

National Park Service
U.S. Department of the Interior

Air Resources Division



Annual Data Summary 2004

Gaseous Pollutant Monitoring Program
Ozone, Sulfur Dioxide, Meteorological Observations



This Annual Data Summary was prepared under NPS Contract C2350010840 by:

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, Colorado 80525
Telephone: (970) 484-7941
Fax: (970) 484-3423

For additional copies of this report contact:

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, Colorado 80525
Telephone: (970) 484-7941
Fax: (970) 484-3423
E-Mail: air-imc@air-resource.com

or

National Park Service Denver Service Center
Technical Information Center
12795 W. Alameda Parkway
Denver, CO 80225-0287
Telephone: (303) 969-2130
E-Mail: TIC_requests@nps.gov

or

The report can be downloaded from
<http://www2.nature.nps.gov/air/monitoring/ads/ADSReport.cfm>

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Foreword
National Park Service
Gaseous Pollutant Monitoring Program
2004 Annual Report

This annual data summary report includes data from all Gaseous Pollutant Monitoring Program (GPMP) stations. Several parks with state operated stations are also included. Air quality and meteorological data from these sites for 2004 have been collected, validated, and made available to the Environmental Protection Agency (EPA), the parks, and the public. The data summarized in this report, as well as data from previous years, can now be accessed and viewed graphically on the National Park Service (NPS) Air Resources Division (ARD) Web site (<http://www2.nature.nps.gov/air/data/>). This report also presents several measures of how well the network has functioned (data precision, accuracy, and collection rates), and contains summaries related to the pollutant National Ambient Air Quality Standards and thresholds for resource injury.

Changes in 2004

Over the past year there has been an increase in the amount of information on the National Park Service Air Resources Division's Web site. Because of this increase, this year's annual data summary does not include pollutant or wind roses. These plots can be created interactively for any period of time on the Web at <http://www2.nature.nps.gov/air/data/>.

2004 saw an increase in the number of portable ozone monitoring systems (POMS) operated by the NPS. These POMS serve as the "baseline monitoring" function described in the 1991 NPS Monitoring Strategy (<http://www2.nature.nps.gov/air/Monitoring/docs/1991trend.pdf>). POMS were used in 11 locations in 2004. Data from these sites are included in many of the summaries in this report and the hourly data are available on the Web site. At least 14 POMS stations will be deployed in 2005 and anywhere from 3-5 stations will move each year. If your park has an interest in deploying a POMS, please contact John Ray at NPS ARD.

In 2004 and 2005, budget constraints led to some changes in the monitoring network. Ozone monitoring was discontinued at some sites where outside funding is no longer available, where ozone concentrations are low, or where multiple stations existed within the same park unit. Ozone monitoring was discontinued in either 2004 or 2005 at the following parks: Hawaii Volcanoes, Olympic, Sequoia/Kings Canyon, and Everglades National Parks. Passive ozone monitoring also ended at about 20 locations in 2004, although several of these parks have separately funded passive ozone sampling for 2005.

Highlights in 2004

During 2004, most sites realized fewer exceedances of the ozone standard than in 2003. An exceedance occurs when an 8-hour average ozone concentration is equal to or greater than 85 ppb. Five sites in three western parks had greater than four exceedances in 2004:

Park/Site	4 th Highest Daily Maximum 8-Hour Avg. O ₃ Concentration (ppb)	Number of Exceedances
Joshua Tree	102	31
Sequoia and Kings Canyon – Ash Mountain	99	52
Sequoia and Kings Canyon – Lower Kaweah	95	24
Sequoia and Kings Canyon – Lookout Point	95	50
Yosemite – Turtleback Dome	89	8

Areas that exceeded the standard in recent years, but not in 2004 include: Acadia NP, Mammoth Cave NP, Cowpens NM, and Rocky Mountain NP. The trends section of this report provides some possible explanation for this decrease in ozone concentrations. Exceedances can lead to a violation of the National Ambient Air Quality Standard (NAAQS) for ozone. A violation of the NAAQS occurs when the three year average of the fourth highest daily maximum is greater than or equal to 85 ppb. The sites listed above, plus five others violated the 3-year standard in 2004; two less than in 2003.

Special Studies in 2004

Each year several special air quality studies are conducted in individual parks. The objectives of these studies fall under the following monitoring objectives of the GPMP:

- Provide data for atmospheric model development and evaluation.
- Identify pollutants which may injure park natural resources or affect human health by measuring these pollutants and correlating observed effects on resources to ambient levels of pollutants.

Yellowstone National Park - Monitoring of carbon monoxide (CO) and fine particulates (PM_{2.5}) was conducted in two locations to relate snowmobile usage to ambient air quality. Over the last couple of years, CO and PM_{2.5} levels at locations with high snowmobile activity has declined. Detailed emission data from snowmobiles and snowcoaches were collected using remote sensing and portable instrumentation. Separate reports will be prepared for these studies. The park plans to use these data in modeling and in the revision to the Winter Use Plan.

Great Smoky Mountains National Park - Blount County, TN, is on the eastern boundary of the park and has no ozone monitoring stations. The county health department and the NPS worked together on a project using passive ozone samplers to characterize ozone concentrations at six locations around the park. A spatial distribution model was developed.

Cumberland-Piedmont - The Cumberland-Piedmont network within the Inventory and Monitoring Program conducted passive ozone sampling and portable ozone monitoring at 28

locations in 14 parks during the Summer of 2004. For many of these parks, the passive sampling was the first direct measurement of ozone concentrations. Results will be compared to the nearest ozone monitors and to the Air Atlas estimates.

Yosemite National Park - An enhanced monitoring station is located within Yosemite Valley to compare ozone concentrations in the valley to those from the regular monitoring station at a higher elevation within the park. Data have shown that ozone is lower in the valley, especially at night. Another objective of the station is to track changes in nitrogen oxides (NO_x) and carbon monoxide (CO) within the valley as transportation modes change. During the winter some very high concentrations of NO_x were observed, suggesting boundary-layer trapping of emissions from a point source within Yosemite Valley.

Network Quality Assurance

Overall data capture for NPS ozone monitoring continues to be high (93.3%) and exceeds NPS objectives and EPA requirements. The Quality Assurance Project Plan (QAPP) and the Quality Management Plan (QMP) were completely revised in 2004 (<http://www2.nature.nps.gov/air/Monitoring/network.cfm#procedures>). These documents, as well as the individual Standard Operation Procedures (SOPs), define how monitoring at NPS units is performed and describes the procedures used to process and validate the data.

The GPMP acknowledges and thanks the many park employees who perform the majority of the air quality monitoring by keeping the stations operational and working on air quality issues.

Dr. John D. Ray
GPMP Program Manager
NPS Air Resources Division
Denver, CO
303-969-2820
john_d_ray@nps.gov

1.0 INTRODUCTION

The overall purpose of the National Park Service (NPS) Gaseous Pollutant Monitoring Program (GPMP) is to monitor the status and trends of ambient air quality conditions in national park units. This purpose is outlined by the Clean Air Act of 1963 (including the 1970, 1977, and 1990 amendments) and the Organic Act of 1916, which assign the federal land managers the responsibility of protecting the natural resources in national parks. Several monitoring objectives have been derived from this purpose:

Primary Monitoring Objectives Gaseous Pollutant Monitoring Program

- Establish baseline concentrations of air pollution in national park units
- Assess trends in air quality
- Determine compliance with national ambient air quality standards
- Provide data for the development and revision of national and regional air pollution control policies that are protective of park resources
- Provide data for atmospheric model development and evaluation
- Identify air pollutants that may injure or damage park natural resources, measure these pollutants, and correlate observed effects on resources to ambient levels of pollutants

Other NPS monitoring objectives call for the collection of data to support the National Park Service's required involvement in both the development of state air quality control plans, and the evaluation of permit applications for new or expanding air pollution sources wishing to locate near park units. The Clean Air Act gives federal land managers an affirmative responsibility to protect air quality related values in Class I areas and to assess whether new sources will have an adverse impact on park unit resources and values. Information on air quality levels in NPS units can also be used to evaluate the performance of atmospheric models that simulate how pollutants are transported into park units, and predict impacts on the park units caused by air pollution sources.

To meet these objectives the NPS Air Resources Division (ARD) has established a network of stations to monitor ozone (O₃), sulfur dioxide (SO₂), carbon monoxide (CO), oxides of nitrogen (NO_x), particulate matter (PM), and meteorological conditions in the parks. This data summary report presents only O₃, SO₂, and meteorological data. Other gas and particulate monitoring are performed at several sites for specific air quality studies. Ozone, meteorological, and some SO₂ monitoring methods and quality assurance procedures adopted by the GPMP network were developed in accordance with the EPA regulations of 40 CFR, Part 58, Appendix D, which, although addressing primarily health-effects based monitoring in areas of high population, are generally pertinent to the GPMP. These design criteria allow for the direct comparison of NPS collected data with that collected by the EPA, and state and local air pollution control agencies.

As a supplement to the basic network, the ARD also conducts shorter-term air quality monitoring including passive ozone, portable ozone, and special studies monitoring in selected parks. In addition, the ARD cooperates with other national and state programs that monitor ambient gases, meteorology, deposition chemistry, particulate matter, and visibility.

Data collected by this network are incorporated in the EPA Air Quality System (AQS) database, which is a national database of air quality data collected throughout the country. These data are also stored in the NPS ARD's Information Management Center (IMC), and publicly available through the NPS ARD's Web site at <http://www2.nature.nps.gov/air/Monitoring/network.cfm#data> □□

2.0 NETWORK DESCRIPTION

The NPS air quality monitoring strategy has focused primarily on Class I areas defined by the Clean Air Act amendments of 1977. The Gaseous Pollutant Monitoring Program network consists of individual stations located in national park units throughout the United States. The NPS also participates with other agencies in cooperative monitoring programs. This section describes the GPMP network and cooperating programs.

2.1 GPMP NETWORK MONITORING

During 2004, fifty-nine (59) monitoring sites in forty-six (46) units of the National Park System conducted some combination of ozone, sulfur dioxide, and meteorological monitoring. The locations of the sites that operated during the year are presented on the map in Figure 2-1. The parameters monitored at each park unit are indicated with colored flags. The CASTNet flag identifies sites where the NPS operates Clean Air Status and Trend Network monitoring systems in cooperation with the EPA's CASTNet program to quantify dry atmospheric deposition. The enhanced gaseous and/or particulates flag indicates that the NPS sponsors additional or high-resolution gaseous or particulate monitoring at the park. Monitoring agencies and park units with more than one monitoring site are indicated. Site specifications, including site names, abbreviations, AQS identification numbers, locations, and monitored parameters are listed in Table 2-1.

In addition to monitoring for regulatory compliance, the NPS added non-certified portable ozone monitoring systems (POMS) to the GPMP in 2003. These sites employ portable non-reference, non-equivalent method ozone and meteorological monitoring stations, generally configured for solar and battery power. The POMS are intended for short-term seasonal use at locations where reference method monitoring has not occurred or is not practical. Throughout this report, POMS site names in tables and figures have been underlined to distinguish them from monitoring sites meeting all EPA guidelines.

2.2 COOPERATING PROGRAMS

Data from cooperating programs are reported by those programs and are not included in this report. The exception to that is ozone, sulfur dioxide, and meteorology collected in NPS units by state agencies which supplement the data collected by the GPMP.

State Programs

The NPS cooperates with a number of state agencies. At some sites, state air quality agencies provide measurement and operations support, and data are generally shared directly among cooperating agencies. Relevant ozone, sulfur dioxide, and meteorological data submitted by states to the EPA AQS are retrieved for inclusion in this report. Throughout this report, state-operated and reported monitoring site names in tables and figures are indicated in *italics*.

CASTNet

Most GPMP stations operate in a cooperative effort with the EPA Clean Air Status and Trends Network (CASTNet). Weekly integrated particulate samples are collected on filter packs at CASTNet sites. The samples are analyzed for ambient atmospheric nitrates, sulfates, ammonium, sulfur dioxide, and nitric acid, and the results are used to estimate atmospheric dry deposition. More information is available at the CASTNet Web site: <http://www.epa.gov/castnet>.

Passive Ozone

To expand the spatial sampling of ozone in national parks, the Research and Monitoring Branch, (RMB) of the NPS ARD adopted the use of low-cost passive ozone samplers. Weekly integrated ozone concentrations are measured in the parks during the ozone season, typically late spring through early fall. Operators change the ozone badges weekly and mail them to a contract laboratory for analysis. The results are compiled and reported by the RMB.

IMPROVE

The Interagency Monitoring of Protected Visual Environments (IMPROVE) is a consortium of federal and state agencies which conduct visibility monitoring in Class I areas, including national parks. A number of instruments are used to monitor visibility, including:

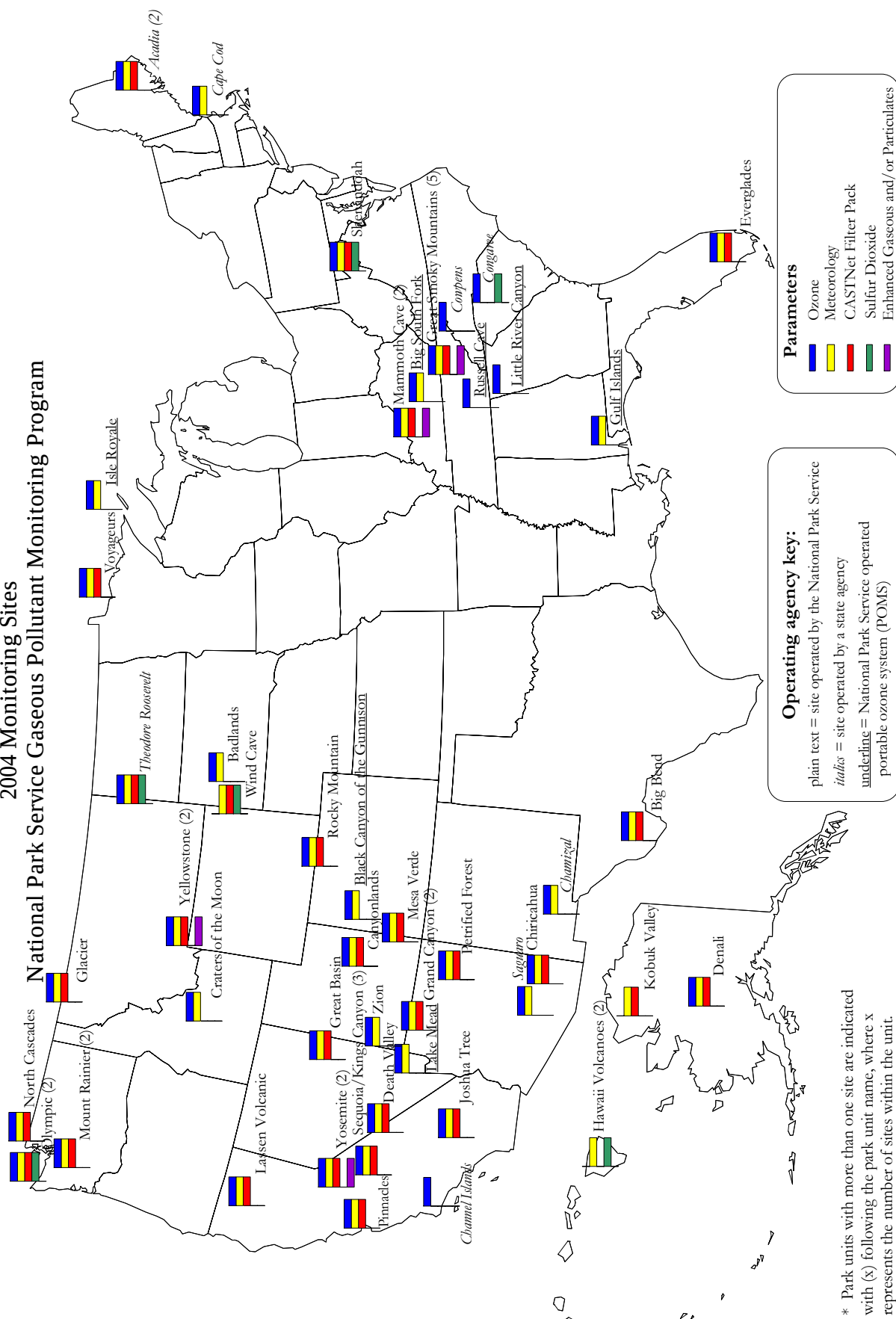
- Aerosol samplers, which collect 24-hr integrated particle samples every 3 days on a series of filter media. Filters are later analyzed for PM_{2.5} and PM₁₀ mass, elements, ions, and carbon.
- Transmissometers, which directly measure the atmospheric light extinction over a sight path of several kilometers.
- Nephelometers, which perform point optical measurements of the scattering component of atmospheric light extinction.
- Cameras which document the appearance of a scene as viewed through the atmosphere. Digital images from many sites are posted to the Internet along with relevant air quality data and other information in near real-time for public viewing.

More information is available at the IMPROVE Web site: <http://vista.cira.colostate.edu/improve>.

NADP/NTN and NADP/MDN

The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) includes wet deposition monitoring at over 250 sites nationwide. The NADP network has been collecting data for over 20 years, and is coordinated from the Program Office at the Illinois State Water Survey in Champaign, Illinois. Data for all major ions are available in concentrations and depositions expressed by kilograms/hectare. The National Atmospheric Deposition Program/Mercury Deposition Network (NADP/MDN) includes wet mercury deposition monitoring at over 80 sites nationwide. More information about both of these programs is available at the NADP Web site: <http://nadp.sws.uiuc.edu/>.

Figure 2-1
2004 Monitoring Sites
National Park Service Gaseous Pollutant Monitoring Program



* Park units with more than one site are indicated with (x) following the park unit name, where x represents the number of sites within the unit.

Table 2-1
Site Specifications
2004
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	State	NPS Abbr.	CASTNet Abbr.	AQS ID Number	Latitude	Longitude	Elev. (m)	O3 Years ¹	SO2	VWD ²	SWS ³	TMP	RH	RNF	WET	DTP	SOL	Filter Pack ⁴
<i>Acadia</i>	Cadillac Mountain	ME	ACAD-CM	—	23-009-0102	44.3472	68.2278	466	10	—	—	X	X	X	—	—	—	—	—
<i>Acadia</i>	McFarland Hill	ME	ACAD-MH	ACA416	23-009-0103	44.3769	68.2608	158	7	—	X	X	X	X	X	X	X	X	X
Badlands	Visitor Center	SD	BADL-VC	—	46-071-1001	43.7436	101.9414	739	8	—	X	X	X	X	X	—	—	—	—
Big Bend	K-Bar Ranch Road	TX	BIBE-KB	BBE401	48-043-0101	29.3022	103.1772	1052	15	—	X	X	X	X	X	X	X	X	X
Big South Fork	Portable Ozone	TN	BISO-PT	—	—	36.4725	84.6806	451	2	—	X	X	X	X	X	—	—	—	—
Black Canyon of the Gunnison	Portable Ozone	CO	BLCA-PT	—	—	38.5803	107.7167	2408	2	—	X	X	X	X	X	—	—	—	—
Cape Cod	Cape Cod	MA	CACO-XX	—	25-001-0002	41.9769	70.0164	40	18	—	X	X	X	X	—	—	—	—	—
Canyonlands	Island in the Sky	UT	CANY-IS	CAN407	49-037-0101	38.4586	109.8211	1809	13	—	X	X	X	X	X	X	X	X	X
Chamizal	Chamizal	TX	CHAM-XX	—	48-141-0044	31.7656	106.455	1128	13	—	X	X	X	X	—	—	—	—	—
Chiricahua	Entrance Station	AZ	CHIR-ES	CHA467	04-003-8001	32.0092	109.3892	1570	14	—	X	X	X	X	X	X	X	X	X
Channel Islands	Santa Rosa Island	CA	CHIS-XX	—	06-083-2012	34.0164	120.05	0	8	—	—	—	—	—	—	—	—	—	—
Congaree	Congaree Bluff	SC	COSW-BL	—	45-079-0021	33.8147	80.7811	34	5	X	—	—	—	—	—	—	—	—	—
Cowpens	Cowpens	SC	COWP-XX	—	45-021-0002	35.1303	81.8164	296	17	—	—	—	—	—	—	—	—	—	—
Craters of the Moon	Visitor Center	ID	CRMO-VC	—	16-023-0101	43.4606	113.5622	1815	13	—	X	X	X	X	—	—	—	—	—
Denali	Headquarters	AK	DENA-HQ	DEN417	02-290-0003	63.7258	148.9633	661	18	—	X	X	X	X	X	X	X	X	X
Death Valley	Park Village	CA	DEVA-PV	DEV412	06-027-0101	36.5092	116.8481	125	12	—	X	X	X	X	X	X	X	X	X
Everglades	Beard Center	FL	EVER-BC	EVE419	12-086-0030	25.3911	80.6806	2	21	—	X	X	X	X	X	X	X	X	X
Glacier	West Glacier Horse Stables	MT	GLAC-WG	GLR468	30-029-8001	48.5103	113.9956	976	13	—	X	X	X	X	X	X	X	X	X
Great Basin	Maintenance Yard	NV	GRBA-MY	GRB411	32-033-0101	39.0053	114.2158	2060	12	—	X	X	X	X	X	X	X	X	X
Grand Canyon	The Abyss	AZ	GRCA-AS	GRC474	04-005-8001	36.0597	112.1822	2073	12	—	X	X	X	X	X	X	X	X	X
Grand Canyon	Portable Ozone	AZ	GRCA-PT	—	—	36.2828	113.0958	1433	2	—	X	X	X	X	X	—	—	—	—
Great Smoky Mountains	Cades Cove	TN	GRSM-CC	—	47-009-0102	35.6042	83.7831	564	12	—	X	X	X	X	X	—	—	—	—
Great Smoky Mountains	Clingmans Dome	TN	GRSM-CD	—	47-155-0102	35.5619	83.4981	2021	12	—	X	X	X	X	X	—	—	—	—
Great Smoky Mountains	Cove Mountain	TN	GRSM-CM	—	47-155-0101	35.6967	83.6086	1243	17	—	X	X	X	X	X	—	—	—	—
Great Smoky Mountains	Look Rock	TN	GRSM-LR	GRS420	47-009-0101	35.6331	83.9422	793	17	—	X	X	X	X	X	X	X	X	X
Great Smoky Mountains	Purchase Knob	NC	GRSM-PK	—	37-087-0036	35.59	83.0775	1500	10	—	—	—	—	—	—	—	—	—	—
Gulf Islands	Portable Ozone	FL	GUIS-PT	—	—	30.3183	87.2553	7	1	—	X	X	X	X	X	—	—	—	—
Hawai'i Volcanoes	Observatory	HI	HAVO-OB	—	15-001-0007	19.4203	155.2881	1123	—	X	X	X	X	X	X	—	—	—	—

Table 2-1 (cont.)
Site Specifications
2004
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	State	NPS Abbr.	CASTNet Abbr.	AQS ID Number	Latitude	Longitude	Elev. (m)	O3 Years ¹	SO2	VWD ²	SWS ³	TMP	RH	RNF	WET	DTP	SOL	Filter Pack ⁴
Hawaii Volcanoes	Visitor Center	HI	HAVO-VC	—	15-001-0005	19.4308	155.2578	1215	—	X	X	X	X	X	X	X	—	X	—
<u>Isle Royale</u>	Portable Ozone	MI	ISRO-PT	—	—	48.1083	88.6064	347	3	—	X	X	X	X	X	—	—	X	X
Joshua Tree	Yucca Valley	CA	JOTR-YV	JOT403	06-071-9002	34.0714	116.3906	1244	12	—	X	X	X	X	X	X	X	X	X
<u>Kobuk Valley</u>	Ambler	AK	KOVA-AM	KVA428	02-290-0004	67.0931	157.8689	88	—	—	X	X	X	X	X	X	X	X	X
<u>Lake Mead</u>	Portable Ozone	AZ	LAME-PT	—	—	36.0194	114.0686	881	2	—	X	X	X	X	X	—	—	X	—
Lassen Volcanic	Manzanita Lake Maint. Area	CA	LAVO-ML	LAV410	06-089-3003	40.5403	121.5764	1756	18	—	X	X	X	X	X	X	X	X	X
<u>Little River Canyon</u>	Portable Ozone	AL	LIRI-PT	—	—	34.4603	85.5972	441	1	—	—	—	—	—	—	—	—	—	—
<u>Mammoth Cave</u>	Houchin Meadow	KY	MACA-HM	MAC426	21-061-0501	37.1319	86.1478	243	8	—	X	X	X	X	X	X	X	X	X
<u>Mammoth Cave</u>	Portable Ozone	KY	MACA-PT	—	—	37.1864	86.0411	258	1	—	X	X	X	X	X	—	—	X	—
<u>Mesa Verde</u>	Maintenance Yard	CO	MEVE-MY	MEV405	08-083-0101	37.1983	108.4903	2165	12	—	X	X	X	X	X	X	X	X	X
<u>Mount Rainier</u>	Portable Ozone	WA	MORA-PT	—	—	46.7958	121.8842	1067	1	—	X	X	X	X	X	—	—	X	—
<u>Mount Rainier</u>	Tahoma Woods	WA	MORA-TW	MOR409	53-053-1010	46.7583	122.1244	415	14	—	X	X	X	X	X	X	X	X	X
North Cascades	Marblemount Ranger Station	WA	NOCA-MM	NCS415	53-057-0013	48.5397	121.4472	109	9	—	X	X	X	X	X	X	X	X	X
<u>Olympic</u>	Portable Ozone	WA	OLYM-PT	—	—	47.9706	123.5028	1543	1	—	X	X	X	X	X	—	—	X	—
Olympic	Visitor Center	WA	OLYM-VC	OLY421	53-009-0012	48.0975	123.4256	125	20	X	X	X	X	X	X	X	X	X	X
<u>Petrified Forest</u>	Horse Barn	AZ	PEFO-HB	PET427	04-017-0119	34.8225	109.8919	1723	3	—	X	X	X	X	X	X	X	X	X
Pinnacles	East Entrance Station	CA	PINN-ES	PIN414	06-069-0003	36.485	121.1556	335	18	—	X	X	X	X	X	X	X	X	X
Rocky Mountain	Longs Peak Ranger Station	CO	ROMO-LP	ROM406	08-069-0007	40.2778	105.5453	2743	18	—	X	X	X	X	X	X	X	X	X
<u>Russell Cave</u>	Portable Ozone	AL	RUCA-PT	—	—	34.9811	85.81	215	1	—	—	—	—	—	—	—	—	—	—
<u>Saguaro</u>	Pima County	AZ	SAGU-PC	—	04-019-0021	32.1744	110.7364	938	13	—	X	X	X	X	—	—	—	X	—
Sequoia and Kings Canyon	Ash Mountain	CA	SEKI-AS	—	06-107-0009	36.4894	118.8269	457	6	—	X	X	X	X	X	—	—	X	—
Sequoia and Kings Canyon	Lower Kaweah	CA	SEKI-LK	—	06-107-0006	36.5658	118.7772	1890	21	—	X	X	X	X	X	—	—	X	—
Sequoia and Kings Canyon	Lookout Point	CA	SEKI-LP	SEK402	06-107-0008	36.4292	118.7625	1225	8	—	X	X	X	X	X	X	X	X	X
Shenandoah	Big Meadows	VA	SHEN-BM	SHN418	51-113-0003	38.5231	78.4347	1073	22	X	X	X	X	X	X	X	X	X	X
<u>Theodore Roosevelt</u>	Visitor Center	ND	THRO-VC	THR422	38-007-0002	46.8947	103.3778	850	7	X	X	X	X	X	X	X	X	X	X
Voyageurs	Sullivan Bay	MN	VOYA-SB	VOY413	27-137-0034	48.4128	92.8292	429	9	—	X	X	X	X	X	X	X	X	X
Wind Cave	Visitor Center	SD	WICA-VC	WNC429	46-033-0132	43.5578	103.4839	1292	—	—	X	X	X	X	X	X	X	X	X
Yellowstone	Water Tank	WY	YELL-WT	YEL408	56-039-1011	44.5597	110.4006	2400	9	—	X	X	X	X	X	X	X	X	X

Table 2-1 (cont.)
Site Specifications
2004

National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	State	NPS Abbr.	CASTNet Abbr.	AQS ID Number	Latitude	Longitude	Elev. (m)	O3 Years ¹	SO2	VWD ²	SWS ³	TMP	RH	RNF	WET	DTP	SOL	Filter Pack ⁴
Yosemite	Merced River	CA	YOSE-MR	—	06-043-0033	37.7431	119.5939	1219	3	—	X	X	X	X	X	—	—	—	X
Yosemite	Turtleback Dome	CA	YOSE-TD	YOS404	06-043-0003	37.7133	119.7061	1605	12	—	X	X	X	X	X	X	X	X	X
Zion	Dalton's Wash	UT	ZION-DW	—	49-053-0130	37.1983	113.1506	1213	1	—	X	X	X	X	X	—	—	—	X
# active park units: 46 # active park sites: 59																			

1. The values in this column represent the number of years an ozone analyzer has been operational at the site.
2. Cape Cod reports wind direction as scalar wind direction rather than vector wind direction.
3. Saguaro reports wind speed as vector wind speed rather than scalar wind speed.

4. A filter pack is a part of the CASTNet network and is used to measure dry deposition using the "inferential method". This method combines air quality concentration data with meteorological measurements and land use functions to compute deposition velocities. Ambient air is drawn across the filter at either 3.0 or 1.5 liters per minute. The filter is then analyzed in a lab to yield weekly average concentrations of particulate sulfate (SO₄²⁻), particulate nitrate (NO₃⁻), particulate ammonium (NH₄⁺), sulfur dioxide (SO₂), and nitric acid (HNO₃). In some cases, the positive ions Na⁺, K⁺, Ca²⁺, and Mg²⁺ are also measured from the filter samples.

Operating agency key:

plain text = site operated by the National Park Service
italics = site operated by a state agency
underline = site operated by the National Park Service, but consisting of non-EPA certified portable instrumentation

Key:

O3 = Ozone Analyzer
SO2 = Sulfur Dioxide Analyzer
VWD = Vector Wind Direction
SWS = Scalar Wind Speed
TMP = Ambient Temperature
RH = Relative Humidity
RNF = Precipitation
WET = Wetness Sensor
DTP = Delta Temperature
SOL = Solar Radiation

3.0 DATA SUMMARIES

Ground-level ozone and sulfur dioxide are regulated under the Clean Air Act, the comprehensive federal law that regulates air quality in the United States. Among other things, the Clean Air Act requires the U.S. EPA to set standards for “criteria pollutants”. These standards, known as the National Ambient Air Quality Standards (NAAQS), define the national targets for acceptable concentrations of each of the criteria pollutants. For each pollutant, EPA has developed two NAAQS standards:

- The “primary standard,” which is intended to protect public health, including the health of “sensitive” populations such as asthmatics, children, and the elderly.
- The “secondary standard,” which is intended to prevent damage to the environment and property, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

This section presents 2004 data summaries for the NPS GPMP. Data collection statistics for all sites are presented first, followed by data summaries for ozone, sulfur dioxide, and meteorological parameters. In these data summary products, site names of EPA-certified sites operated by the NPS are indicated with plain text, site names of EPA-certified sites operated by state agencies are written in *italics*, and site names of portable ozone monitoring systems (POMS) operated by the NPS are underlined.

3.1 DATA COLLECTION

Table 3-1 presents data collection statistics for each parameter by site and presents the overall network average by parameter. The network average valid data collection for ozone was 93.3% , and for sulfur dioxide was 86.7% .

Table 3-2 presents a network summary of data collection statistics by parameter. Annual and quarterly network average statistics are presented, along with the number and percentage of NPS operated (including POMS) and state operated sites which met the minimum EPA data collection criteria of 75%. For 2004, 48 of 55 ozone sites and 5 of 6 sulfur dioxide sites met or exceeded the annual EPA criteria.

Table 3-1
Data Collections Statistics by Site
2004
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	Parameter Code											
		O3 % valid ¹	SO2 % valid ¹	VWD ² % valid ¹	SWS ³ % valid ¹	TMP % valid ¹	RH % valid ¹	RNF % valid ¹	WET % valid ¹	DTP % valid ¹	SOL % valid ¹	FLOW % valid ¹	
<i>Acadia</i>	Cadillac Mountain	99.2	—	99.2	99.2	99.2	99.2	—	—	—	—	—	
<i>Acadia</i>	McFarland Hill	99.4	—	99.9	99.9	99.9	99.8	92.7	99.7	94.7	99.8	97.6	
Badlands	Visitor Center	99.5	—	75.8	97.7	99.5	99.7	76.3	—	—	75.9	—	
Big Bend	K-Bar Ranch Road	98.9	—	97.8	97.8	99.3	99.4	99.1	90.6	99.2	99.4	91.4	
<u>Big South Fork</u>	Portable Ozone	72.4	—	99.5	99.5	100.0	100.0	100.0	—	—	100.0	—	
<u>Black Canyon of the Gunnison</u>	Portable Ozone	43.7	—	99.9	99.9	99.9	99.9	99.9	—	—	99.8	—	
<i>Cape Cod</i>	Cape Cod	97.5	—	99.0	93.0	99.1	98.7	—	—	—	99.1	—	
Canyonlands	Island in the Sky	98.1	—	99.7	99.7	91.9	99.5	99.3	99.3	91.9	97.3	100.0	
<i>Chamizal</i>	Chamizal	99.5	—	99.9	99.9	99.9	99.9	—	—	—	100.0	—	
Chiricahua	Entrance Station	99.2	—	91.8	99.1	99.3	99.2	98.6	95.7	99.3	99.2	99.4	
<i>Channel Islands</i>	Santa Rosa Island	84.5	—	—	—	—	—	—	—	—	—	—	
<i>Congaree</i>	Congaree Bluff	99.3	99.4	—	—	—	—	—	—	—	—	—	
<i>Cowpens</i>	Cowpens	99.2	—	—	—	—	—	—	—	—	—	—	
Craters of the Moon	Visitor Center	94.2	—	73.1	98.8	98.0	93.9	—	—	—	98.9	—	
Denali	Headquarters	99.7	—	99.8	99.8	99.9	98.6	99.8	98.5	99.9	100.0	99.9	
Death Valley	Park Village	95.0	—	99.3	99.3	98.6	99.5	98.7	98.8	98.6	99.3	99.5	
Everglades	Beard Center	94.8	—	95.2	95.2	98.3	85.8	95.5	86.2	94.4	93.0	96.2	
Glacier	West Glacier Horse Stables	92.3	—	96.2	96.2	99.7	99.8	99.1	99.4	99.7	99.3	99.7	
Great Basin	Maintenance Yard	97.8	—	97.9	97.9	98.9	99.0	98.3	98.4	98.9	98.9	99.2	
Grand Canyon	The Abyss	99.1	—	99.5	99.5	99.6	98.2	99.0	71.5	99.6	99.2	99.7	
<u>Grand Canyon</u>	Portable Ozone	58.8	—	99.9	99.9	99.9	99.9	99.9	—	—	99.9	—	
Great Smoky Mountains	Cades Cove	96.4	—	99.1	99.1	97.9	97.9	98.1	—	—	99.7	—	
Great Smoky Mountains	Clingmans Dome	97.5	—	93.2	93.5	95.3	95.4	97.6	—	—	90.1	—	
Great Smoky Mountains	Cove Mountain	96.2	—	98.9	98.9	99.5	99.5	99.6	—	—	99.4	—	
Great Smoky Mountains	Look Rock	98.9	—	99.2	99.2	99.2	98.2	98.7	98.7	99.2	99.2	99.5	
<i>Great Smoky Mountains</i>	Purchase Knob	93.3	—	—	—	—	—	—	—	—	—	—	
<u>Gulf Islands</u>	Portable Ozone	88.8	—	100.0	100.0	100.0	100.0	100.0	—	—	94.4	—	
Hawaii Volcanoes	Observatory	—	88.3	99.9	99.9	100.0	95.5	99.6	—	—	—	—	

Table 3-1 (cont.)
Data Collections Statistics by Site
2004
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	Parameter Code											
		O3 % valid ¹	SO2 % valid ¹	VWD ² % valid ¹	SWS ³ % valid ¹	TMP % valid ¹	RH % valid ¹	RNF % valid ¹	WET % valid ¹	DTP % valid ¹	SOL % valid ¹	FLOW % valid ¹	
Hawaii Volcanoes	Visitor Center	—	99.6	99.6	99.6	99.7	99.7	99.3	—	—	54.1	—	
<u>Isle Royale</u>	Portable Ozone	92.3	—	100.0	100.0	100.0	100.0	100.0	—	—	100.0	96.2	
Joshua Tree	Yucca Valley	99.1	—	99.6	99.6	88.4	99.8	98.8	99.1	74.7	99.7	99.8	
Kobuk Valley	Ambler	—	—	44.4	100.0	100.0	72.8	44.4	72.4	100.0	72.8	44.4	
<u>Lake Mead</u>	Portable Ozone	69.8	—	100.0	100.0	100.0	100.0	100.0	—	—	100.0	—	
Lassen Volcanic	Manzanita Lake Maint. Area	98.5	—	97.4	97.6	99.0	99.0	98.4	97.0	99.0	99.0	99.2	
<u>Little River Canyon</u>	Portable Ozone	91.8	—	—	—	—	—	—	—	—	—	—	
Mammoth Cave	Houchin Meadow	99.7	—	97.9	99.9	99.4	99.1	99.3	99.3	85.6	99.9	98.7	
<u>Mammoth Cave</u>	Portable Ozone	72.5	—	100.0	100.0	100.0	100.0	100.0	—	—	99.9	100.0	
Mesa Verde	Maintenance Yard	99.3	—	62.8	99.7	99.7	100.0	99.3	99.3	91.5	62.7	60.5	
<u>Mount Rainier</u>	Portable Ozone	70.3	—	99.9	99.9	100.0	99.9	99.9	—	—	99.9	—	
Mount Rainier	Tahoma Woods	98.5	—	92.7	98.2	99.8	98.2	99.2	92.7	99.8	97.1	99.9	
North Cascades	Marblemount Ranger Station	98.0	—	95.6	98.5	99.1	99.2	98.6	98.8	99.1	99.2	64.1	
<u>Olympic</u>	Portable Ozone	100.0	—	100.0	100.0	100.0	100.0	100.0	—	—	100.0	—	
Olympic	Visitor Center	81.1	99.0	100.0	100.0	81.8	100.0	98.8	99.5	81.8	100.0	100.0	
Petrified Forest	Horse Barn	93.4	—	47.7	47.7	99.8	99.9	98.9	99.3	99.8	94.1	99.9	
Pinnacles	East Entrance Station	95.7	—	97.0	97.0	98.3	98.4	97.7	94.8	98.3	98.3	98.4	
Rocky Mountain	Longs Peak Ranger Station	99.9	—	98.7	99.4	99.9	99.9	99.3	91.7	99.9	100.0	100.0	
<u>Russell Cave</u>	Portable Ozone	95.9	—	—	—	—	—	—	—	—	—	—	
<u>Saguaro</u>	Pima County	99.0	—	99.3	99.5	99.9	99.9	—	—	—	99.7	—	
Sequoia and Kings Canyon	Ash Mountain	81.6	—	99.5	99.5	99.5	99.5	98.9	—	—	99.4	—	
Sequoia and Kings Canyon	Lower Kaweah	92.8	—	98.9	98.9	98.9	99.1	97.2	—	—	93.2	—	
Sequoia and Kings Canyon	Lookout Point	87.6	—	98.8	98.8	98.8	98.9	98.2	98.2	92.9	98.6	99.0	
Shenandoah	Big Meadows	96.3	77.2	95.6	97.8	97.8	97.9	97.7	96.6	97.8	86.7	69.7	
<u>Theodore Roosevelt</u>	Visitor Center	58.3	57.9	92.6	92.6	98.2	98.2	97.6	97.7	98.2	98.2	96.7	
Voyageurs	Sullivan Bay	98.3	—	92.9	92.9	98.1	99.8	99.3	99.5	98.1	99.8	98.2	
Wind Cave	Visitor Center	—	—	99.7	99.7	99.8	99.7	99.5	87.3	99.8	87.1	74.3	
Yellowstone	Water Tank	96.4	—	99.3	99.3	99.3	99.2	99.0	34.4	99.3	69.3	96.8	

Table 3-1 (cont.)
Data Collections Statistics by Site
2004
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	Parameter Code											
		O3 % valid ¹	SO2 % valid ¹	VWD ² % valid ¹	SWS ³ % valid ¹	TMP % valid ¹	RH % valid ¹	RNF % valid ¹	WET % valid ¹	DTP % valid ¹	SOL % valid ¹	FLOW % valid ¹	
Yosemite	Merced River	90.7	—	96.3	96.3	95.4	95.2	97.2	—	—	97.5	—	
Yosemite	Turtleback Dome	98.8	—	97.0	97.0	99.0	90.9	95.2	76.5	98.2	99.0	99.2	
Zion	Dalton's Wash	94.4	—	99.2	99.2	94.7	94.8	98.8	—	—	99.1	—	
Average Network Data Collection		93.3	86.7	94.5	97.3	98.2	98.1	97.3	93.0	96.1	94.8	93.4	

Operating agency key:

plain text = site operated by the National Park Service
italics = site operated by a state agency
underline = site operated by the National Park Service, but consisting of non-EPA certified portable instrumentation

Key:

O3 = Ozone Analyzer
SO2 = Sulfur Dioxide Analyzer
VWD = Vector Wind Direction
SWS = Scalar Wind Speed
TMP = Ambient Temperature
RH = Relative Humidity
RNF = Precipitation
WET = Wetness Sensor
DTP = Delta Temperature
SOL = Solar Radiation
FLOW = Filter Pack Flow Rate

1. The percent is calculated against the number possible. Percent valid can be less than 100% due to routine maintenance, power failures, audits or other circumstances where the instrument was not available to collect data. Percent valid can also be less than 100% due to influencing factors such as instrument error, timing problems, flow issues, and other factors that affect instrument operation. When calculating percent valid for O₃ and SO₂, calibration events were removed from the number possible.

2. Cape Cod reports wind direction as scalar wind direction rather than vector wind direction.

3. Saguaro reports wind speed as vector wind speed rather than scalar wind speed.

Table 3-2
Network Summary of Data Collections Statistics
2004
National Park Service Gaseous Pollutant Monitoring Program

Calendar Quarter	Network Data Collection Statistic¹	Units	Parameter Code										
			O3	SO2	VWD	SWS	TMP	RH	RNF	WET	DTP	SOL	FLOW
Annual	Annual Network Average	%	93.3	86.7	94.5	97.3	98.2	98.1	97.3	93.0	96.1	94.8	93.4
	No. Sites >=75% Valid	No. Sites (%)	48 (87%)	5 (83%)	49 (93%)	52 (98%)	53 (100%)	52 (98%)	47 (98%)	26 (90%)	28 (97%)	47 (92%)	26 (84%)
	No. Sites <75% Valid	No. Sites (%)	7 (13%)	1 (17%)	4 (8%)	1 (2%)	0 (0%)	1 (2%)	1 (2%)	3 (10%)	1 (3%)	4 (8%)	5 (16%)
1	Quarterly Network Average	%	92.3	82.3	98.4	98.6	98.7	97.6	96.4	95.2	96.7	96.0	89.1
	No. Sites >=75% Valid	No. Sites (%)	36 (90%)	5 (83%)	41 (100%)	41 (100%)	41 (100%)	40 (98%)	36 (97%)	26 (96%)	27 (96%)	39 (98%)	25 (89%)
	No. Sites <75% Valid	No. Sites (%)	4 (10%)	1 (17%)	0 (0%)	0 (0%)	0 (0%)	1 (2%)	1 (3%)	1 (4%)	1 (4%)	1 (2%)	3 (11%)
2	Quarterly Network Average	%	93.9	85.4	95.1	97.6	98.7	99.3	99.1	95.5	97.7	97.8	94.5
	No. Sites >=75% Valid	No. Sites (%)	49 (94%)	5 (83%)	48 (94%)	50 (98%)	50 (98%)	51 (100%)	46 (100%)	27 (96%)	27 (96%)	47 (96%)	28 (93%)
	No. Sites <75% Valid	No. Sites (%)	3 (6%)	1 (17%)	3 (6%)	1 (2%)	1 (2%)	0 (0%)	0 (0%)	1 (4%)	1 (4%)	2 (4%)	2 (7%)
3	Quarterly Network Average	%	91.9	81.6	91.9	95.8	98.3	97.6	98.2	87.2	97.0	90.5	95.0
	No. Sites >=75% Valid	No. Sites (%)	50 (91%)	4 (67%)	49 (93%)	52 (98%)	52 (98%)	51 (96%)	48 (100%)	24 (83%)	28 (97%)	44 (86%)	30 (97%)
	No. Sites <75% Valid	No. Sites (%)	5 (9%)	2 (33%)	4 (8%)	1 (2%)	1 (2%)	2 (4%)	0 (0%)	5 (17%)	1 (3%)	7 (14%)	1 (3%)
4	Quarterly Network Average	%	95.4	97.4	93.2	97.4	97.2	97.8	95.2	94.5	93.1	95.6	94.8
	No. Sites >=75% Valid	No. Sites (%)	42 (98%)	6 (100%)	41 (95%)	42 (98%)	42 (98%)	43 (100%)	37 (95%)	27 (93%)	27 (93%)	41 (98%)	28 (97%)
	No. Sites <75% Valid	No. Sites (%)	1 (2%)	0 (0%)	2 (5%)	1 (2%)	1 (2%)	0 (0%)	2 (5%)	2 (7%)	2 (7%)	1 (2%)	1 (3%)

Key:

O3 = Ozone Analyzer
SO2 = Sulfur Dioxide Analyzer
VWD = Vector Wind Direction
SWS = Scalar Wind Speed
TMP = Ambient Temperature
RH = Relative Humidity
RNF = Precipitation
WET = Wetness Sensor
DTP = Delta Temperature
SOL = Solar Radiation
FLOW = Filter Pack Flow Rate05

1. Network data collection statistics include: 1) the percent of valid hourly averages for each parameter across the network; 2) the number and percent of sites which achieved the minimum EPA requirement of 75% valid data capture; and 3) the number and percent of sites which failed to meet 75% valid data capture.

3.2 OZONE DATA SUMMARIES

Ground-level ozone, produced by the reaction of nitrogen oxides (NO_x) and volatile organic compounds (VOCs) in the presence of sunlight, is one of the most widespread pollutants affecting vegetation and public health in the U.S. Although ozone is principally viewed as an urban problem, ozone and its precursor emissions can travel long distances, resulting in elevated ozone levels in national parks. Combustion processes from power plants, automobiles, and industries are the main anthropogenic emitters of NO_x. Vehicles, industries, and natural vegetation emit VOCs.

Exposure to ozone affects human health, causing acute respiratory problems, aggravation of asthma, temporary decreases in lung capacity in some adults, inflammation of lung tissue, and impairment of the body's immune system. Ozone also affects vegetation in national parks. Research shows that some plants are more sensitive than humans to ozone and that effects on plants occur well below the EPA National Ambient Air Quality Standard (NAAQS).

The NAAQS primary standard for ozone is 0.08 ppm over an 8-hour period. An exceedance of the standard occurs when an 8-hour average ozone concentration is greater than or equal to 85 ppb. An exceedance of the standard is not the same as a violation. A violation occurs when the 3-year average of the fourth highest daily maximum 8-hour average ozone concentration equals or exceeds 85 ppb. The secondary ozone standard defined by the EPA is the same as the primary standard.

To quantify ozone exposure to plants, various indices other than the primary and secondary standards are often used. These indices, described further in Section 3.2.4, are believed to be biologically relevant because they take into account both peak ozone concentrations and cumulative exposure to ozone.

3.2.1 Annual Ozone Summaries

Table 3-3 summarizes O₃ measurements with respect to the daily 8-hour average maximum concentrations at each EPA-certified monitoring site. The five highest 8-hour average maximum ozone concentrations are listed, as well as the total number of days with exceedances of the NAAQS 8-hour standard (8-hour average ozone values greater than or equal to 85 ppb). The fourth highest value column and the number of days column are both color-coded to identify sites where the 4th highest 8-hour average ozone value exceeded the 8-hour standard during 2004. Note that other sites may have experienced fewer than four exceedances of the 8-hour standard but are not color coded.

In 2004, 11 sites exceeded the 8-hour standard, as compared to 18 sites in 2003. From 2003 to 2004, 18 sites had a decrease in the number of days with an exceedance of the 8-hour standard and only 2 sites had an increase.

Table 3-4 presents similar information for the non-EPA certified (portable) sites. Ozone summary statistics from POMS should be compared to EPA standards for reference purposes only.

The map in Figure 3-1 presents the annual fourth highest 8-hour average ozone concentrations for all network sites listed in Tables 3-3 and 3-4. Ozone values for EPA-certified sites are color-coded to represent values below (green) and above (orange and red) the national standard. Data from portable sites (no color) are included for reference only.

The map in Figure 3-2 presents the annual number of days which exceeded the 8-hour standard for all network sites listed in Tables 3-3 and 3-4. The data points are color-coded to distinguish between sites that did not exceed NAAQS (green) and those that did (orange and red). Data from portable sites (no color) are included for reference only.

The map in Figure 3-3 presents the annual second highest 1-hour average ozone concentrations for all network sites. Ozone values for EPA-certified sites are color-coded to represent 4 distinct levels. Ozone values from portable sites (no color) are included for reference only.

Table 3-3
Summary of Ozone Data by Site
Highest Daily 8-Hour Average Maximum Concentrations (ppb)
2004
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	Valid Number of Days	1st Highest	2nd Highest	3rd Highest	4th Highest ¹	5th Highest	# Days with 8-Hour Average O3 Values >=85 ppb ¹
<i>Acadia</i>	Cadillac Mountain	172	84	83	82	82	80	0
<i>Acadia</i>	McFarland Hill	363	79	77	76	73	73	0
Badlands	Visitor Center	361	66	66	63	63	62	0
Big Bend	K-Bar Ranch Road	358	63	63	62	61	60	0
<i>Cape Cod</i>	Cape Cod	181	107	89	85	83	80	3
Canyonlands	Island in the Sky	355	77	75	74	72	72	0
<i>Chamizal</i>	Chamizal	362	78	75	74	73	72	0
<i>Chiricahua</i>	Entrance Station	360	73	72	72	70	70	0
<i>Channel Islands</i>	Santa Rosa Island	323	93	86	76	75	73	2
<i>Congaree</i>	Congaree Bluf	357	86	70	69	67	66	1
<i>Cowpens</i>	Cowpens	359	75	73	70	68	67	0
Craters of the Moon	Visitor Center	341	65	65	64	63	63	0
Denali	Headquarters	362	64	60	56	52	51	0
Death Valley	Park Village	334	81	79	79	79	78	0
Everglades	Beard Center	339	73	66	65	64	64	0
Glacier	West Glacier Horse Stables	333	56	55	54	54	53	0
Great Basin	Maintenance Yard	346	82	77	77	72	72	0
Grand Canyon	The Abyss	359	77	76	74	72	72	0
Great Smoky Mountains	Cades Cove	230	70	68	67	66	66	0
Great Smoky Mountains	Clingmans Dome	176	83	83	78	76	74	0
Great Smoky Mountains	Cove Mountain	347	86	84	77	74	74	1
Great Smoky Mountains	Look Rock	357	86	85	83	82	80	2
<i>Great Smoky Mountains</i>	Purchase Knob	202	78	75	71	71	70	0
Joshua Tree	Yucca Valley	359	107	107	106	102	101	31
Lassen Volcanic	Manzanita Lake Maint. Area	351	73	70	68	68	67	0
Mammoth Cave	Houchin Meadow	364	72	72	70	70	70	0
Mesa Verde	Maintenance Yard	360	73	71	69	69	68	0
Mount Rainier	Tahoma Woods	355	64	64	64	63	62	0
North Cascades	Marblemount Ranger Station	352	57	54	54	52	51	0
Olympic	Visitor Center	293	52	51	50	49	49	0
Petrified Forest	Horse Barn	317	84	72	71	71	70	0
Pinnacles	East Entrance Station	345	83	79	78	77	76	0
Rocky Mountain	Longs Peak Ranger Station	364	76	74	74	73	72	0
<i>Saguaro</i>	Pima County	360	75	74	73	73	72	0
Sequoia and Kings Canyon	Ash Mountain	269	103	103	102	99	98	52
Sequoia and Kings Canyon	Lower Kaweah	298	99	98	95	95	92	24
Sequoia and Kings Canyon	Lookout Point	307	101	98	97	95	95	50
Shenandoah	Big Meadows	341	87	77	76	75	74	1
<i>Theodore Roosevelt</i>	Visitor Center	210	61	56	55	55	55	0

Table 3-3 (cont.)
Summary of Ozone Data by Site
Highest Daily 8-Hour Average Maximum Concentrations (ppb)
2004
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	Valid Number of Days	1st Highest	2nd Highest	3rd Highest	4th Highest ¹	5th Highest	# Days with 8-Hour Average O3 Values ≥85 ppb ¹
Voyageurs	Sullivan Bay	350	65	64	62	61	59	0
Yellowstone	Water Tank	339	62	62	61	60	60	0
Yosemite	Merced River	329	71	69	69	69	68	0
Yosemite	Turtleback Dome	357	124	121	92	89	87	8
Zion	Dalton's Wash	314	80	78	77	74	73	0

1. The primary and secondary National Ambient Air Quality Standard for ozone is 0.08 ppm over an 8-hour period. (An exceedance of the standard occurs when an 8-hour average ozone concentration is greater than or equal to 85 ppb. A violation of the standard occurs when the 3-year average of the fourth highest daily maximum 8-hour average ozone concentration equals or exceeds 85 ppb.) Exceedances of the standard are highlighted here in orange or red.

Note: The color coding break points follow the color categories used on the EPA's AIRNOW Web Site (www.airnow.gov).

Operating agency key:

plain text = site operated by the National Park Service
italics = site operated by a state agency

Color shading key:

4th highest 8-hr. avg.

 = 85 - 104 ppb ozone concentration
 >105 ppb ozone concentration

days with 8-hr. avg. ≥ 85 ppb

 = 4 - 10 days
 >10days

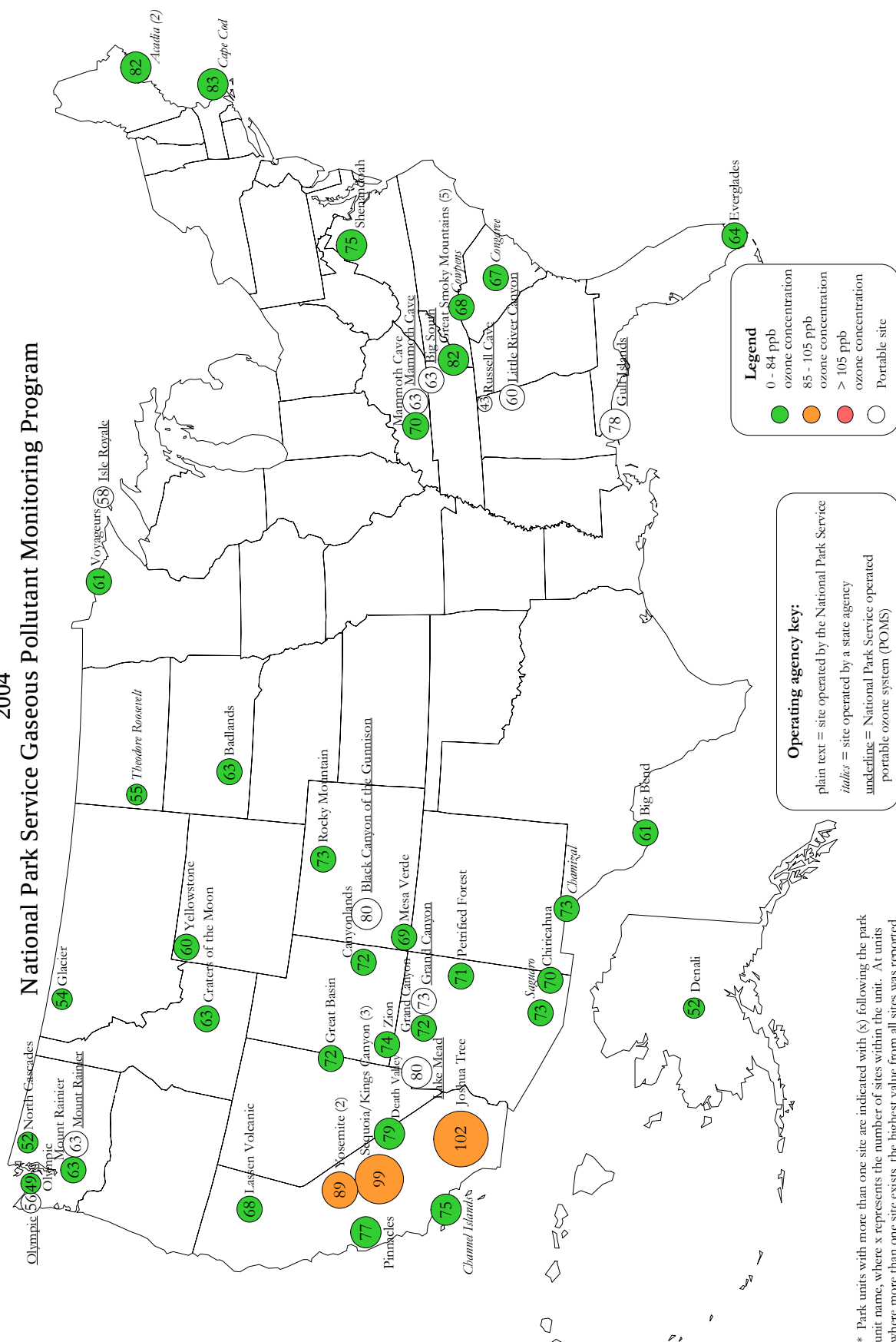
Table 3-4
Summary of Ozone Measurements from Portable Ozone Monitoring Systems (POMS)¹
Highest Daily 8-Hour Average Maximum Concentrations (ppb)
2004
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	Valid Number of Days	1st Highest	2nd Highest	3rd Highest	4th Highest ¹	5th Highest	# Days with 8-Hour Average O ₃ Values >=85 ppb ¹
<u>Big South Fork</u>	Portable Ozone	94	65	65	64	63	62	0
<u>Black Canyon of the Gunnison</u>	Portable Ozone	56	91	80	80	80	79	1
<u>Grand Canyon</u>	Portable Ozone	69	77	76	74	73	72	0
<u>Gulf Islands</u>	Portable Ozone	35	96	89	84	78	76	2
<u>Isle Royale</u>	Portable Ozone	129	65	64	58	58	58	0
<u>Lake Mead</u>	Portable Ozone	155	89	86	80	80	78	2
<u>Little River Canyon</u>	Portable Ozone	18	68	65	62	60	60	0
<u>Mammoth Cave</u>	Portable Ozone	68	68	65	64	63	58	0
<u>Mount Rainier</u>	Portable Ozone	89	75	74	66	63	62	0
<u>Olympic</u>	Portable Ozone	127	59	58	57	56	56	0
<u>Russell Cave</u>	Portable Ozone	20	51	46	45	43	43	0

1. The GPMP POMS do not meet EPA standards for regulatory monitoring. However, ozone summary statistics from portable systems can be compared to EPA standards for reference purposes.

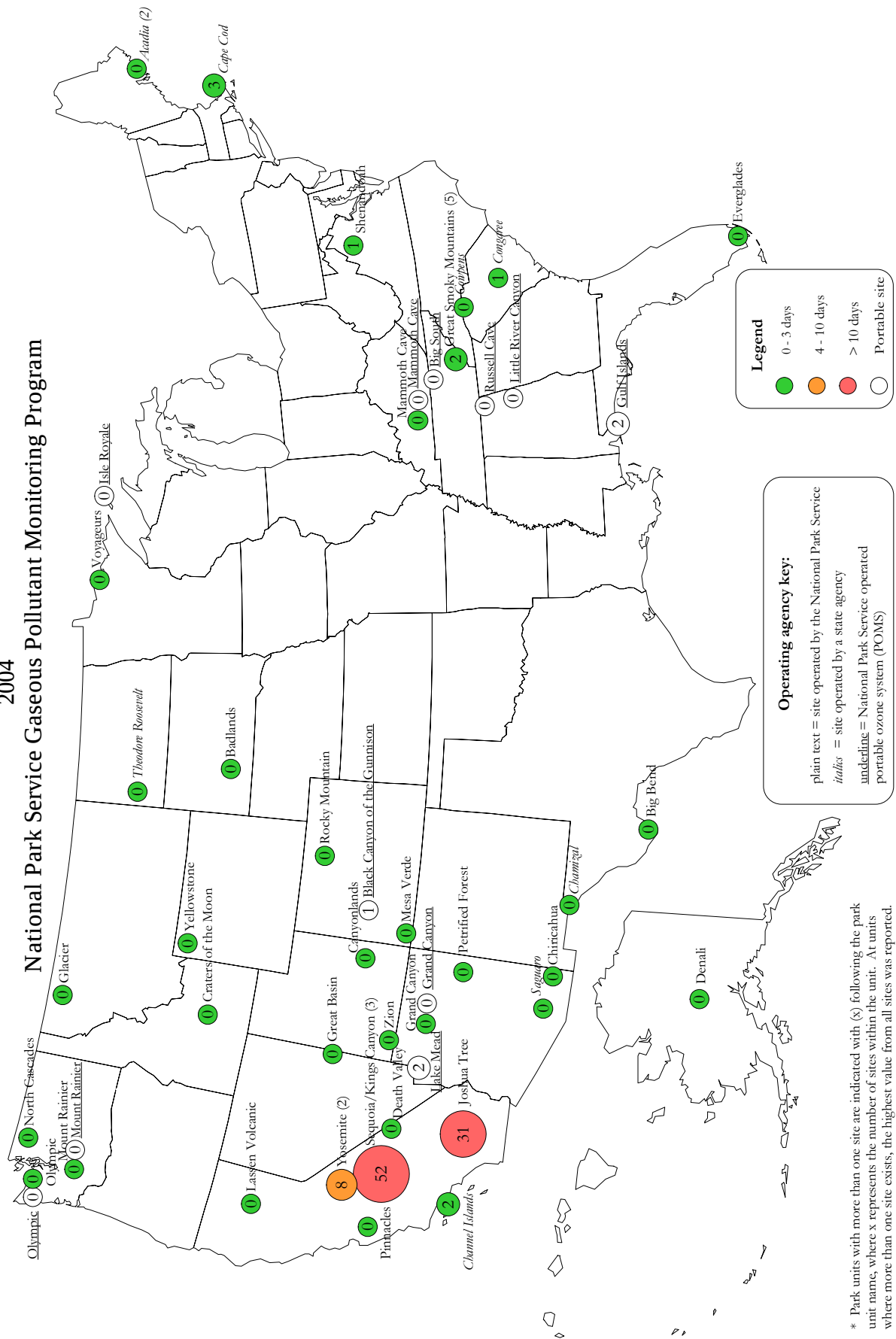
2. The primary and secondary National Ambient Air Quality Standard for ozone is 0.08 ppm over an 8-hour period. (An exceedance of the standard occurs when an 8-hour average ozone concentration is greater than or equal to 85 ppb. A violation of the standard occurs when the 3-year average of the fourth highest daily maximum 8-hour average ozone concentration equals or exceeds 85 ppb.)

Figure 3-1
Annual Fourth Highest 8-Hour Average Ozone Concentrations (in ppb)
2004



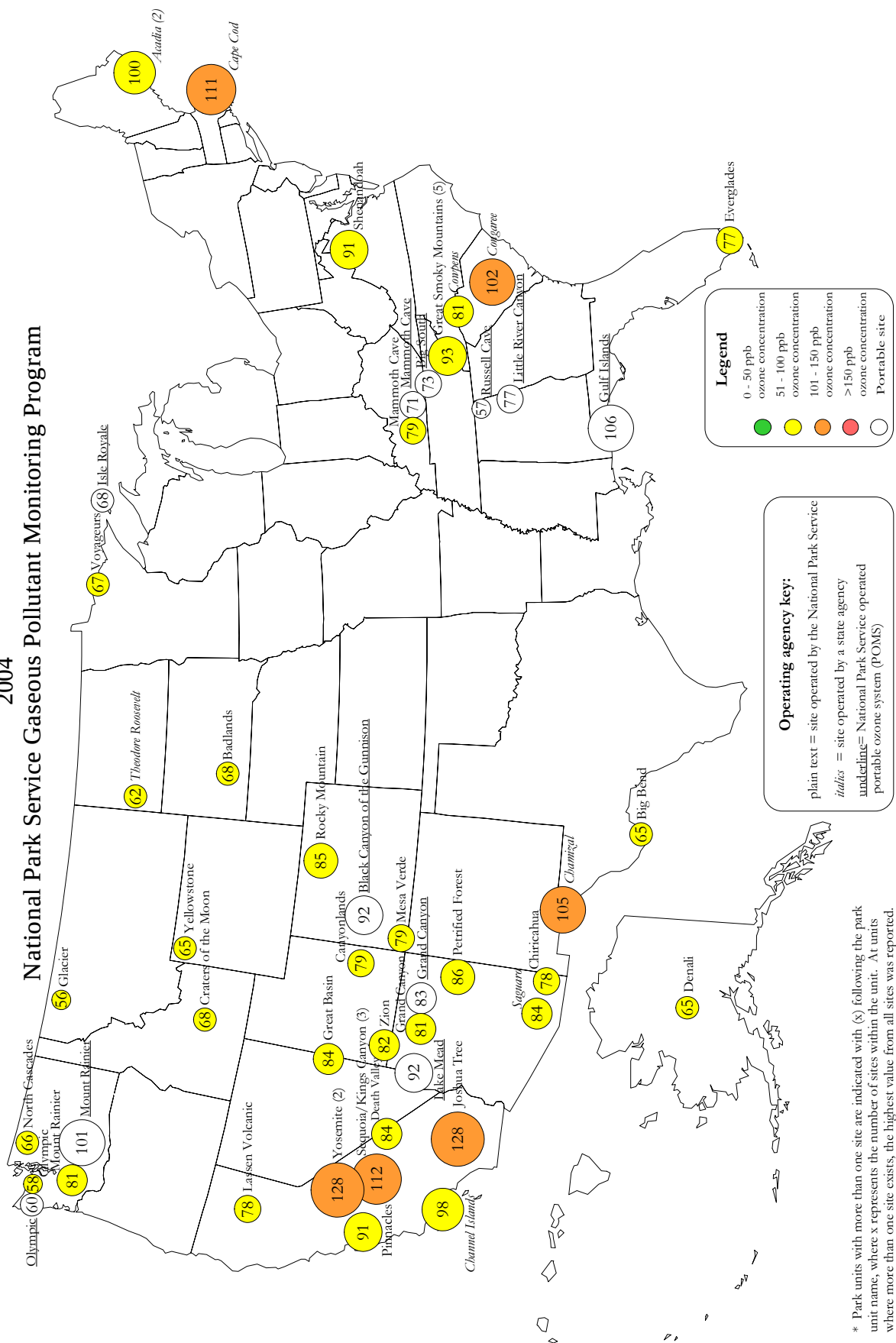
* Park units with more than one site are indicated with (x) following the park unit name, where x represents the number of sites within the unit. At units where more than one site exists, the highest value from all sites was reported.

Figure 3-2
Annual Number of Days with 8-Hour Average Ozone Values ≥ 85 ppb
2004



* Park units with more than one site are indicated with (x) following the park unit name, where x represents the number of sites within the unit. At units where more than one site exists, the highest value from all sites was reported.

Figure 3-3
Annual Second Highest 1-Hour Average Ozone Concentrations (in ppb)
2004



* Park units with more than one site are indicated with (x) following the park unit name, where x represents the number of sites within the unit. At units where more than one site exists, the highest value from all sites was reported.

3.2.2 Ozone Violation Summaries

Table 3-5 presents an ozone violation summary for all 3-year periods over the last ten years, with violations indicated in orange and red. A violation of the standard occurs when the 3-year average of the fourth highest daily maximum 8-hour average ozone concentration equals or exceeds 85 ppb. Table values in parentheses indicate that the EPA data completeness requirement for the 3-year period was not met. However, annual fourth highest daily maximum 8-hour ozone concentrations greater than or equal to 85 ppb for calendar years not meeting the EPA data completeness requirement are included in the NAAQS violation computation.

In 2004, 10 sites within 6 national park units were in violation of the NAAQS 8-hour standard, whereas in 2003, 13 sites within 7 units violated the standard.

Figure 3-4 presents a ranked list of sites based on the 2002 – 2004 ozone violation summary data presented in the first column of Table 3-5.

Table 3-5
Ozone Violation Summary
3-Year Average 4th Highest Daily Maximum 8-Hour Average Ozone Concentration¹ (ppb)
1997 - 2004
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	2002 - 2004	2001 - 2003	2000 - 2002	1999 - 2001	1998 - 2000	1997 - 1999	1996 - 1998	1995 - 1997
<i>Acadia</i>	Cadillac Mountain	88	94	93	89	87	(89)	(87)	(79)
<i>Acadia</i>	McFarland Hill	80	87	84	85	83	(90)	(88)	—
Badlands	Visitor Center	(64)	(67)	—	—	—	—	—	—
Big Bend	K-Bar Ranch Road	62	62	(62)	(63)	66	65	68	(67)
<i>Cape Cod</i>	Cape Cod	88	95	93	96	89	(95)	(93)	(100)
Canyonlands	Island in the Sky	72	70	(71)	(71)	73	70	70	68
<i>Chamizal</i>	Chamizal	78	79	81	75	(79)	(76)	(79)	77
Chiricahua	Entrance Station	70	69	69	70	70	68	68	(68)
<i>Channel Islands</i>	Santa Rosa Island	68	64	(65)	(66)	(66)	66	(64)	(63)
<i>Congaree</i>	Congaree Bluff	74	77	77	(74)	(73)	—	—	—
<i>Cowpens</i>	Cowpens	80	84	87	87	92	93	89	85
Craters of the Moon	Visitor Center	67	(65)	(63)	(63)	66	(64)	(63)	(60)
Denali	Headquarters	53	54	49	49	48	53	52	52
Death Valley	Park Village	80	81	81	79	80	79	79	(74)
Everglades	Beard Center	(62)	(60)	(60)	64	68	68	67	62
Glacier	West Glacier Horse Stables	55	53	49	48	51	47	50	47
Great Basin	Maintenance Yard	72	70	72	72	73	72	72	71
Grand Canyon	The Abyss	74	74	73	72	73	73	72	71
Great Smoky Mountains	Cades Cove	73	76	79	81	(85)	(83)	79	76
Great Smoky Mountains	Clingmans Dome	(87)	(92)	(98)	(98)	(102)	(98)	(94)	(88)
Great Smoky Mountains	Cove Mountain	86	92	96	96	101	(100)	97	93
Great Smoky Mountains	Look Rock	91	92	94	96	104	104	98	(95)
<i>Great Smoky Mountains</i>	Purchase Knob	82	86	88	87	90	90	(85)	(83)
Joshua Tree	Yucca Valley	106	99	94	92	102	109	112	109
Lassen Volcanic	Manzanita Lake Maint. Area	71	72	74	77	78	76	72	(71)
Mammoth Cave	Houchin Meadow	77	80	84	88	94	(92)	(89)	(81)
Mesa Verde	Maintenance Yard	68	67	69	69	70	(66)	(67)	(65)
Mount Rainier	Tahoma Woods	63	61	56	60	57	51	52	56
North Cascades	Marblemount Ranger Station	51	50	46	48	46	43	(43)	(44)
Olympic	Visitor Center	40	39	39	44	43	43	44	45

Table 3-5 (cont.)
Ozone Violation Summary
3-Year Average 4th Highest Daily Maximum 8-Hour Average Ozone Concentration¹ (ppb)
1997 - 2004
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	2002 - 2004	2001 - 2003	2000 - 2002	1999 - 2001	1998 - 2000	1997 - 1999	1996 - 1998	1995 - 1997
Petrified Forest	Horse Barn	(66)	(64)	(55)	—	—	—	—	—
Pinnacles	East Entrance Station	80	81	81	(79)	(82)	82	86	84
Rocky Mountain	Longs Peak Ranger Station	82	81	78	74	77	74	74	72
<i>Saguaro</i>	Pima County	(75)	(76)	(54)	(33)	(33)	(33)	(33)	(31)
Sequoia and Kings Canyon	Ash Mountain	(105)	(107)	(105)	(104)	(105)	(105)	—	—
Sequoia and Kings Canyon	Lower Kaweah	101	101	98	(94)	(93)	(96)	98	99
Sequoia and Kings Canyon	Lookout Point	(102)	(104)	(103)	(103)	(102)	(102)	(100)	(101)
Shenandoah	Big Meadows	82	87	85	87	93	96	92	85
<i>Theodore Roosevelt</i>	Visitor Center	60	61	59	58	(57)	(56)	(54)	—
Voyagers	Sullivan Bay	64	65	(64)	67	68	70	(66)	(66)
Yellowstone	Water Tank	63	65	65	67	67	65	(62)	(61)
Yosemite	Merced River	(67)	(66)	(72)	—	—	—	—	—
Yosemite	Turtleback Dome	90	90	89	86	88	86	88	87
Zion	Dalton's Wash	(74)	—	—	—	—	—	—	—
# Park Units with Violations:		6	7	8	9	9	9	10	7
# Sites with Violations:		10	13	13	15	15	15	15	10

1. The primary and secondary National Ambient Air Quality Standard for ozone is 0.08 ppm over an 8-hour period. (An exceedance of the standard occurs when an 8-hour average ozone concentration is greater than or equal to 85 ppb. A violation of the standard occurs when the 3-year average of the fourth highest daily maximum 8-hour average ozone concentration equals or exceeds 85 ppb.) Violations of the standard are highlighted here in orange and red.

Operating agency key:

Color shading key:

plain text = site operated by the National Park Service

4th highest 8-hr. avg.

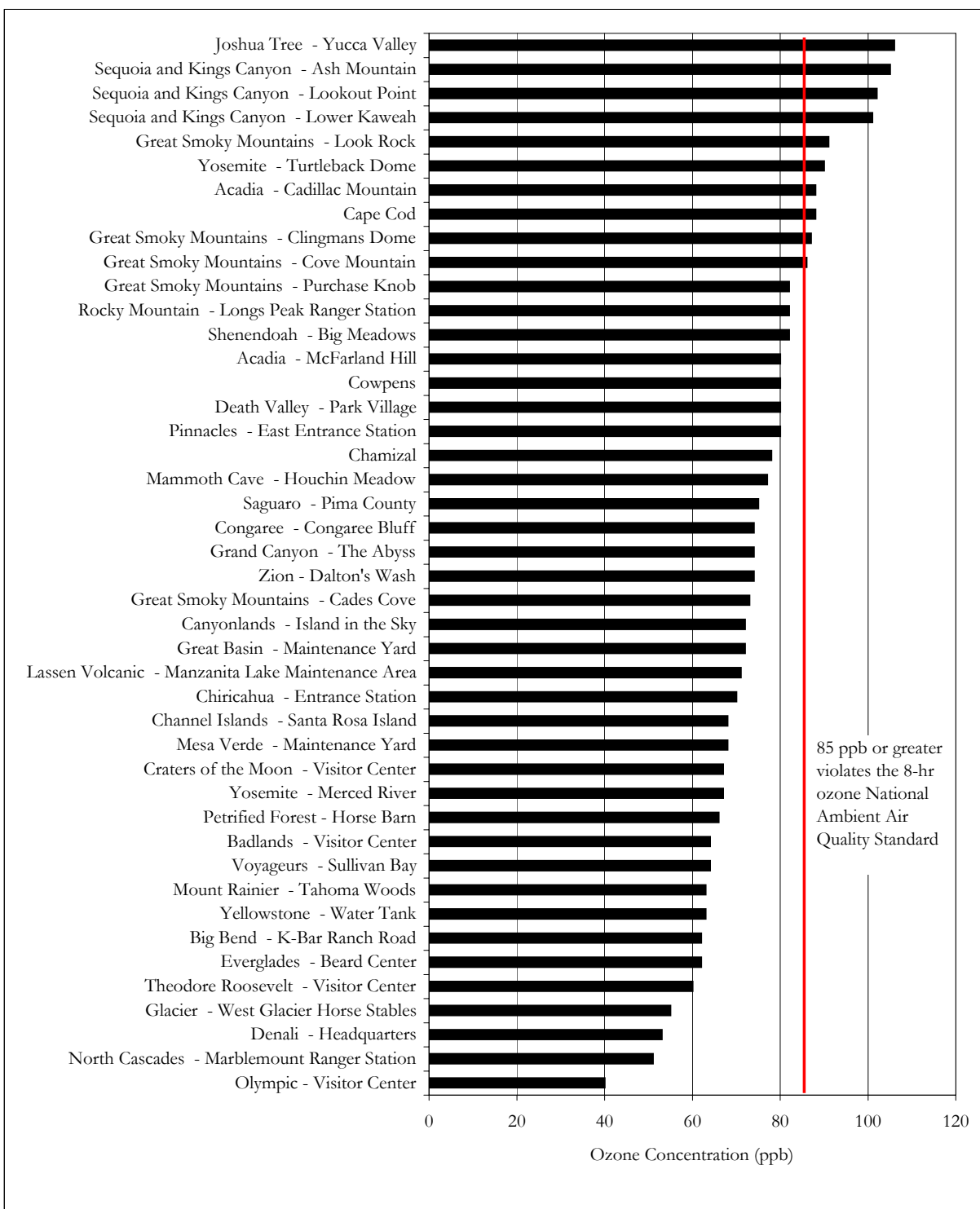
italics = site operated by a state agency

■ = 85 - 104 ppb ozone concentration

■ >= 105 ppb ozone concentration

() Note: A number in parenthesis () indicates that data completeness was not met. The primary standard requires 90 percent data completeness, on average, during the 3-year period, with no single year within the period having less than 75 percent data completeness. This data completeness requirement would have to be satisfied in order to determine that the standard has been met at a monitoring site. However, calendar years with less than 75 percent data completeness are included in the computation if the annual fourth-highest daily maximum 8-hour concentration is greater than the level of the standard. A site could be found not to have met the standard with less than complete data.

Figure 3-4
Ozone Violation Summary Ranking
3-Year Average 4th Highest Daily Maximum 8-Hour Average Ozone Concentrations (ppb)
2002 - 2004
National Park Service Gaseous Pollutant Monitoring Program



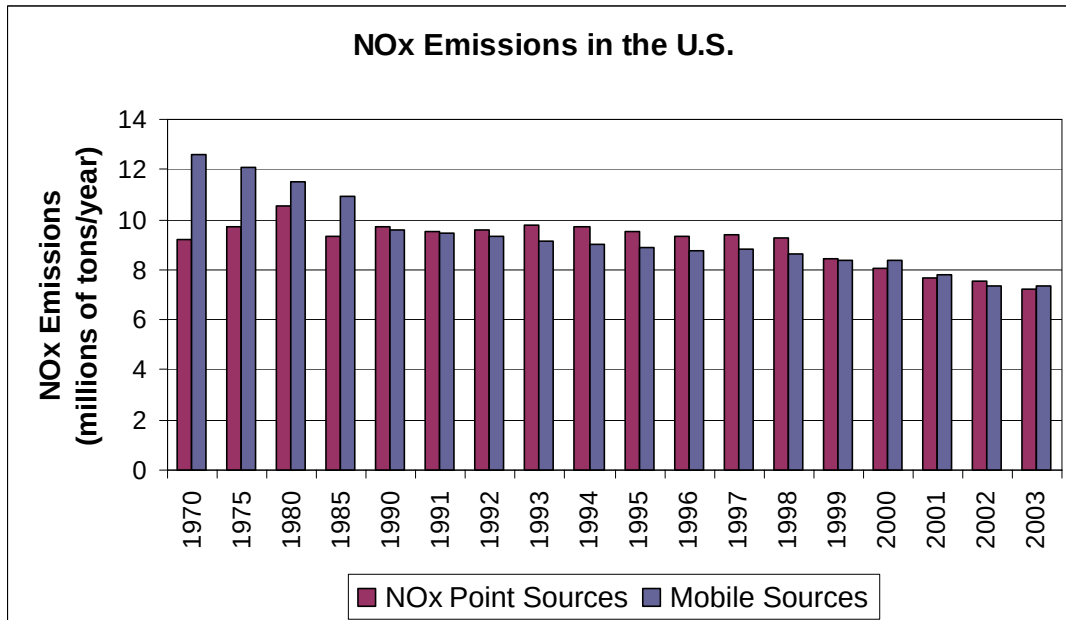
3.2.3 Long-Term Ozone Trends

Ozone is monitored not only to determine when air quality conditions are unacceptable, but also to see how the conditions are changing. Changes in ozone should relate to factors that control its concentration, such as precursor emissions, climate variability, changing transport patterns, global transport, and short-term events such as wildfires. Over broad regions, if precursor emission changes are large enough and persistent, then a change in ozone concentrations can be observed.

Determining ozone trends is an important monitoring network objective. It is also difficult, because trends are often poorly defined and interpretation is complicated by such factors as pollutant emission rates, which are constantly changing, and annual climate variations, which can dominate ozone production and transport factors. A commonly used trend technique is linear regression. This method has several limitations, including the expectation of a consistent geometric progression. Comparisons of the linear trend and the time series plots of ozone can be helpful. At some monitoring sites trends are evident while at other sites fluctuations are large and the trend line may be dominated by a small number of points.

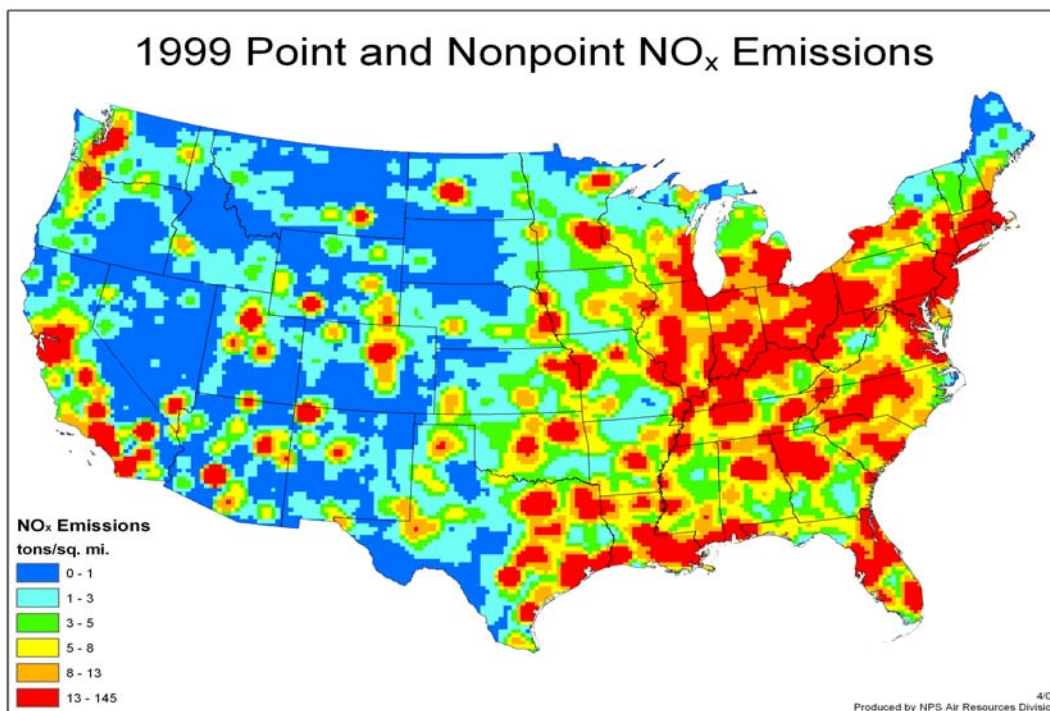
When considering ozone trends it is important to recall that ozone is formed in sunlight by the reaction of nitrogen oxides (NO_x) and reactive volatile organic compounds (VOCs). In most non-urban areas in the eastern U.S., the availability of NO_x to react with VOCs is the limiting factor in the production of ozone. Most non-urban areas are therefore classified as NO_x -limited (EPA, 1998; OTAG, 1997; SOS, 1995; Tong, 2005). Therefore, trends in NO_x emissions can be reasonably expected to relate to trends in ozone production. Figure 3-5 shows the change in NO_x emissions from both point and mobile sources over time in the United States. NO_x levels decrease in the 1970s and 1980s, are stable throughout the 1990s, and decrease again after 2000. Since NO_x is a precursor of ozone it is expected that ozone trends might follow a similar pattern, which is what the EPA discovered in a review of all the ozone monitoring stations in the U.S. (<http://www.epa.gov/airtrends/>). Areas of significant NO_x emissions density from the latest full inventory (1999) can be seen across much of the eastern U.S. Figure 3-6 indicates that the distribution of NO_x emissions is uneven, so regional and local differences in ozone can be expected. Also, specific control programs were initiated in the eastern U.S. (NO_x SIP Call, for example) so that relatively greater NO_x reductions have occurred in the East.

Figure 3-5
Total NO_x Emissions for Point and Mobile Sources in the United States



Source: EPA NO_x emissions table by year (<http://www.epa.gov/airtrends/pdfs/NOXNational.pdf>)

Figure 3-6
NO_x Emissions Density

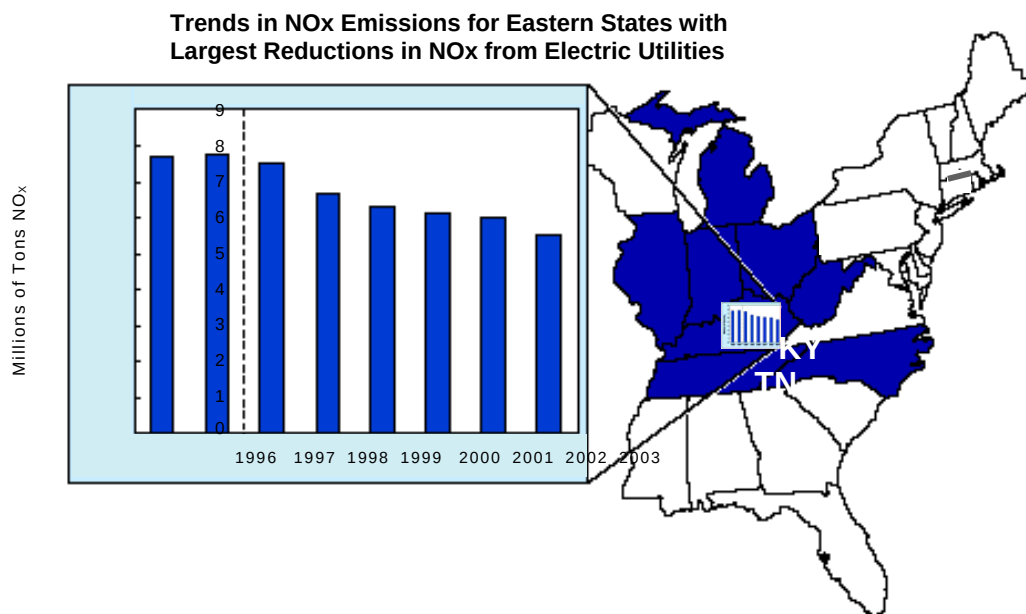


NO_x emissions density based on the EPA 1999 emission inventory. Reductions in NO_x emissions would be expected to be unevenly distributed just as the sources are. Regional patterns are expected, especially in the Midwest, coastal Northeast, and Southeast.

In 1999 NO_x emissions changed dramatically in the Midwest and in portions of the South due to the implementation of NO_x emission controls on several large point sources. Figure 3-7 highlights the eight eastern states with the largest NO_x reductions from 1996 through 2003. Consequently, ozone concentrations in the national parks surrounding these areas appear to respond to the lower NO_x emissions. Figure 3-8 presents ozone timelines for selected eastern U.S. park units. Ozone concentrations peaked in 1999-2000 at Mammoth Cave NP, Great Smoky Mountains NP, Shenandoah NP, and Cowpens National Battlefield (NB). Since then, ozone concentrations in these areas have decreased. Modeling indicates these parks are NO_x-limited in ozone formation (Tong, 2005), but climate variability cannot be ruled out since recent years have been cooler and wetter than average.

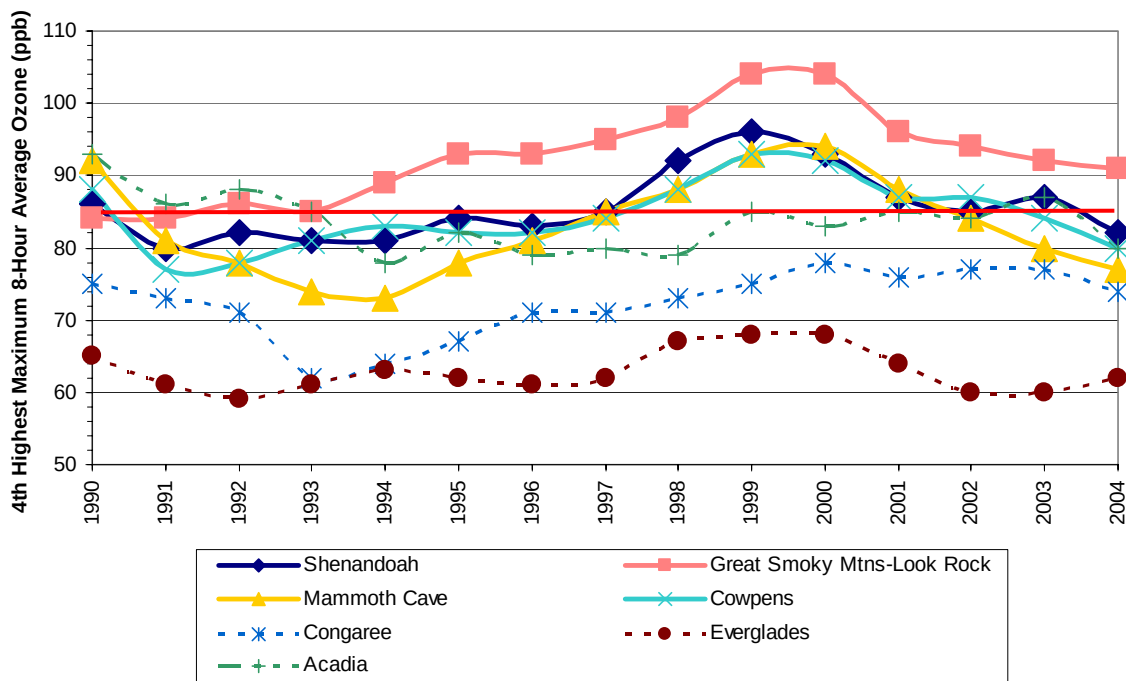
Ozone trends display similar patterns within regions. The EPA Ozone Report for 2003 <http://www.epa.gov/air/airtrends/aqtrnd04/ozone.html> reports that several parks follow the same patterns as nearby major urban areas. For example, as shown in Figure 3-9, Great Smoky Mountains NP follows the trends for nearby Knoxville and farther away Nashville, TN; Cowpens NB follows the changes in ozone of Charlotte, NC.

Figure 3-7
Trends in NO_x Emissions for Eastern States



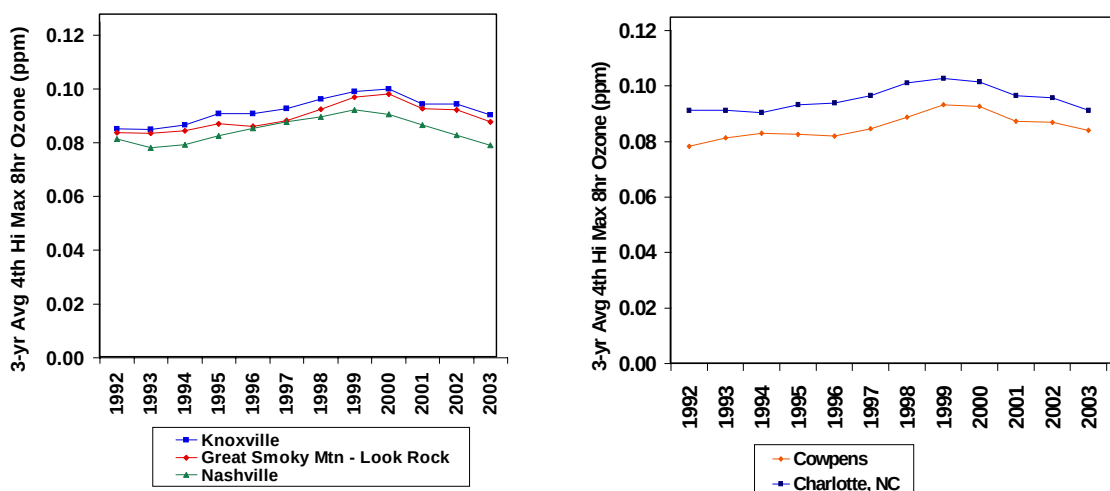
States with the largest reductions in NO_x from point sources includes KY, TN, and NC.
Source: Figure 20 from EPA “The Ozone Report, 2003”
(<http://www.epa.gov/air/airtrends/aqtrnd04/2003ozonereport/closer.pdf#page=6>)

Figure 3-8
Comparison of 3-Year Rolling Average 4th Highest Daily Maximum
8-Hour Average Ozone Concentration for Selected Eastern Parks



Time series plot of ozone concentrations at eastern U.S. national park units. The red line indicates the 8-hour NAAQS. The parks with thicker lines follow a similar pattern, with a peak in 1999-2000 and decreasing ozone after that. The parks with dashed lines appear to have a different pattern.

Figure 3-9
Ozone Trends for Great Smoky Mountains NP and Cowpens NB



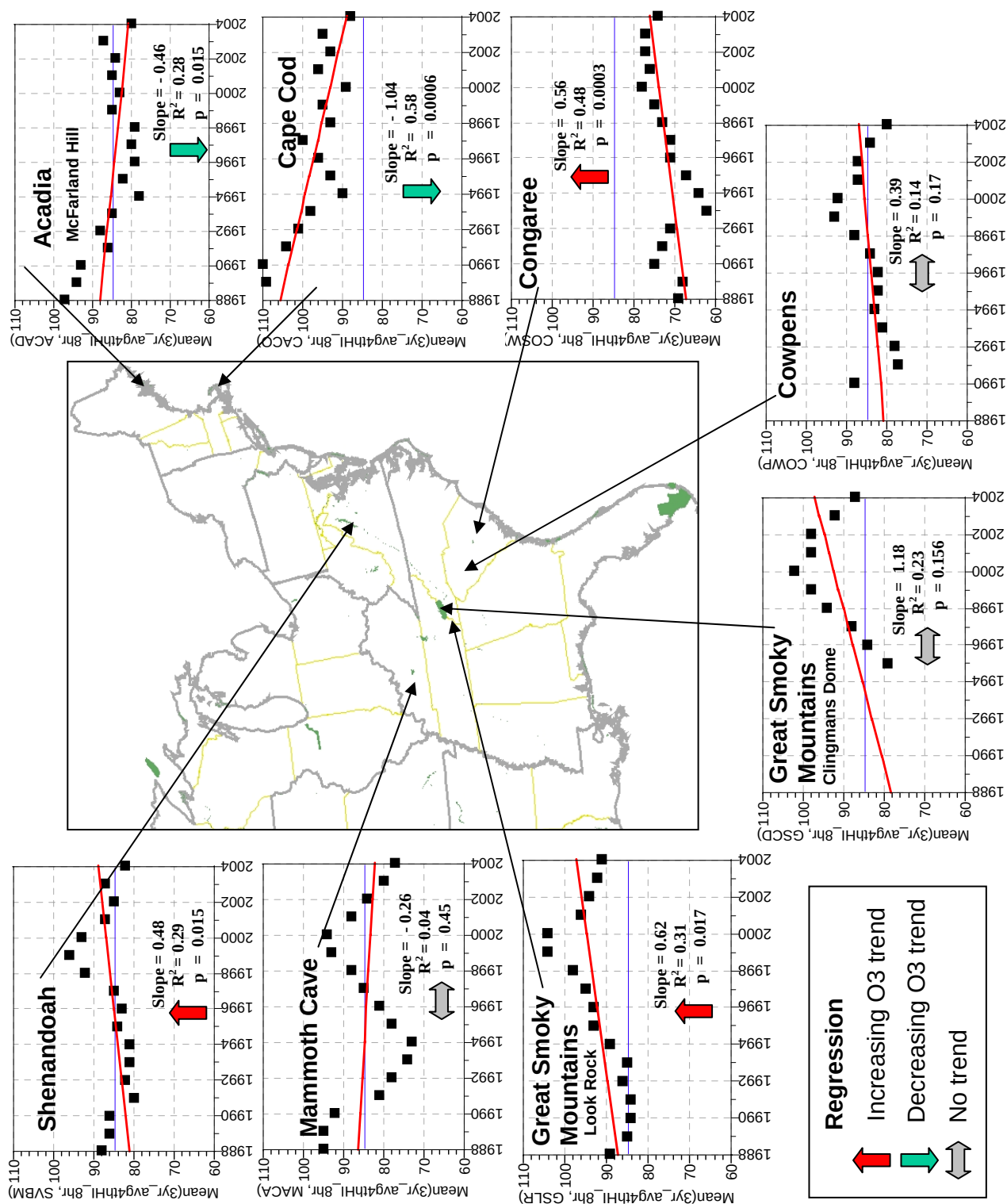
Ozone trends for Great Smoky Mountains NP and Cowpens NB follow the patterns of nearby major urban areas. This shows the regional nature of ozone concentrations and trends. (Ozone units in ppm).
Source: Figure 21 from EPA "The Ozone Report, 2003".

Three-year rolling averages of the 4th highest 8-hour ozone concentration time series plots and linear regression trends for eastern parks are plotted surrounding the map in Figure 3-10. Similar information for western parks is presented in Figure 3-11. The correlation coefficient (R^2) represents how well the data fit the linear model and the p value gives the statistical significance of the trend. The closer the R^2 value is to 1, the better the data fit the linear regression, and p values less than 0.05 represent a high significance. In each plot, the regression trend arrows indicate an increase, a decrease, or no change in ozone levels. The blue line on each graph marks the level of the National Ambient Air Quality Standard (NAAQS) for ozone which is based on a three year average of the annual 4th highest daily maximum 8-hr average ozone concentration. Each park shows considerable variation in annual ozone concentrations, which is reflected in the low R^2 values and the poor statistical significance associated with the linear regression trends for most of the eastern parks.

A possible explanation for this variability is that ozone increased during much of the 1990s and then decreased after 1999-2000 at four of the eastern U.S. parks (as displayed in Figure 3-8). Linear regression shows an increasing trend at Congaree NP. While parks in the mid-atlantic and south eastern states show no trends or increasing trends, the parks in New England show decreasing trends. At Acadia NP, a decreasing trend is observed through at least 1996. After 1996 ozone has remained nearly constant or slightly increased. The monitoring station at Acadia moved across the road in 1998, which may have affected the ozone record for this site.

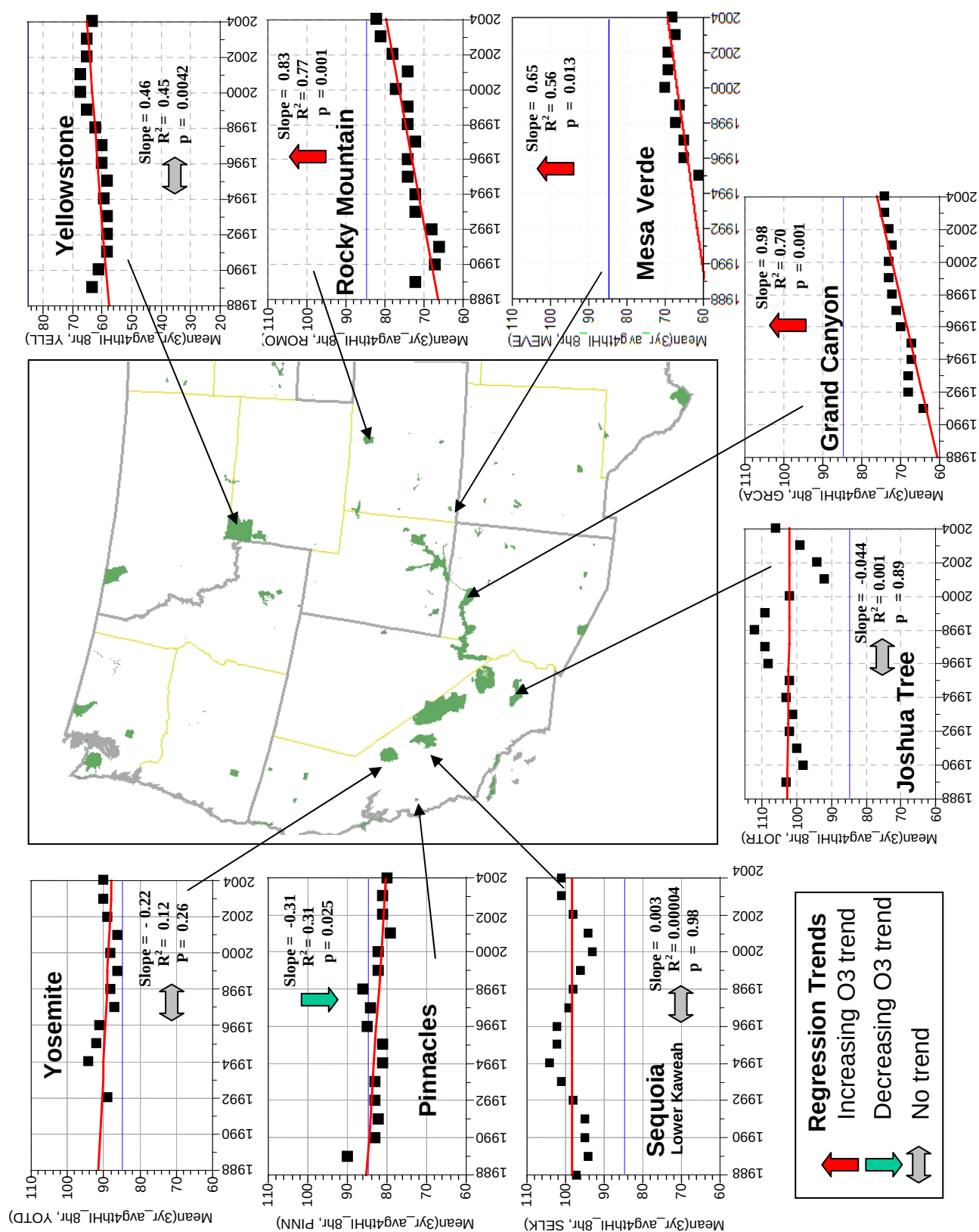
Compared to the East, the West has a lower density of emission sources (Figure 3-6) and has not benefited from NO_x reductions to the extent that the eastern U.S. has. Ozone data at most western parks display less year-to-year variability as well as less variability over several years than eastern parks. The linear regression trends for selected western parks are shown in Figure 3-11. Joshua Tree and Sequoia-Kings Canyon NPs have seen major swings in ozone concentrations over time. These changes should be assessed in conjunction with trends at the upwind urban areas that dominate the area's air quality. While the California parks show decreasing or no trends, much of the central western parks have increasing ozone trends.

Figure 3-10
Ozone Trends in Eastern Parks



Ozone concentrations and linear regression trends for selected eastern parks. Arrows in the boxes give the direction of the trend.

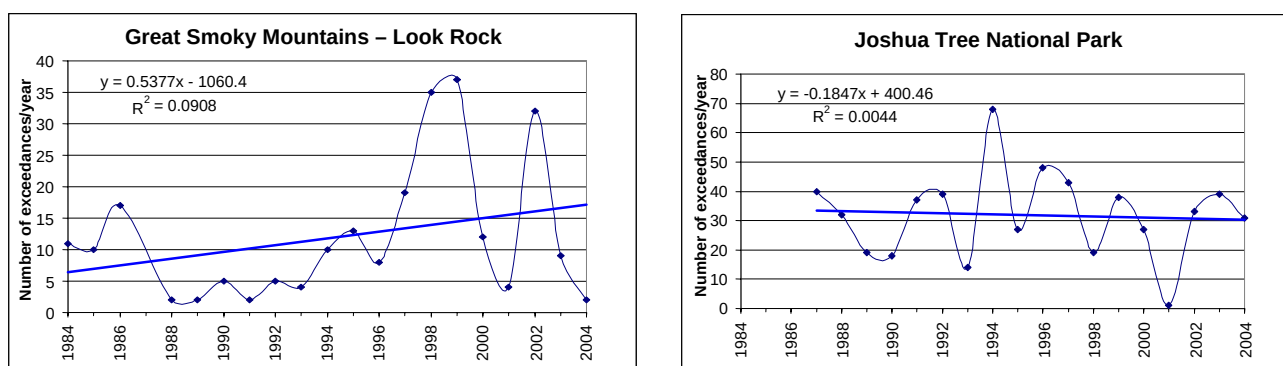
Figure 3-11
Ozone Trends in Western Parks



Ozone concentrations and linear regression trends for selected western parks. Arrows in the boxes give the direction of the trend.

Another useful statistic that indicates the frequency of and potential trend in poor air quality is the number of exceedances per year. An exceedance is defined as an occurrence where the daily maximum 8-hour average ozone concentration is greater than or equal to 85 ppb. Two examples are given in Figure 3-12; Great Smoky Mountains NP (Look Rock) and Joshua Tree NP both have very high numbers of exceedances and as a result often issue ozone advisories to the public when the air quality is expected to exceed the NAAQS for ozone. There is much more year-to-year variability in the number of exceedances than there is in the 4th highest 8-hr average concentration. The patterns look different than those in Figure 3-10 and 3-11, yet it is clear that the ozone concentrations continue to be above the NAAQS standard and the number of exceedances per year are quite high.

Figure 3-12
Trends in Number of 8-Hour Average Ozone Exceedances



Trend plots for the number of ozone exceedances at Great Smoky Mountains and Joshua Tree National Parks. Compare to concentration plots in Figure 3-10 and 3-11.

Ideally, trends should indicate changes attributable to changes in emissions, control strategies, and changes in other human activities. However, because of weather variability that also affects ozone concentrations, only large changes in emissions or activities that happen abruptly are likely to result in obvious changes in ozone concentrations. Some areas in the eastern U.S. now seem to be responding to NO_x emission reductions as predicted by researchers and computer modeling. This is good news for future predictions of air quality in eastern parks and something to be tracked carefully.

More information related to ozone trends in national parks can be found on the Web at these sites:

Annual 4th highest 8-hr concentrations in parks

http://www2.nature.nps.gov/air/monitoring/docs/2005_ParkO3Conc.pdf

Annual NAAQS exceedence counts in parks

http://www2.nature.nps.gov/air/Monitoring/docs/2005_O3_ParkExceedDays.pdf

Performance measures (GPRA report on trends)

<http://www2.nature.nps.gov/air/who/npsPerfMeasures.cfm>

Ozone interpolation maps as 5-year averages (Air Atlas)

<http://www.nps.nsm.du.edu/website/AirAtlas9903/viewer.htm>

References

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Tong, D. Q., D. Kang, V.P. Aneja, and J. D. Ray (2005). Reactive nitrogen oxides in the southeast US national parks: source identification, origin, and process budget, *Atmos. Environ.*, 39, 315-327. <http://www2.nature.nps.gov/air/Studies/enhanced.cfm#refs> (June 30, 2005).

3.2.4 Resource Injury Indices

To quantify ozone exposure to plants, various indices other than the NAAQS primary and secondary standards are often used. These indices, defined below, take into account both peak ozone concentrations and cumulative exposure to ozone.

- SUM06 – A cumulative index that is calculated as the maximum 3-month sum of the 0800-2000 hourly average ozone concentrations equal to or greater than 0.06 ppm (60 ppb). The units of this index are ppm-hr. Several thresholds have been developed for SUM06 (Heck and Cowling, 1997):

No risk to ozone sensitive vegetation	0 - 7 ppm-hr
Higher risk to ozone sensitive vegetation	8 - 16 ppm-hr
Highest risk to ozone sensitive vegetation	> 16 ppm-hr

- W126 – A cumulative index that is calculated as the sum of the 0800-2000 weighted hourly ozone concentrations during the EPA-designated ozone season, where a weighting function is used to give increasing significance (weights between 0 and 1) to concentrations of ozone greater than 0.040 ppm (40 ppb), and no weight to concentrations below 0.040 ppm (40 ppb). Units of this index are ppm-hr.
- N100 – The number of hours with ozone concentrations greater than or equal to 0.10 ppm (100 ppb). This index is reported without units. The N100 index is often considered along with the W126 in assessing the possible impact of the exposure. Several thresholds have been developed for W126 and N100 (Lefohn et al, 1997):

	<u>W126</u>	<u>N100</u>
Highly Sensitive Species	5.9 ppm-hr	6
Moderately Sensitive Species	23.8 ppm-hr	51
Low Sensitivity	66.6 ppm-hr	135

Table 3-6 presents the ozone exposure indices summary statistics for 2004. Summaries for portable ozone sites are included for reference only. Since portable sites are deployed for short-term seasonal use, there may be significant biases in SUM06, W126, and N100 exposure indices calculated from their data. These statistics were not calculated for sites that were operational for less than three months during the year. In 2004 these sites were Gulf Islands National Seashore, Little River Canyon National Preserve, and Russell Cave National Monument.

The map in Figure 3-13 presents the annual 3-month maximum SUM06 exposure index for all network sites listed in Table 3-6. Index values are color-coded to represent three distinct levels of cumulative exposure. Data from portable sites (no color) are included for reference only. The Sum06 risk thresholds are relative and not absolute.

Ozone effects depend not only on ozone exposure, but on other factors that may ameliorate or magnify the extent of ozone injury, including soil moisture, presence of other air pollutants, insects or diseases, and other environmental stresses. A high SUM06 exposure in a drought year, for example, may not result in vegetation injury because stomatal closure to prevent moisture loss will also prevent ozone uptake.

In evaluating risk to vegetation from ozone, it is useful to consider not only the SUM06 but also the W126 and N100 exposures. If more than one exposure indices is above the threshold for effects, the potential for injury increases.

In 2004, assessments were completed to evaluate the potential for ozone injury to vegetation at many national park service units. The assessments are available at <http://www2.nature.nps.gov/air/Pubs/ozone.cfm>

Information on ozone-sensitive plant species is available at <http://www2.nature.nps.gov/air/Pubs/pdf/BaltFinalReport1.pdf>.

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Table 3-6
Summary of Indices for Resource Injury (SUM06, W126, and N100)
2004
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	O3 % Valid	SUM06 ¹ (ppm-hr)	W126 ² (ppm-hr)	N100 ³
<i>Acadia</i>	Cadillac Mountain	99.2	12.9	20.7	3
<i>Acadia</i>	McFarland Hill	99.4	5.9	17.0	0
Badlands	Visitor Center	99.5	4.6	15.9	0
Big Bend	K-Bar Ranch Road	98.9	3.6	21.9	0
<u>Big South Fork</u>	Portable Ozone	72.4	2.7	7.0	0
<u>Black Canyon of the Gunnison</u>	Portable Ozone	43.7	41.0	51.7	0
<i>Cape Cod</i>	Cape Cod	97.5	17.8	23.3	7
Canyonlands	Island in the Sky	98.1	24.2	51.9	0
<i>Chamizal</i>	Chamizal	99.5	11.7	19.6	4
Chiricahua	Entrance Station	99.2	24.7	39.9	0
<i>Channel Islands</i>	Santa Rosa Island	84.5	8.8	19.9	1
<i>Congaree</i>	Congaree Bluff	99.3	8.3	13.0	2
<i>Cowpens</i>	Cowpens	99.2	8.9	15.7	0
Craters of the Moon	Visitor Center	94.2	7.4	27.6	0
Denali	Headquarters	99.7	0.9	8.6	0
Death Valley	Park Village	95.0	69.8	74.2	0
Everglades	Beard Center	94.8	4.6	10.6	0
Glacier	West Glacier Horse Stables	92.3	0.0	5.3	0
Great Basin	Maintenance Yard	97.8	25.1	40.8	0
Grand Canyon	The Abyss	99.1	35.5	55.0	0
<u>Grand Canyon</u>	Portable Ozone	58.8	8.6	22.8	0
Great Smoky Mountains	Cades Cove	96.4	7.1	13.9	0
Great Smoky Mountains	Clingmans Dome	97.5	34.9	46.5	0
Great Smoky Mountains	Cove Mountain	96.2	30.1	54.3	0
Great Smoky Mountains	Look Rock	98.9	37.3	65.0	0
<i>Great Smoky Mountains</i>	Purchase Knob	93.3	26.1	32.3	0
<u>Isle Royale</u>	Portable Ozone	92.3	1.6	4.7	0
Joshua Tree	Yucca Valley	99.1	108.1	140.2	70
<u>Lake Mead</u>	Portable Ozone	91.4	58.9	52.4	0
Lassen Volcanic	Manzanita Lake Maint. Area	98.5	19.5	28.0	0
Mammoth Cave	Houchin Meadow	99.7	10.9	22.1	0
<u>Mammoth Cave</u>	Portable Ozone	72.5	3.1	4.4	0
Mesa Verde	Maintenance Yard	99.3	16.0	44.2	0
<u>Mount Rainier</u>	Portable Ozone	70.3	4.2	5.6	2
Mount Rainier	Tahoma Woods	98.5	1.8	4.2	0
North Cascades	Marblemount Ranger Station	98.0	0.5	2.5	0
<u>Olympic</u>	Portable Ozone	00.0	0.1	4.6	0
Olympic	Visitor Center	81.1	0.0	1.6	0
Petrified Forest	Horse Barn	93.4	33.1	42.4	0
Pinnacles	East Entrance Station	95.7	18.5	29.3	0
Rocky Mountain	Longs Peak Ranger Station	99.9	34.0	58.0	0
<i>Saguaro</i>	Pima County	99.0	22.6	43.3	0

Table 3-6 (cont.)
Summary of Indices for Resource Injury (SUM06, W126, and N100)
2004
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	O3 % Valid	SUM06 ¹ (ppm-hr)	W126 ² (ppm-hr)	N100 ³
Sequoia and Kings Canyon	Ash Mountain	81.6	65.0	122.5	57
Sequoia and Kings Canyon	Lower Kaweah	92.8	97.2	96.3	17
Sequoia and Kings Canyon	Lookout Point	87.6	120.7	133.7	45
Shenandoah	Big Meadows	96.3	20.5	41.6	0
<i>Theodore Roosevelt</i>	Visitor Center	58.3	0.6	4.3	0
Voyageurs	Sullivan Bay	98.3	1.4	11.9	0
Yellowstone	Water Tank	96.4	2.6	24.3	0
Yosemite	Merced River	90.7	11.0	16.2	0
Yosemite	Turtleback Dome	98.8	97.9	109.0	12
Zion	Dalton's Wash	94.4	41.1	48.2	0

1. SUM06 exposure index represents the sum of all hourly ozone concentrations equaling or exceeding 0.06 ppm. The value reported here represents a three month maximum value for the year. Units are ppm-hr.

2. W126 exposure index represents the sum of all hourly ozone concentrations where each concentration is weighted by a function that gives greater emphasis to the higher hourly concentrations while still including the lower ones. Units are ppm-hr. For more information on the W126 exposure index go to http://www2.nature.nps.gov/air/maps/AirAtlas/air_quality_glossary.pdf

3. N100 represents the number of hourly ozone concentrations greater than or equal to 0.100 ppm (100 ppb).

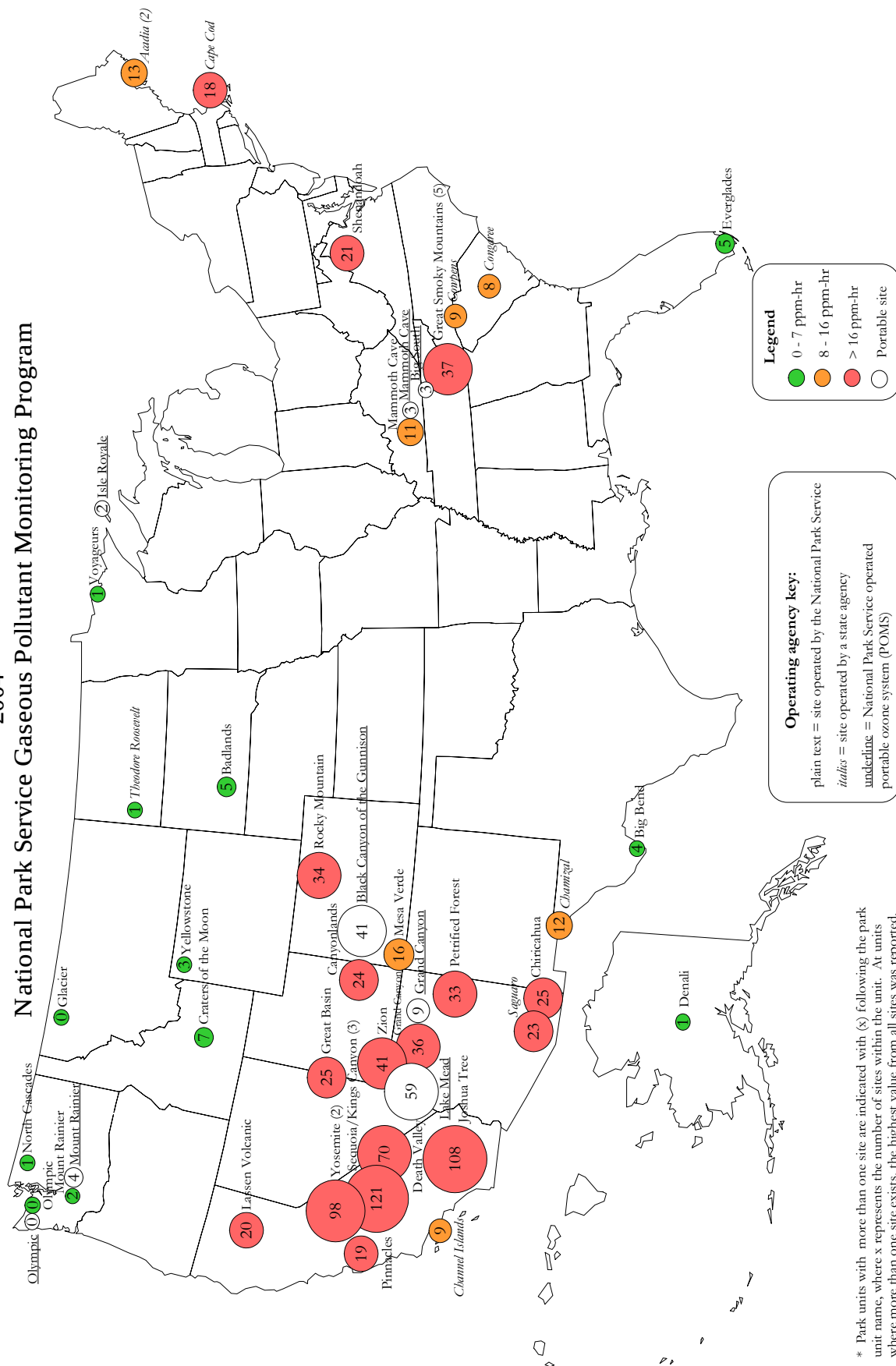
Operating agency key:

plain text = site operated by the National Park Service

italics = site operated by a state agency

underline = site operated by the National Park Service, but consisting of non-EPA certified portable instrumentation

Figure 3-13
Annual 3 Month Maximum Sum06 Exposure Index
2004
National Park Service Gaseous Pollutant Monitoring Program



* Park units with more than one site are indicated with (x) following the park unit name, where x represents the number of sites within the unit. At units where more than one site exists, the highest value from all sites was reported.

3.3 SULFUR DIOXIDE DATA SUMMARIES

Sulfur dioxide (SO₂) is a criteria pollutant that over time undergoes chemical transformations in the atmosphere to form aqueous sulfur compounds, such as sulfuric acid, and particulate sulfate that can lead to environmental and health effects. Both sulfur dioxide and fine particulate sulfate can cause respiratory problems. Sulfur dioxide and acidic sulfate deposited on the earth's surface can affect aquatic and terrestrial ecosystems. Sulfur compounds are a major constituent of acid rain and sulfate is one of the particulate species responsible for visibility degradation and regional haze.

The Primary National Ambient Air Quality Standards for sulfur dioxide are an annual arithmetic mean of 0.03 ppm (34 ppb) and a 24-hour mean of 0.14 ppm (144 ppb), not to be exceeded more than once per year. The secondary NAAQS is a 3-hour mean of 0.50 ppm (549 ppb), not to be exceeded more than once per year. Table 3-7 summarizes sulfur dioxide measurements for comparison to these standards and lists the number of exceedances for each. Maximum hourly concentrations for each site are also presented in the table for reference.

At Hawaii Volcanoes National Park sulfur dioxide data are collected using a lower range and an upper range. The lower range does not capture values higher than 999 ppb, but is considered to be an EPA equivalency method. The upper range captures values above 999 ppb accurately, but is not an EPA reference method. Data presented in this report were collected using the upper range to give a more accurate representation of sulfur dioxide values.

Table 3-7
Summary of Sulfur Dioxide Data by Site
2004
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit Site Name	Annual Arithmetic Mean (ppb) ¹	Highest Daily 24-Hour Average Concentrations ² (ppb)				No. of days with 24-Hour Average >= 145 ppb	Highest Daily Maximum 3-Hour Average Concentration ³ (ppb)				No. of days with 3-Hour Maximum >= 550 ppb	Highest Daily Maximum 1-Hour Average Concentration (ppb)				
		1st Highest	2nd Highest	3rd Highest	4th Highest		1st Highest	2nd Highest	3rd Highest	4th Highest		1st Highest	2nd Highest	3rd Highest	4th Highest	
Congaree	Congaree Bluff	1	10	9	7	7	0	55	32	31	29	0	81	49	46	46
Hawaii Volcanoes *	Observatory	20	181	144	140	140	1	535	527	501	441	0	987	797	757	739
Hawaii Volcanoes *	Visitor Center	10	143	136	129	106	0	545	416	404	362	0	785	769	717	707
Olympic *	Visitor Center	1	5	5	4	4	0	14	12	11	10	0	24	18	16	16
Shenandoah *	Big Meadows	2	11	10	9	8	0	18	16	16	16	0	31	27	23	23
Theodore Roosevelt	Visitor Center	0	2	2	2	2	0	6	4	4	4	0	16	12	8	8

1. The primary annual National Ambient Air Quality Standard for sulfur dioxide is an annual arithmetic mean of 0.03 ppm. (A value greater than 0.03 ppm, 34 ppb, or 80 µg/m³ exceeds the standard.) (40 CFR 50.4.)

2. The primary daily National Ambient Air Quality Standard for sulfur dioxide is 0.14 ppm over a 24-hour period not to be exceeded more than once per year. (A value greater than 0.14 ppm, 144 ppb, or 365 µg/m³ exceeds the standard.) (40 CFR 50.4.)

3. The secondary National Ambient Air Quality Standard for sulfur dioxide is 0.5 ppm over a 3-hour period not to be exceeded more than once per year. (A value greater than 0.5 ppm, 549 ppb, or 1300 µg/m³ exceeds the standard.) (40 CFR 50.5.)

*This site collected sulfur dioxide data using an instrument or a range that is not an EPA reference method.

Operating agency key:

plain text = site operated by the National Park Service
italics = site operated by a state agency

Color shading key:

>34 ppb annual arithmetic mean, >144 ppb 24-hour average, or >549 ppb 3-hour average

3.4 METEOROLOGICAL DATA SUMMARIES

Meteorological data collected along with air quality parameters are used to better understand the local conditions and transport of air pollutants. In addition, meteorological data are essential for air quality deposition modeling efforts. Refer to Table 2-1 for a list of meteorological parameters collected at each site.

Table 3-8 presents a summary of selected meteorological data for all sites. The parameters included are wind speed, ambient temperature, relative humidity, and precipitation.

Table 3-8
Summary of Selected Meteorological Data by Site
2004
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	Wind Speed (Scalar ¹) (m/s)		Ambient Temperature (degrees C)		Relative Humidity (%)		Precipitation (mm)	
		Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Accumulated during period
<u>Adia</u>	Cadillac Mountain	6.3	13.8	27.5	-0.2	84	100	18	—
<u>Adia</u>	McFarland Hill	3.2	6.2	30.8	-26.8	70	100	14	580.1
Badlands	Visitor Center	4.1	10.3	38.4	-22.5	56	99	8	250.1
Big Bend	K-Bar Ranch Road	3.4	19.5	38.1	-6.0	50	100	5	410.4
Big South Fork	Portable Ozone	0.6	20.6	31.7	-0.5	82	100	28	490.2
<u>Black Canyon of the Gunnison</u>	Portable Ozone	2.2	15.1	30.0	-2.5	39	99	8	122.5
<u>Cape Cod</u>	Cape Cod	2.7	8.9	27.9	-21.1	80	100	22	—
Canyonlands	Island in the Sky	2.8	10.7	32.6	-11.0	41	99	2	207.3
<u>Chamizal</u>	Chamizal	3.3	18.8	38.5	-6.8	39	98	4	—
Chiricahua	Entrance Station	3.1	15.1	34.6	-7.5	45	100	6	397.6
Craters of the Moon	Visitor Center	3.4	6.3	31.7	-21.2	54	100	6	—
<u>Denali</u>	Headquarters	1.4	0.2	27.6	-36.8	67	99	11	197.0
Death Valley	Park Village	3.8	26.0	47.8	5.0	21	100	2	103.3
Everglades	Beard Center	2.2	23.4	33.8	7.0	77	100	26	1061.4
Glacier	West Glacier Horse Stables	1.1	5.8	32.1	-36.3	74	98	14	836.8
Great Basin	Maintenance Yard	2.7	8.8	31.0	-15.6	46	98	5	365.2
Grand Canyon	The Abyss	2.8	10.4	30.1	-9.8	44	100	4	493.2
<u>Grand Canyon</u>	Portable Ozone	2.8	23.3	37.8	4.5	29	95	5	69.6
Great Smoky Mountains	Cades Cove	1.2	13.3	30.8	-16.5	77	100	8	1350.2
Great Smoky Mountains	Clingmans Dome	3.5	12.2	19.6	-5.0	92	100	3	1250.3
Great Smoky Mountains	Cove Mountain	4.5	10.7	24.7	-17.7	75	100	2	1320.6
Great Smoky Mountains	Look Rock	2.4	13.1	28.1	-15.8	72	100	16	1438.2
<u>Gulf Islands</u>	Portable Ozone	3.5	27.3	32.8	19.0	75	96	41	279.8
<u>Hawai'i Volcanoes</u>	Observatory	4.7	16.4	25.9	9.1	86	100	27	1723.6
Hawai'i Volcanoes	Visitor Center	3.4	16.1	24.8	8.4	91	100	41	2497.4
<u>Isle Royale</u>	Portable Ozone	5.7	13.8	26.5	1.3	72	100	27	343.7

Table 3-8 (cont.)
Summary of Selected Meteorological Data by Site
2004
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	Wind Speed (Scalar ¹) (m/s)		Ambient Temperature (degrees C)		Relative Humidity (%)		Precipitation (mm)	
		Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
Joshua Tree	Yucca Valley	3.9	14.7	35.9	-3.5	37	100	4	303.9
Kobuk Valley	Ambler	2.5	-0.1	28.8	-41.5	75	98	24	224.5
Lake Mead	Portable Ozone	4.0	27.9	41.5	8.3	18	78	5	21.0
Lassen Volcanic	Manzanita Lake Maint. Area	2.0	7.4	28.0	-15.1	60	99	8	729.6
Mammoth Cave	Houchin Meadow	1.8	14.1	31.4	-16.2	72	100	14	1483.5
Mammoth Cave	Portable Ozone	0.5	21.9	33.7	6.0	80	98	32	442.5
Mesa Verde	Maintenance Yard	2.9	10.0	30.7	-13.6	41	97	5	371.7
Mount Rainier	Portable Ozone	0.6	13.6	32.3	2.0	75	99	15	767.3
Mount Rainier	Tahoma Woods	1.0	9.5	34.5	-8.9	83	100	12	1355.0
North Cascades	Marblemount Ranger Station	1.3	10.4	36.4	-9.5	84	100	14	2064.1
Olympic	Portable Ozone	0.8	10.2	25.8	-1.4	74	100	19	241.0
Olympic	Visitor Center	0.9	10.1	30.5	-9.7	81	100	22	594.2
Petrified Forest	Horse Barn	3.8	12.6	33.4	-13.5	43	99	3	227.1
Pinnacles	East Entrance Station	2.2	14.6	39.1	-4.7	61	98	4	384.4
Rocky Mountain	Longs Peak Ranger Station	2.7	3.8	25.0	-24.8	53	99	5	650.8
Saguaro	Pima County	2.8	21.2	40.0	-0.5	30	96	1	—
Sequoia and Kings Canyon	Ash Mountain	2.5	17.1	38.5	-0.9	51	100	5	436.1
Sequoia and Kings Canyon	Lower Kaweah	1.7	9.1	28.6	-11.0	59	99	6	448.4
Sequoia and Kings Canyon	Lookout Point	4.3	12.8	33.6	-5.9	52	99	7	420.6
Shenandoah	Big Meadows	2.5	8.2	25.6	-21.4	73	100	4	1455.1
Theodore Roosevelt	Visitor Center	5.2	6.3	36.6	-31.2	64	100	7	257.3

Table 3-8 (cont.)
Summary of Selected Meteorological Data by Site
2004
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	Wind Speed (Scalar ¹) (m/s)		Ambient Temperature (degrees C)		Relative Humidity (%)		Precipitation (mm)
		Average	Minimum	Average	Minimum	Average	Minimum	Accumulated during period
Voyagers	Sullivan Bay	2.8	-35.5	30.7	71	100	18	672.4
Wind Cave	Visitor Center	3.0	-24.1	35.7	53	100	7	301.6
Yellowstone	Water Tank	1.6	-27.1	25.5	68	100	11	515.8
Yosemite	Merced River	0.5	-8.4	35.7	65	99	5	735.3
Yosemite	Turtleback Dome	4.0	-8.5	31.0	42	99	2	520.7
Zion	Dalton's Wash	2.8	-6.6	38.9	36	100	5	291.7

1. Saguaro reports wind speed as vector wind speed rather than scalar wind speed.

Note: Dashed lines represent no data available for that particular parameter at that site.

Operating agency key:

plain text = site operated by the National Park Service

italics = site operated by a state agency

underline = site operated by the National Park Service, but consisting of non-EPA certified portable instrumentation

4.0 PRECISION AND ACCURACY OF OZONE MEASUREMENTS

Ozone analyzers are automatically challenged daily with known zero and span concentrations. Most sites also undergo an automatic daily precision check. At a few sites, precision checks are performed weekly. All EPA reference method ozone sites operate both an analyzer (with ozone generator) and calibrator on site. The daily zero, span, and precision values are measured by both instruments, providing an independent reference to the on-site measurements. The NPS goal is for precision checks to fall within $\pm 10\%$ of the calibration gas concentration.

Routine quality assurance multipoint calibrations of the GPMP ozone analyzers and calibrators are performed by the site operators monthly, and by the NPS-contracted network field specialists upon initial installation and every six months thereafter. Network field specialists perform their quality assurance checks using an ozone transfer standard (traceable to a NIST-certified primary standard). The NPS goal is for these accuracy checks to fall within $\pm 10\%$ of the transfer standard gas concentrations. For more information on quality assurance within the network, please refer to the Quality Management Plan (QMP) and the Quality Assurance Project Plan (QAPP) which can be found on the Web at: <http://www2.nature.nps.gov/air/Monitoring/network.cfm#procedures>.

Table 4-1 presents a summary of ozone analyzer precision results and semiannual accuracy results, by quarter, for 2004. Results are color-coded to indicate ideal performance (no shading), acceptable performance (yellow), and unacceptable performance (red). Accuracy results are presented only for NPS-operated sites, and typically include 2 entries for the year.

Table 4-2 presents a network summary of ozone analyzer precision and accuracy, by quarter, for 2004. Included in the table are the number of sites whose precision and accuracy checks fell within $\pm 5\%$, $\pm 10\%$, and outside of $\pm 10\%$.

Table 4-1
Ozone Analyzer Precision and Accuracy Summary
2004
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit			Site Name	Calendar Quarter	Precision				Accuracy			
					Required No. of Precision Checks Met? ¹	Avg. Absolute Percent Difference ^{3,4}	Lower 95% Probability Limit ⁶	Upper 95% Probability Limit ⁶	Accuracy Check Performed During the Quarter? ²	Avg. Absolute Percent Difference ^{3,4}	Maximum Percent Difference ⁵	
Acadia	Cadillac Mountain	1			—	—	—	—	—	—	—	
		2		N	1.2	0.0	2.4	N	—	—		
		3		Y	1.2	-0.1	2.5	N	—	—		
		4		—	—	—	—	—	—			
Acadia	McFarland Hill	1		Y	0.6	-5.3	4.1	N	—	—		
		2		Y	1.2	-4.4	6.7	N	—	—		
		3		Y	0.6	-0.7	1.9	N	—	—		
		4		N	—	—	—	N	—	—		
Badlands	Visitor Center	1		Y	1.0	-4.7	2.6	Y	8.9	-10.0		
		2		Y	1.7	-4.5	1.0	N	—	—		
		3		Y	1.2	-5.8	3.3	N	—	—		
		4		Y	1.2	-3.1	0.8	Y	1.4	-2.1		
Big Bend	K-Bar Ranch Road	1		Y	1.6	-2.2	5.4	Y	1.4	2.9		
		2		Y	0.2	-2.0	1.6	N	—	—		
		3		Y	2.7	-4.4	-1.0	N	—	—		
		4		Y	4.0	-7.9	0.0	Y	11.2	-11.3		
Cape Cod	Cape Cod	1		—	—	—	—	—	—	—		
		2		Y	2.7	1.7	3.7	N	—	—		
		3		Y	0.7	-3.5	4.9	N	—	—		
		4		—	—	—	—	—	—			
Canyonlands	Island in the Sky	1		Y	1.3	-3.8	1.1	N	—	—		
		2		Y	2.3	-3.7	-0.9	N	—	—		
		3		Y	0.6	-5.2	4.0	Y	2.6	-4.1		
		4		N	4.6	-2.0	11.2	Y	0.7	1.4		
Chamizal	Chamizal	1		Y	1.9	-2.9	-0.8	N	—	—		
		2		Y	1.6	-4.7	1.6	N	—	—		
		3		Y	1.7	-3.5	0.2	N	—	—		
		4		Y	1.3	-4.5	1.9	N	—	—		
Chiricahua	Entrance Station	1		Y	0.3	-0.7	1.3	N	—	—		
		2		Y	0.1	-0.8	0.9	Y	0.8	-1.4		
		3		Y	0.3	-1.4	0.7	N	—	—		
		4		Y	0.1	-1.8	1.6	Y	0.5	-1.4		
Channel Islands	Santa Rosa Island	1		N	0.4	-1.5	0.7	N	—	—		
		2		Y	0.1	-1.1	1.4	N	—	—		
		3		Y	0.1	-2.3	2.6	N	—	—		
		4		Y	0.8	-5.4	7.1	N	—	—		

Table 4-1 (cont.)
Ozone Analyzer Precision and Accuracy Summary
2004
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit			Site Name	Calendar Quarter	Precision				Accuracy		
					Required No. of Precision Checks Met? ¹	Avg. Absolute Percent Difference ^{3,4}	Lower 95% Probability Limit ⁶	Upper 95% Probability Limit ⁶	Accuracy Check Performed During the Quarter? ²	Avg. Absolute Percent Difference ^{3,4}	Maximum Percent Difference ⁵
Congaree	Congaree Bluff	1	N	0.7	-3.9	5.4	N	—	—	—	
		2	N	1.3	-4.0	6.5	N	—	—		
		3	N	2.2	0.2	4.3	N	—	—		
		4	N	2.1	-4.9	9.1	N	—	—		
Cowpens	Cowpens	1	Y	3.4	-15.6	8.8	N	—	—	—	
		2	Y	0.8	-11.3	12.9	N	—	—	—	
		3	N	0.8	-3.2	4.8	N	—	—	—	
		4	N	0.5	-9.3	8.3	N	—	—	—	
Craters of the Moon	Visitor Center	1	Y	2.4	-8.9	4.0	Y	0.9	-1.4	—	
		2	Y	4.0	2.5	5.4	N	—	—	—	
		3	Y	1.9	-1.5	5.3	N	—	—	—	
		4	Y	0.0	-4.0	4.0	N	—	—	—	
Denali	Headquarters	1	Y	0.2	-1.1	0.7	N	—	—	—	
		2	Y	0.2	-2.6	2.1	Y	3.1	3.6	—	
		3	Y	0.6	-1.7	0.6	Y	2.8	-3.5	—	
		4	Y	1.8	-2.8	-0.7	N	—	—	—	
Death Valley	Park Village	1	N	6.9	-10.8	-3.1	Y	1.6	-4.3	—	
		2	Y	6.1	-9.7	-2.5	N	—	—	—	
		3	Y	1.3	-6.7	4.1	Y	0.1	0.3	—	
		4	Y	0.9	-5.0	3.2	Y	9.4	-11.6	—	
Everglades	Beard Center	1	Y	1.0	-6.5	4.5	N	—	—	—	
		2	Y	3.0	-7.1	1.1	N	—	—	—	
		3	Y	1.1	-9.6	7.5	Y	2.3	3.2	—	
		4	Y	0.2	-4.6	5.0	N	—	—	—	
Glacier	West Glacier Horse Stables	1	Y	0.7	-3.1	1.7	N	—	—	—	
		2	Y	1.0	-2.7	4.8	Y	0.2	-0.5	—	
		3	Y	2.0	-1.2	5.1	Y	1.1	1.4	—	
		4	Y	1.9	-1.5	5.3	N	—	—	—	
Great Basin	Maintenance Yard	1	Y	3.0	-7.6	1.5	Y	3.7	-5.8	—	
		2	Y	0.4	-1.9	2.7	N	—	—	—	
		3	Y	0.0	-1.9	1.9	Y	0.3	-0.6	—	
		4	Y	0.6	-2.0	3.2	Y	1.5	1.8	—	
Grand Canyon	The Abyss	1	Y	0.1	-1.5	1.3	N	—	—	—	
		2	Y	1.4	-0.1	2.9	Y	1.8	2.2	—	
		3	Y	0.9	-0.4	2.2	N	—	—	—	
		4	Y	0.2	-2.5	2.1	Y	1.2	1.8	—	

Table 4-1 (cont.)
Ozone Analyzer Precision and Accuracy Summary
2004
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit			Site Name	Calendar Quarter	Precision				Accuracy			
					Required No. of Precision Checks Met? ¹	Avg. Absolute Percent Difference ^{3,4}	Lower 95% Probability Limit ⁶	Upper 95% Probability Limit ⁶	Accuracy Check Performed During the Quarter? ²	Avg. Absolute Percent Difference ^{3,4}	Maximum Percent Difference ⁵	
Great Smoky Mountains	Cades Cove	1			Y	2.5	-6.4	1.4	N	—	—	
		2			Y	1.5	-5.2	2.1	Y	0.4	-1.4	
		3			Y	0.0	-2.3	2.4	N	—	—	
		4			Y	0.1	-2.7	2.9	Y	6.2	6.5	
Great Smoky Mountains	Clingmans Dome	1			—	—	—	—	—	—	—	
		2			Y	0.3	-7.7	8.2	N	—	—	
		3			N	0.7	-7.2	8.7	N	—	—	
		4			Y	0.4	-2.1	2.9	Y	14.9	15.3	
Great Smoky Mountains	Cove Mountain	1			Y	0.8	-6.5	5.0	N	—	—	
		2			Y	1.7	-8.9	12.2	Y	1.1	1.5	
		3			Y	2.3	-1.2	5.9	N	—	—	
		4			Y	0.3	-2.1	2.7	Y	7.4	7.8	
Great Smoky Mountains	Look Rock	1			Y	1.0	-3.2	1.1	N	—	—	
		2			Y	2.7	-3.5	8.9	Y	2.7	-3.7	
		3			Y	1.6	-2.7	5.9	N	—	—	
		4			Y	0.6	-2.2	3.4	Y	3.8	4.2	
Great Smoky Mountains	Purchase Knob	1			—	—	—	—	—	—	—	
		2			Y	0.8	-0.9	2.4	N	—	—	
		3			Y	0.6	-1.1	2.2	N	—	—	
		4			Y	0.8	-1.3	2.9	N	—	—	
Joshua Tree	Yucca Valley	1			Y	1.0	-3.3	1.3	N	—	—	
		2			Y	0.7	-3.5	2.2	Y	0.8	-1.4	
		3			Y	2.8	-5.3	-0.3	N	—	—	
		4			Y	2.0	-4.6	0.7	Y	0.7	-1.4	
Lassen Volcanic	Manzanita Lake Maint. Area	1			Y	1.8	-10.7	7.2	N	—	—	
		2			Y	4.8	-6.8	-2.8	N	—	—	
		3			Y	3.6	-6.7	-0.4	Y	1.4	-2.9	
		4			Y	3.4	-5.7	-1.1	N	—	—	
Mammoth Cave	Houchin Meadow	1			Y	0.4	-1.6	2.3	N	—	—	
		2			Y	1.8	-0.3	3.9	Y	0.1	-0.3	
		3			Y	2.2	-2.0	6.4	N	—	—	
		4			Y	2.5	-1.8	6.8	N	—	—	

Table 4-1 (cont.)
Ozone Analyzer Precision and Accuracy Summary
2004
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit			Calendar Quarter	Precision				Accuracy		
Site Name	Required No. of Precision Checks Met? ¹	Avg. Absolute Percent Difference ^{3,4}		Lower 95% Probability Limit ⁶	Upper 95% Probability Limit ⁶	Accuracy Check Performed During the Quarter? ²	Avg. Absolute Percent Difference ^{3,4}	Maximum Percent Difference ⁵		
Mesa Verde	Maintenance Yard	1	Y	0.3	-2.4	2.9	N	—	—	
		2	Y	2.8	-2.5	8.1	Y	1.2	-1.5	
		3	Y	7.0	1.1	13.0	N	—	—	
		4	Y	0.0	-1.3	1.3	Y	1.4	-2.8	
Mount Rainier	Tahoma Woods	1	Y	2.0	-6.6	2.6	N	—	—	
		2	Y	5.2	-8.2	-2.2	Y	3.7	-5.7	
		3	Y	5.5	-9.8	-1.2	N	—	—	
		4	Y	4.1	-10.5	2.4	Y	1.3	-2.8	
North Cascades	Marblemount Ranger Station	1	N	7.1	-10.7	-3.5	N	—	—	
		2	Y	6.1	-10.8	-1.4	Y	5.9	8.5	
		3	Y	5.9	-9.3	-2.4	N	—	—	
		4	Y	5.6	-10.5	-0.7	Y	3.0	-8.6	
Olympic	Visitor Center	1	Y	1.7	-7.4	4.0	N	—	—	
		2	Y	2.4	-7.3	2.5	Y	0.5	-1.4	
		3	Y	2.1	-7.5	3.3	N	—	—	
		4	Y	4.8	-10.6	0.9	Y	0.4	-1.4	
Petrified Forest	Horse Barn	1	Y	1.9	-6.4	2.5	N	—	—	
		2	Y	0.3	-1.2	1.9	Y	0.8	1.6	
		3	Y	0.0	-1.8	1.9	N	—	—	
		4	Y	0.7	-3.8	2.4	Y	2.3	2.9	
Pinnacles	East Entrance Station	1	Y	0.2	-2.9	2.6	N	—	—	
		2	Y	0.4	-2.4	1.5	N	—	—	
		3	Y	0.2	-2.0	2.4	Y	6.9	7.6	
		4	Y	1.5	-3.1	0.1	N	—	—	
Rocky Mountain	Longs Peak Ranger Station	1	Y	0.8	-2.3	3.9	Y	0.5	1.4	
		2	Y	3.9	2.2	5.6	N	—	—	
		3	Y	3.1	1.4	4.9	Y	3.0	4.2	
		4	Y	1.6	-3.0	6.1	N	—	—	
Saguaro	Pima County	1	Y	1.0	-0.6	2.5	N	—	—	
		2	N	0.0	-1.3	1.3	N	—	—	
		3	N	0.2	-2.8	2.5	N	—	—	
		4	Y	0.8	-0.3	1.9	N	—	—	

Table 4-1 (cont.)
Ozone Analyzer Precision and Accuracy Summary
2004
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit			Site Name	Calendar Quarter	Precision				Accuracy			
					Required No. of Precision Checks Met? ¹	Avg. Absolute Percent Difference ^{3,4}	Lower 95% Probability Limit ⁶	Upper 95% Probability Limit ⁶	Accuracy Check Performed During the Quarter? ²	Avg. Absolute Percent Difference ^{3,4}	Maximum Percent Difference ⁵	
Sequoia and Kings Canyon	Ash Mountain	1			Y	0.3	-2.1	1.4	Y	2.2	-2.9	
		2			Y	0.7	-3.9	2.5	N	—	—	
		3			Y	1.2	-3.9	1.6	Y	2.8	3.2	
		4			Y	0.0	-2.6	2.6	N	—	—	
Sequoia and Kings Canyon	Lower Kaweah	1			Y	0.2	-3.5	4.0	Y	1.7	-2.7	
		2			Y	0.8	-3.6	2.0	N	—	—	
		3			Y	0.8	-3.5	1.9	Y	0.3	0.6	
		4			Y	0.5	-2.0	1.1	N	—	—	
Sequoia and Kings Canyon	Lookout Point	1			Y	4.8	-11.7	2.2	Y	2.4	-3.5	
		2			Y	3.9	-8.4	0.6	N	—	—	
		3			N	2.7	-8.1	2.7	Y	3.9	4.3	
		4			Y	6.4	-12.4	-0.5	N	—	—	
Shenandoah	Big Meadows	1			Y	0.4	-1.5	0.8	N	—	—	
		2			Y	0.5	-1.5	2.5	N	—	—	
		3			Y	3.2	-5.0	-1.3	Y	2.9	4.0	
		4			Y	0.6	-3.3	4.5	Y	7.3	8.5	
Theodore Roosevelt	Visitor Center	1			—	—	—	—	—	—	—	
		2			Y	0.7	-0.5	2.0	N	—	—	
		3			Y	1.7	-8.4	5.0	N	—	—	
		4			Y	2.4	-6.6	1.9	N	—	—	
Voyageurs	Sullivan Bay	1			Y	2.0	-2.9	-1.1	N	—	—	
		2			Y	2.2	-3.5	-0.9	Y	0.9	1.4	
		3			Y	2.7	-3.8	-1.6	N	—	—	
		4			Y	2.3	-3.2	-1.4	Y	1.7	2.8	
Yellowstone	Water Tank	1			Y	2.5	-4.4	-0.6	N	—	—	
		2			Y	1.7	-3.7	0.3	Y	1.3	-1.4	
		3			Y	0.9	-2.5	0.6	Y	1.0	1.4	
		4			Y	2.5	-5.1	0.0	N	—	—	
Yosemite	Merced River	1			Y	0.8	-1.4	2.9	Y	1.8	-2.9	
		2			Y	0.9	-1.9	0.2	N	—	—	
		3			Y	0.7	-1.9	0.5	Y	1.8	-2.9	
		4			Y	1.1	-2.3	0.1	N	—	—	

Table 4-1 (cont.)
Ozone Analyzer Precision and Accuracy Summary
2004
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	Calendar Quarter	Required No. of Precision Checks Met? ¹	Precision			Accuracy		
				Avg. Absolute Percent Difference ^{3,4}	Lower 95% Probability Limit ⁶	Upper 95% Probability Limit ⁶	Accuracy Check Performed During the Quarter? ²	Avg. Absolute Percent Difference ^{3,4}	Maximum Percent Difference ⁵
Yosemite	Turtleback Dome	1	Y	0.8	-2.6	1.0	N	—	—
		2	Y	0.9	-3.1	1.3	N	—	—
		3	Y	0.1	-1.8	2.1	Y	0.8	-1.2
Zion	Dalton's Wash	4	Y	0.1	-2.1	1.9	N	—	—
		1	Y	0.5	-2.7	1.6	N	—	—
		2	Y	0.8	-2.5	0.9	Y	1.0	-1.4
		3	Y	2.1	-2.9	-1.3	N	—	—
		4	Y	1.9	-3.0	-0.9	Y	0.5	-1.4

Operating agency key:

plain text = site operated by the National Park Service

italics = site operated by a state agency

underline = site operated by the National Park Service, but consisting of non-EPA certified portable instrumentation

Color shading key:

- Ideal: indicates a percent difference within +/-5% or a probability limit within +/-10%
 Acceptable: indicates a percent difference between +/-5.1-10% or a probability limit between +/-10.1-15%
 Unacceptable: indicates a percent difference greater than +/-10% or a probability limit greater than +/-15%

- Precision checks are required by the Environmental Protection Agency (EPA) of all pollutant analyzers collecting data which are to be submitted to the EPA Air Quality System (AQS). A precision check is performed by challenging the pollutant analyzer with a known concentration of gas from the pollutant transfer standard. This precision check must be performed at least every 14 days of monitoring operation. The percent difference between the analyzer and the transfer standard is then calculated.³ According to NPS Standard Operating Procedures, the
- Accuracy checks are required by the Environmental Protection Agency (EPA) of all pollutant analyzers collecting data which are to be submitted to the EPA Air Quality System (AQS). An accuracy check is performed by challenging the pollutant analyzer with a known concentration of gas from the pollutant transfer standard at several different points. The percent difference between the analyzer and the transfer standard is then calculated.³ According to NPS Standard Operating Procedures, the pollutant analyzer must respond within 10% of the transfer standard. All accuracy checks reported here were performed by the reporting organization and not by an outside auditor.
- Percent Difference = ((analyzer - transfer std)/transfer std)x100
- Average Absolute Percent Difference is the mean of the absolute value of all individual precision check percent differences during the quarter, or the mean of the absolute value of all the percent differences from each point challenged during an accuracy check.
- Maximum Percent Difference is the highest percent difference from the points of a multipoint (or accuracy) calibration. A positive value indicates the analyzer read high, a negative value indicates the analyzer read low.
- Upper/Lower 95% Probability Limits = (Average Percent Difference) +/- (1.96)(Standard Deviation of precision check percent differences in the quarter). The probability limits represent the interval having a 95% chance of containing the true average percent difference. Probability limits must be within +/-15%.

Table 4-2
Ozone Analyzer Precision and Accuracy Overall Network Summary
2004
National Park Service Gaseous Pollutant Monitoring Program

Calendar Quarter	# Operational Sites	Precision ¹			Accuracy ²		
		Average Absolute Percent Difference			Average Absolute Percent Difference		
		# Sites within +/- 5%	# Sites within +/- 5.1 - 10%	# Sites > +/- 10%	# Sites within +/- 5%	# Sites within +/- 5.1 - 10%	# Sites > +/- 10%
1	39	37	2	0	9	1	0
2	44	41	3	0	16	1	0
3	44	41	3	0	15	1	0
4	42	39	2	0	14	4	2

1. Precision checks are required by the Environmental Protection Agency (EPA) of all pollutant analyzers collecting data which are to be submitted to the EPA Air Quality System (AQS). A precision check is performed by challenging the pollutant analyzer with a known concentration of gas from the pollutant transfer standard. This precision check must be performed at least every 14 days of monitoring operation. The percent difference between the analyzer and the transfer standard is then calculated. According to NPS Standard Operating Procedures, the pollutant analyzer must respond within 10% of the transfer standard.

2. Accuracy checks are required by the Environmental Protection Agency (EPA) of all pollutant analyzers collecting data which are to be submitted to the EPA Air Quality System (AQS). An accuracy check is performed by challenging the pollutant analyzer with a known concentration of gas from the pollutant transfer standard at several different points. The percent difference between the analyzer and the transfer standard is then calculated. According to NPS Standard Operating Procedures, the pollutant analyzer must respond within 10% of the transfer standard.