.48	0.28	0.24	0.15%
BENZENE (45201)	6	0.31	0.33	0.32	0.41	0.73	1.09	0.45	0.38	0.41	19.18%
CYCLOHEXANE (43248)	6,000	0.14	0.05	0.02	0.08	0.04	0.48	0.15	0.06	0.04	0.01%
HEPTANE (43232)	8,249	0.71	0.16	0.15	0.17	0.13	0.79	0.21	0.14	0.11	0.01%
METHYLCYCLOHEXANE (43261)	23,958	1.23	0.15	0.15	0.11	0.16	0.49	0.14	0.07	0.06	0.01%
TOLUENE (45202)	5,000	1.00	1.05	1.11	1.01	0.77	2.48	1.36	0.80	0.56	0.05%
OCTANE (43233)	7,000	0.91	0.17	0.27	0.11	0.06	0.40	0.23	0.07	0.04	0.01%
ETHYLBENZENE (45203)	1,000	0.35	0.20	0.59	0.21	0.15	0.42	0.18	0.13	0.07	0.06%
M & P-XYLENES (45109)	1,550	1.88	0.37	2.38	0.46	0.23	1.22	0.42	0.42	0.19	0.15%
STYRENE (45220)	1,000	1.03	1.13	1.80	0.40	0.08	0.18	0.14	0.05	0.18	0.18%
O-XYLENE (45204)	1,550	0.60	0.13	0.67	0.15	0.08	0.45	0.20	0.16	0.08	0.04%
NONANE (43235)	15,625	8.83	1.33	0.57	0.23	0.08	0.16	0.20	0.36	0.05	0.06%
1,3,5-TRIMETHYLBENZENE (45207)	619	1.75	0.08	0.29	0.13	0.04	0.10	0.12	0.08	0.01	0.28%
1,2,4-TRIMETHYLBENZENE (45208)	619	3.91	1.34	0.79	0.53	0.14	0.38	0.26	0.08	0.09	0.63%

*All data in ug/m3

5. OZONE EXCEEDANCES - 2014

Summer of 2014 was cooler and much wetter than previous years based on National Weather Service station data for Concord, New Hampshire. The average temperature in Concord was 67.3 degrees Fahrenheit (F), 0.5 F below normal; 2014 was the coolest summer since 2009. Normally, Concord experiences 11.5 days of 90 F or higher. June through August of 2014, only three days reached 90 F, the fewest number to reach 90 F since 1996.

Total rainfall during the summer of 2014 was higher than normal, most of it falling during just three significant events. Concord received more than two inches of rain on June 25, another three inches July 2-4, and two more inches on August 13. A total of 15.14 inches fell during the summer, 4.53 inches above normal. Summer 2014 ranked as the 12th wettest summer in the 147-year history measured in Concord.

In 2014, New Hampshire only experienced one ozone exceedance of the National Ambient Air Quality Standard (NAAQS) (75ppb). This took place at Miller State Park on June 3 with an ozone concentration of 79 ppb. Weather patterns in 2014 were similar to those of 2013 and 2009, which were also years with also lower ozone concentrations. Figures 24 and 25 summarize average ozone concentration trends.

Figure 24: Gilson Rd. PAMS Seasonal Ozone Averages 2005-2014

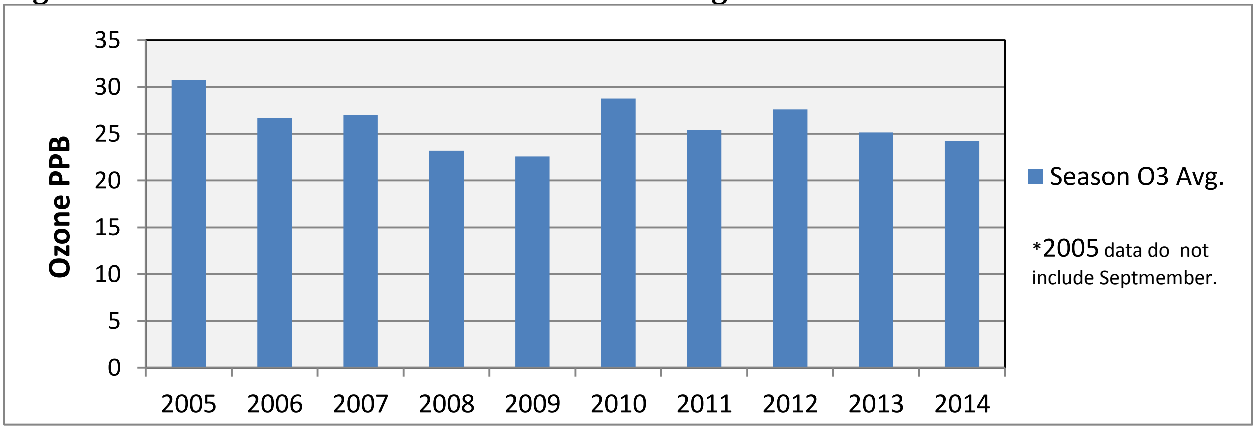
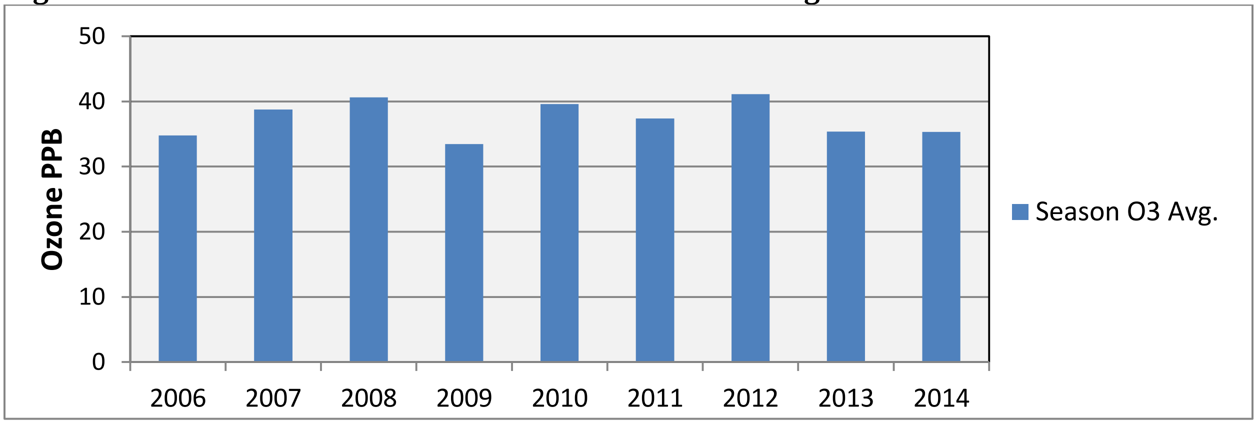
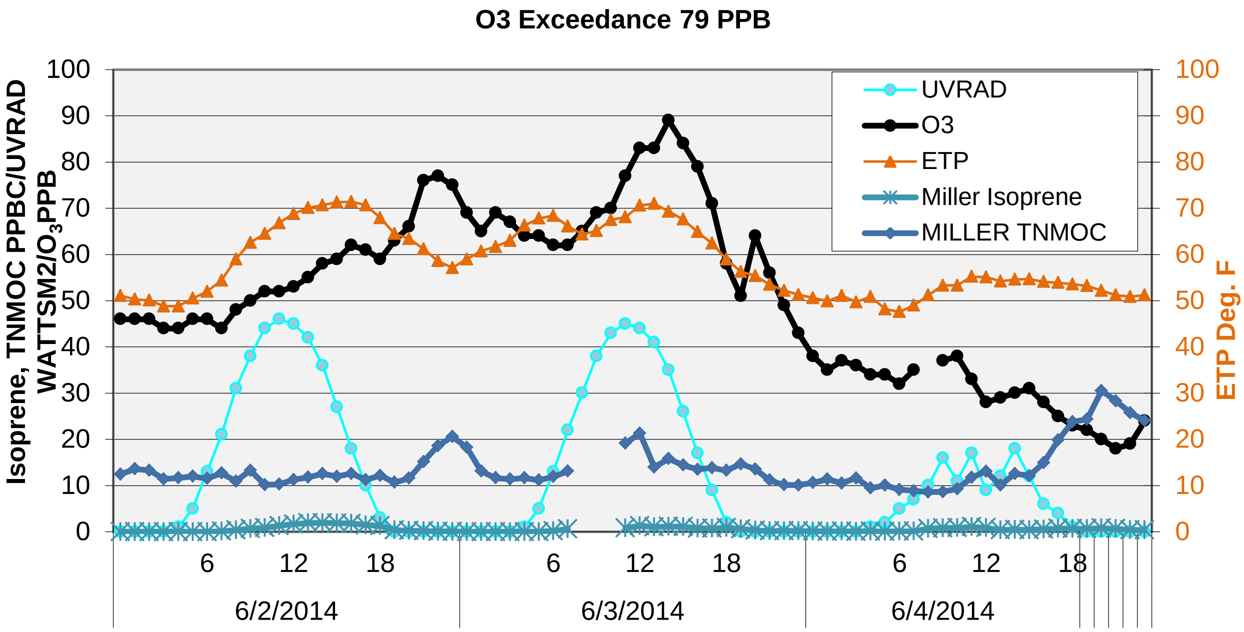


Figure 25: Miller State Park PAMS Seasonal Ozone Averages 2006-2014



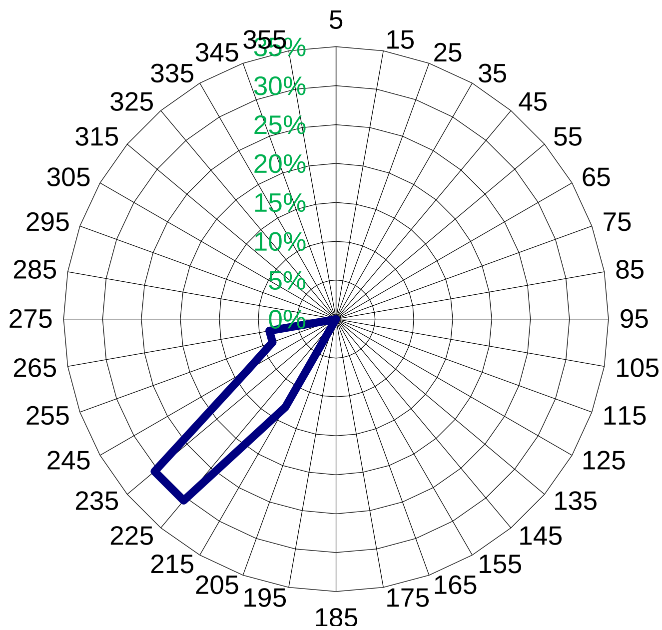
In a closer examination of the June 3 ozone exceedance at Miller State Park, TNMOC peaks the night prior, indicating an influx of ozone organic precursors. A second influx occurred shortly before peak ozone was measured. Temperatures on top of the mountain only reached the lower 70s during this event, and ozone concentrations fell when even cooler air moved in on June 4.

Figure 26: Isoprene, UVRAD, ETP Values for June 2-4, 2014 Miller State Park



Local wind direction measured at Miller State Park the day prior to the exceedance (June 3) indicates that a polluted air mass entered the region from the southwest and increased background ozone in the region. Ozone concentrations remained high through most of June 4.

Figure 27: Miller State Park PAMS - Wind Direction Frequency June 2, 2014



A backward trajectory for the hour of maximum ozone indicates that the final push of polluted air moved in from the greater Boston, Massachusetts area. Local winds shifted from southwest to southeast at about 10AM on June 4, and ozone increased until about 8PM. After that, the ozone event cleared as cooler air moved into the region.

Figure 28: Backward Trajectory for Miller State Park June 3, 2014

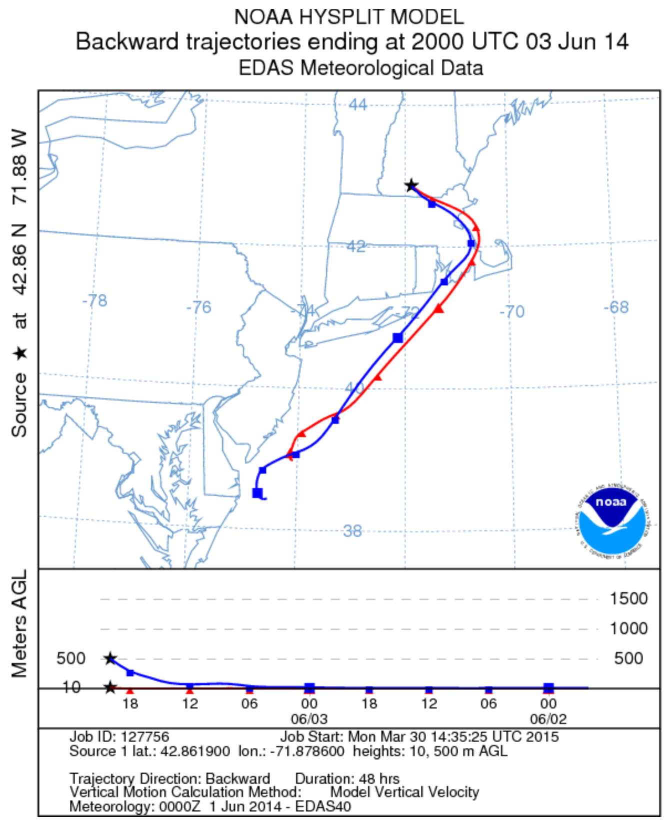
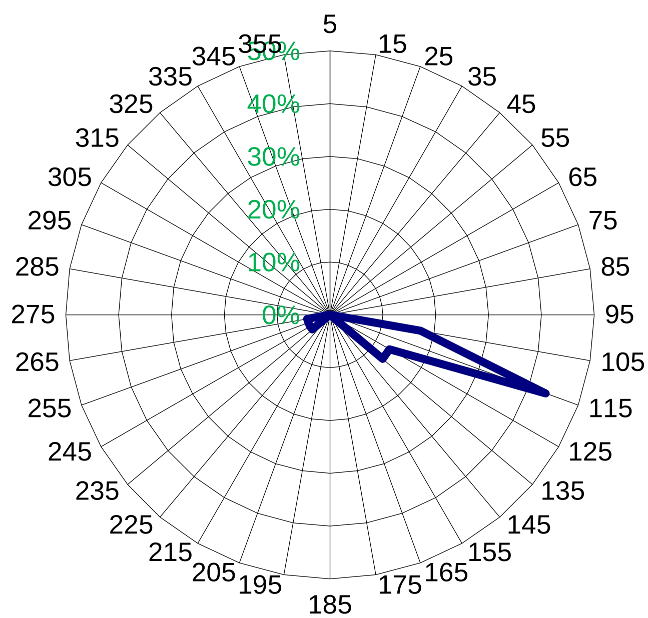


Figure 29: Miller State Park PAMS - Wind Direction Frequency June 3, 2014



6. CONCLUSION

In summary, NHDES achieved a very strong PAMS data capture rate and analysis performance during the 2014 PAMS season. Collected information indicates the recent trends of decreasing PAMS and ozone concentrations continued during 2014. At least some of the trends may have been caused by the cooler, wetter summers of recent years. During cooler weather, there is less need for extra electric generation, which produces surplus ozone precursor emissions. Cool weather is also associated with air that enters the state from cleaner directions (eg. northwesterly), and passes over fewer air pollution sources.

Some of the recent decreases in ozone are due to recent emissions controls implemented in and upwind of New Hampshire. During an ozone NAAQS exceedance at Miller State Park, despite relatively cool temperatures, air pollution was transported into the region from the southwest, which is a long-time classic upwind fetch for high ozone in New Hampshire.

Should the summer of 2015 return to more typical patterns, it is possible ozone and PAMS concentrations could increase. Conversely, continued cool and wet weather will likely lead to more summers with the low ozone concentration patterns seen in 2013 and 2014.