National Park Service
U.S. Department of the Interior

Air Resources Division

Annual Data Summary 2003

Gaseous Pollutant Monitoring Program

Ozone, sulfur dioxide, meteorological observations

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Forward to the National Park Service
Gaseous Pollutant Monitoring Program
2003 Annual Report

Starting this year, we have moved to a combined report that 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 2003 have been collected, validated, and made available to EPA, the parks, and the public. The data summarized in this report can now be accessed and viewed graphically on the 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 capture rates), and contains summaries related to the pollutant National Ambient Air Quality Standards and thresholds for resource injury.

The NPS Gaseous Pollutant Monitoring Program objectives are:

Primary Monitoring Objectives
Gaseous Pollutant Monitoring Program

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

The baseline pollutant concentrations, the trends, and the degree of compliance with the national air quality standards, along with indicators that may relate to natural resource injury are included in this report. This report is also a score card on how well the data was collected and what the air quality conditions are in each park with gaseous pollutant monitoring. The data provides a foundation for further analysis by the Air Resources Division, EPA, and researchers to meet objectives 4 and 5.

Recently, the EPA designated the ozone non-attainment areas under the new 8-hour ozone standard. These are areas determined by the EPA to be in violation of the standards and to have unhealthy air quality. Figure 1 presents a map of the non-attainment areas. There are 106 park units within these non-attainment areas; 9 of these parks have ozone monitoring that was used in making the non-attainment designations. The magnitude of ozone concentrations and the trends are especially important for these park units in non-attainment areas.

We now have hourly ozone monitoring in 42 park units, but monitoring in all the park units is clearly too expensive. The Air Resources Division and the Inventory and Monitoring program have therefore produced a series of geographic information system (GIS) maps of interpolated data from all network monitors that can be used to estimate the air quality in places where direct measurements are not being made. Figure 2 presents a sample map for the mean annual 4th highest daily maximum ozone relative to the national 8-hour ozone standard. More maps for ozone and other pollutants are available at the Air Atlas Web site (http://www2.nature.nps.gov/air/maps/airatlas/index.htm).

Figure 1

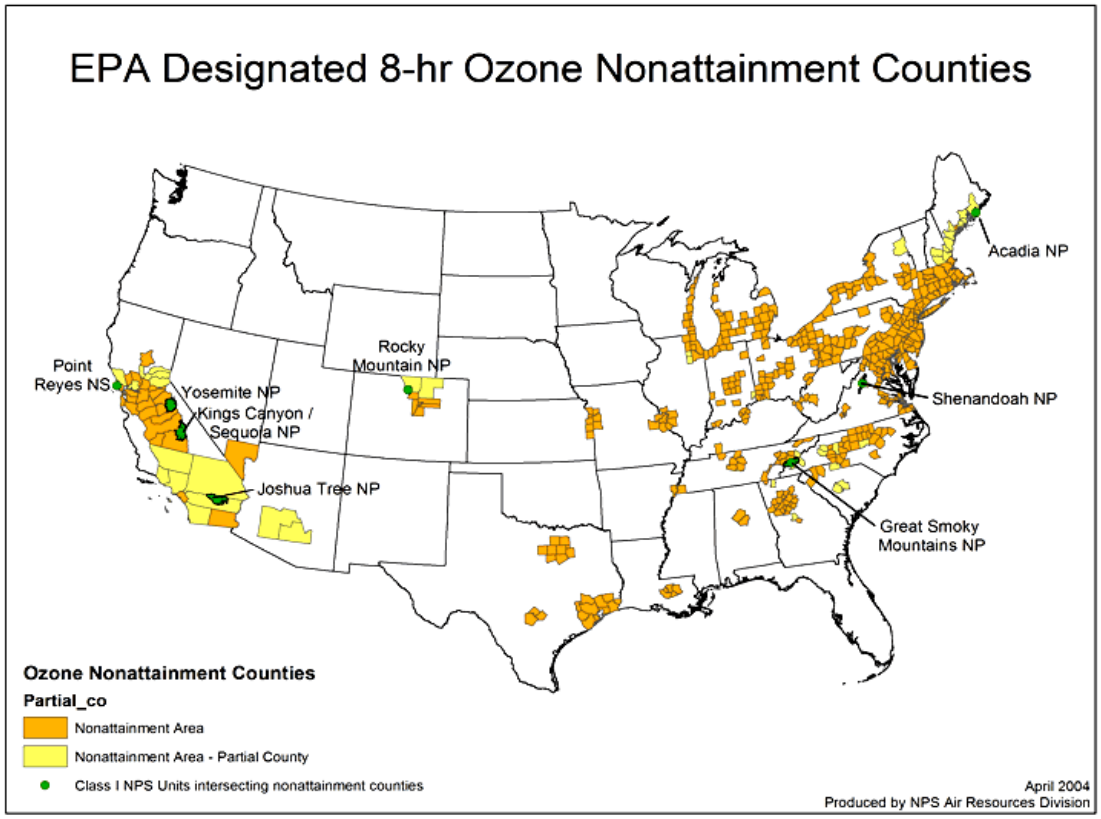
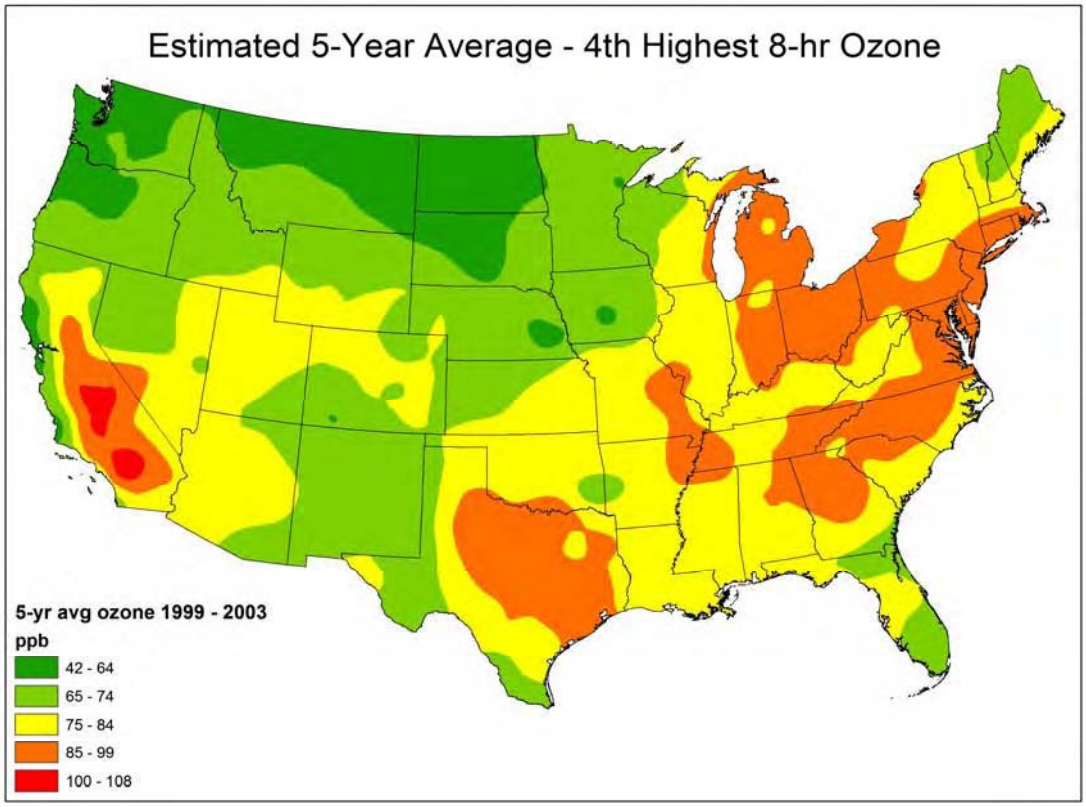


Figure 2



People familiar with previous GPMP annual data summary reports will notice several things missing; no longer will you receive a data disk, site-specific stackplots of data or other selected graphics, and summaries of deposition data. These items are now, or will soon be, available on the ARD Web page (http://www2.nature.nps.gov/air/data/) and from the CASTNet program Web page (http://www.epa.gov/castnet/). The CASTNet program now includes the dry deposition data and some ozone comparisons in their annual report. Changes in the GPMP annual air quality data summary report reduces the amount of paper usage, recognizes the changing reports of our monitoring network partners, and effectively uses the Internet to make data and results more broadly available.

Interpretation and outreach of air quality information has become increasingly important. The data from the GPMP network monitoring stations is being used in new ways and is available to the parks and the public on the Internet. Some examples include:

- Several parks now issue ozone advisories using monitoring data and forecasts (http://www2.nature.nps.gov/air/data/).

- Current, near real-time data are being presented on the Internet for most parks with monitoring through the EPA AirNow program summary maps (http://www.epa.gov/airnow/index.html), and on the ARD Web page (http://www2.nature.nps.gov/air/data/current/index.htm).

- One of our most popular products is the collection of NPS Web camera pages which incorporate live images of scenic views within parks and current air quality and weather data (http://www2.nature.nps.gov/air/WebCams/index.htm).

We encourage you to summarize and share the air quality data within your own park, with the superintendent, with interpreters and rangers, with natural research staff, and with the public. If you have comments, questions, or need help on air quality issues, e-mail or call us at the Air Resources Division.

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1.0 INTRODUCTION

The primary objective of the National Park Service (NPS) Gaseous Pollutant Monitoring Program (GPMP) is to establish the status and trends of park unit air quality conditions and to determine if a park unit is exceeding the National Ambient Air Quality Standards (NAAQS) established by the U.S. Environmental Protection Agency (EPA) to protect public health and welfare. This objective is mandated 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.

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 unit caused by air pollution sources.

To meet these objectives the NPS Air Resources Division (ARD) has established a network of stations to monitor ozone (O_3), sulfur dioxide (SO_2), carbon monoxide (CO), oxides of nitrogen (NO_x), and meteorological conditions in the parks. The 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, ARD cooperates with other national and state programs that monitor ambient gases, meteorology, deposition chemistry, particulate matter, ultraviolet radiation, 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 Air Resources Division's Information Management Center (IMC), and publicly available through the NPS ARD's Web sites at http://www2.nature.nps.gov/air/data/.

2.0 NETWORK DESCRIPTION

The National Park Service air quality monitoring strategy has focused primarily on Class I Areas defined by the Clean Air Act and its amendments, and 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 2003, fifty three (53) monitoring sites in forty two (42) 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 enhanced gaseous category indicates that additional or high resolution gaseous monitoring occurs 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 monitoring sites 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 portable stations are intended for short-term seasonal use at locations where reference method monitoring has not occurred or is not practical. Throughout this report, portable network monitoring site names in tables and figures have been underlined to distinguish them from EPA-certified sites.

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 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 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 have 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 RMB.

IMPROVE

The Interagency Monitoring of Protected Visual Environments (IMPROVE) is a consortium of federal and state land managers and agencies which conduct visibility monitoring in Class I wilderness 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 PM_{10} mass, elements, ions, and carbon compounds.
- 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 and dry 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-Urbana, Illinois. Data are presented in terms of both the mean concentrations of major ions, along with total chemical loading in annual rainfall and snowfall, 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/

PRIMENet

The Park Research and Intensive Monitoring of Ecosystems Network (PRIMENet), is a joint EPA-NPS program to assess the effects of environmental stressors on ecological systems nation wide. A system of monitoring and research sites has been established in National Parks, and in addition to monitoring air at those parks, ultraviolet radiation (UV-B), is measured using a spectrophotometer. More information is available at the PRIMENet Web site: http://www.forestry.umt.edu/research/MFCES/programs/primenet/

Figure 2-1

2003 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.

Parameters

- Ozone
- Meteorology
- CASTNet Filter Pack
- Sulfur Dioxide
- Enhanced Gaseous

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

Table 2-1
Site Specifications
2003
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	State	NPS Abbr.	CASTNet Abbr.	AQS ID Number	Latitude	Longitude	Elevation (m)	O3 Years[1]	SO2	Wind Dir.	Wind Speed	Relative Hum.	Temp.	Precip.	Wetness	Delta Temp.	Solar Rad.	Filter Pack[2]
Acadia	Cadillac Mountain	ME	ACAD-CM	———	23-009-0102	44.3472	68.2278	466	9	—	X	X	X	X	—	—	—	—	—
Acadia	McFarland Hill	ME	ACAD-MH	ACA416	23-009-0103	44.3769	68.2608	158	6	—	X	X	X	X	X	X	X	X	X
Badlands	Visitor Center	SD	BADL-VC	———	46-071-1001	43.7436	101.9414	739	7	—	X	X	X	X	X	—	—	X	—
Big Bend	K-Bar Ranch Road	TX	BIBE-KB	BBE401	48-043-0101	29.3022	103.1772	1052	14	—	X	X	X	X	X	X	X	X	X
Big South Fork	Portable Ozone	TN	BISO-PT	———	———	36.4725	84.6806	451	1	—	X	X	X	X	X	—	—	X	—
Black Canyon of the Gunnison	Portable Ozone	CO	BLCA-PT	———	———	38.5803	107.7167	2408	1	—	X	X	X	X	X	—	—	X	—
Cape Cod	Cape Cod	MA	CACO-XX	———	25-001-0002	41.9769	70.0164	40	17	—	—	X	X	X	—	—	—	X	—
Canyonlands	Island in the Sky	UT	CANY-IS	CAN407	49-037-0101	38.4586	109.8211	1809	12	—	X	X	X	X	X	X	X	X	X
Chamizal	Chamizal	TX	CHAM-XX	———	48-141-0044	31.7656	106.455	1128	12	—	X	X	X	X	—	—	—	X	—
Chiricahua	Entrance Station	AZ	CHIR-ES	CHA467	04-003-8001	32.0092	109.3892	1570	13	—	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	7	—	—	—	—	—	—	—	—	—	—
Congaree Swamp	Congaree Bluff	SC	COSW-BL	———	45-079-0021	33.8147	80.7811	34	4	X	—	—	—	—	—	—	—	—	—
Cowpens	Cowpens	SC	COWP-XX	———	45-021-0002	35.1303	81.8164	296	16	—	—	—	—	—	—	—	—	—	—
Craters of the Moon	Visitor Center	ID	CRMO-VC	———	16-023-0101	43.4606	113.5622	1815	12	—	X	X	X	X	—	—	—	X	—
Denali	Headquarters	AK	DENA-HQ	DEN417	02-290-0003	63.7258	148.9633	661	17	—	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	11	—	X	X	X	X	X	X	X	X	X
Everglades	Beard Center	FL	EVER-BC	EVE419	12-086-0030	25.3911	80.6806	2	20	—	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	12	—	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	11	—	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	11	—	X	X	X	X	X	X	X	X	X
Grand Canyon	Portable Ozone	AZ	GRCA-PT	———	———	36.2828	113.0958	1433	1	—	X	X	X	X	X	—	—	X	—
Great Smoky Mountains	Cades Cove	TN	GRSM-CC	———	47-009-0102	35.6042	83.7831	564	11	—	X	X	X	X	X	—	—	X	—
Great Smoky Mountains	Clingmans Dome	TN	GRSM-CD	———	47-155-0102	35.5619	83.4981	2021	11	—	X	X	X	X	X	—	—	X	—
Great Smoky Mountains	Cove Mountain	TN	GRSM-CM	———	47-155-0101	35.6967	83.6086	1243	16	—	X	X	X	X	X	—	—	X	—
Great Smoky Mountains	Look Rock	TN	GRSM-LR	GRS420	47-009-0101	35.6331	83.9422	793	16	—	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	9	—	—	—	—	—	—	—	—	—	—
Hawaii Volcanoes	Observatory	HI	HAVO-OB	———	15-001-0007	19.4203	155.2881	1123	—	X	X	X	X	X	X	—	—	—	—
Hawaii Volcanoes	Thurston Lava Tubes	HI	HAVO-TH	HVT424	15-001-0006	19.4197	155.24	1199	5	—	X	X	X	X	X	X	X	X	X
Hawaii Volcanoes	Visitor Center	HI	HAVO-VC	———	15-001-0005	19.4308	155.2578	1215	—	X	X	X	X	X	X	—	—	X	—
Isle Royale	Portable Ozone	MI	ISRO-PT	———	———	48.1083	88.6064	347	2	—	X	X	X	X	X	—	—	X	X
Joshua Tree	Yucca Valley	CA	JOTR-YV	JOT403	06-071-9002	34.0714	116.3906	1244	11	—	X	X	X	X	X	X	X	X	X
Lake Mead	Portable Ozone	AZ	LAME-PT	———	———	36.0194	114.0686	881	1	—	X	X	X	X	X	—	—	X	—
Lassen Volcanic	Monzanita Lake Maintenance Area	CA	LAVO-ML	LAV410	06-089-3003	40.5403	121.5764	1756	17	—	X	X	X	X	X	X	X	X	X
Mammoth Cave	Houchin Meadow	KY	MACA-HM	MAC426	21-061-0501	37.1319	86.1478	243	7	—	X	X	X	X	X	X	X	X	X
Mesa Verde	Maintenance Yard	CO	MEVE-MY	MEV405	08-083-0101	37.1983	108.4903	2165	11	—	X	X	X	X	X	X	X	X	X
Mount Rainier	Tahoma Woods	WA	MORA-TW	MOR409	53-053-1010	46.7583	122.1244	415	13	—	X	X	X	X	X	X	X	X	X

Table 2-1 (cont.)
Site Specifications
2003
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	State	NPS Abbr.	CASTNet Abbr.	AQS ID Number	Latitude	Longitude	Elevation (m)	O3 Years[1]	SO2	Wind Dir.	Wind Speed	Relative Hum.	Temp.	Precip.	Wet-ness	Delta Temp.	Solar Rad.	Filter Pack[2]
North Cascades	Marblemount Ranger Station	WA	NOCA-MM	NCS415	53-057-0013	48.5397	121.4472	109	8	—	X	X	X	X	X	X	X	X	X
Olympic	Visitor Center	WA	OLYM-VC	OLY421	53-009-0012	48.0975	123.4256	125	19	X	X	X	X	X	X	X	X	X	X
Petrified Forest	Horse Barn	AZ	PEFO-HB	PET427	04-017-0119	34.8225	109.8919	1723	2	—	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	17	—	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	17	—	X	X	X	X	X	X	X	X	X
Saguaro	Pima County	AZ	SAGU-PC	———	04-019-0021	32.1744	110.7364	938	12	—	X	X	X	X	—	—	—	X	—
Sequoia and Kings Canyon	Ash Mountain	CA	SEKI-AS	———	06-107-0009	36.4894	118.8269	457	5	—	X	X	X	X	X	—	—	X	—
Sequoia and Kings Canyon	Lower Kaweah	CA	SEKI-LK	———	06-107-0006	36.5658	118.7772	1890	20	—	X	X	X	X	X	—	—	X	—
Sequoia and Kings Canyon	Lookout Point	CA	SEKI-LP	SEK402	06-107-0008	36.4292	118.7625	1225	7	—	X	X	X	X	X	X	X	X	X
Shenendoah	Big Meadows	VA	SHEN-BM	SHN418	51-113-0003	38.5231	78.4347	1073	21	X	X	X	X	X	X	X	X	X	X
Theodore Roosevelt	Visitor Center	ND	THRO-VC	THR422	38-007-0002	46.8947	103.3778	850	6	X	X	X	X	X	X	X	X	X	X
Virgin Islands	Lind Point	VI	VIIS-LP	VII423	78-003-0001	18.3364	64.7964	80	6	—	X	X	X	X	X	X	X	X	X
Voyageurs	Sullivan Bay	MN	VOYA-SB	VOY413	27-137-0034	48.4128	92.8292	429	8	—	X	X	X	X	X	X	X	X	X
Yellowstone	Water Tank	WY	YELL-WT	YEL408	56-039-1011	44.5597	110.4006	2400	8	—	X	X	X	X	X	X	X	X	X
Yosemite	Merced River	CA	YOSE-MR	———	06-043-0033	37.7431	119.5939	1219	2	—	X	X	X	X	X	—	—	X	—
Yosemite	Turtleback Dome	CA	YOSE-TD	YOS404	06-043-0003	37.7133	119.7061	1605	11	—	X	X	X	X	X	X	X	X	X
Yukon Flats	Poker Flat	AK	YUFL-PF	POF425	02-090-0030	65.1178	147.4333	495	—	—	X	X	X	X	X	X	X	X	X

 # active park units: 42 **# active park sites: 53**

1. The values in this column represent the number of years an ozone analyzer has been operational at the site.

2. 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 (SO_4^{2-}), particulate nitrate (NO_3^-), particulate ammonium (NH_4^+), sulfur dioxide (SO_2), and nitric acid (HNO_3). In some cases, the positive ions Na^+, K^+, Ca^{2+}, and Mg^{2+} 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

3.0 DATA SUMMARIES

Ground-level ozone and sulfur dioxide are regulated under the Clean Air Act, the comprehensive federal law that regulates air emissions 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 2003 data summaries for the NPS Gaseous Pollutant Monitoring Program. Data collection statistics for all sites are presented first, followed by data summaries for ozone, sulfur dioxide, and meteorological parameters. In all 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 sites operated by the NPS are <u>underlined</u>.

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 94.5%, and for sulfur dioxide was 96.9%.

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 sites which met the minimum EPA data collection criteria of 75%. For 2003, 48 of 50 ozone sites and 6 of 6 sulfur dioxide sites met or exceeded the annual EPA criteria.

Table 3-1
Data Collections Statistics by Site
2003
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	Parameter Code										
		O3 % valid[1]	SO2 % valid[1]	VWD % valid[1]	SWS % valid[1]	TMP % valid[1]	RH % valid[1]	RNF % valid[1]	WET % valid[1]	DTP % valid[1]	SOL % valid[1]	FLOW % valid[1]
Acadia	Cadillac Mountain	99.9	—	99.6	99.6	99.7	99.7	—	—	—	—	—
Acadia	McFarland Hill	99.4	—	99.2	99.8	99.8	99.8	99.9	96.5	99.5	99.8	99.7
Badlands	Visitor Center	99.5	—	100.0	100.0	100.0	100.0	0.0	—	—	0.0	—
Big Bend	K-Bar Ranch Road	98.1	—	99.2	99.2	99.4	99.4	99.0	99.0	99.4	99.5	99.5
Big South Fork	Portable Ozone	79.3	—	99.2	99.2	99.2	99.2	99.2	—	—	99.2	—
Black Canyon of the Gunnison	Portable Ozone	99.9	—	100.0	100.0	100.0	100.0	99.9	—	—	100.0	—
Cape Cod	Cape Cod	95.7	—	—	99.8	99.8	99.8	—	—	—	99.8	—
Canyonlands	Island in the Sky	89.0	—	99.5	99.5	99.8	99.4	99.1	98.2	99.8	97.4	99.2
Chamizal	Chamizal	96.0	—	98.7	99.8	99.8	99.8	—	—	—	99.9	—
Chiricahua	Entrance Station	94.2	—	99.7	99.7	99.7	99.8	99.1	94.5	99.7	99.7	95.6
Channel Islands	Santa Rosa Island	89.2	—	—	—	—	—	—	—	—	—	—
Congaree Swamp	Congaree Bluff	97.0	99.6	—	—	—	—	—	—	—	—	—
Cowpens	Cowpens	99.7	—	—	—	—	—	—	—	—	—	—
Craters of the Moon	Visitor Center	95.3	—	99.2	99.2	99.2	98.8	—	—	—	99.0	—
Denali	Headquarters	99.3	—	99.3	99.3	99.3	99.6	82.5	99.7	99.3	99.3	99.7
Death Valley	Park Village	97.6	—	97.8	97.8	99.1	99.8	99.0	99.1	99.1	97.8	99.6
Everglades	Beard Center	88.8	—	91.6	91.6	91.7	89.0	89.1	91.9	84.2	92.3	92.1
Glacier	West Glacier Horse Stables	91.2	—	95.5	95.5	71.0	70.9	99.2	52.1	67.1	99.6	99.9
Great Basin	Maintenance Yard	98.5	—	96.0	96.0	99.3	99.3	40.3	98.7	62.2	99.3	99.4
Grand Canyon	The Abyss	99.1	—	59.1	99.2	99.2	99.3	98.6	85.4	91.7	99.4	86.0
Grand Canyon	Portable Ozone	99.9	—	100.0	100.0	99.4	99.4	99.9	—	—	99.9	—
Great Smoky Mountains	Cades Cove	89.2	—	99.9	99.9	99.9	99.9	98.3	—	—	99.8	—
Great Smoky Mountains	Clingmans Dome	93.3	—	73.3	73.3	92.6	92.8	86.9	—	—	79.1	—
Great Smoky Mountains	Cove Mountain	98.6	—	97.5	97.5	99.2	98.6	98.6	—	—	91.7	—
Great Smoky Mountains	Look Rock	99.2	—	98.4	98.4	99.3	99.3	98.7	98.7	99.3	99.3	99.4
Great Smoky Mountains	Purchase Knob	93.5	—	—	—	—	—	—	—	—	—	—
Hawaii Volcanoes	Observatory	—	99.6	100.0	100.0	100.0	100.0	99.7	—	—	—	—
Hawaii Volcanoes	Thurston Lava Tubes	95.4	—	99.8	99.8	97.9	99.9	99.3	99.3	97.9	98.8	99.9
Hawaii Volcanoes	Visitor Center	—	94.0	99.8	99.8	99.8	99.8	99.6	—	—	99.8	—
Isle Royale	Portable Ozone	43.3	—	99.9	99.8	99.2	99.9	99.9	—	—	99.9	80.9
Joshua Tree	Yucca Valley	96.3	—	98.8	98.8	99.5	88.1	98.9	98.8	99.2	96.2	99.6
Lake Mead	Portable Ozone	87.4	—	92.0	92.0	92.0	92.0	92.0	—	—	92.0	—
Lassen Volcanic	Monzanita Lake Maintenance Area	98.8	—	92.2	92.2	93.9	99.3	98.6	98.9	93.9	93.9	99.4
Mammoth Cave	Houchin Meadow	99.0	—	99.5	99.5	99.6	99.7	99.0	99.2	99.6	99.5	98.3
Mesa Verde	Maintenance Yard	98.6	—	88.5	90.5	88.2	99.8	94.2	96.5	88.2	95.3	60.7
Mount Rainier	Tahoma Woods	97.6	—	88.4	93.7	99.2	70.0	98.6	77.3	99.2	99.0	99.3

Table 3-1 (cont.)
Data Collections Statistics by Site
2003
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	Parameter Code										
		O3 % valid[1]	SO2 % valid[1]	VWD % valid[1]	SWS % valid[1]	TMP % valid[1]	RH % valid[1]	RNF % valid[1]	WET % valid[1]	DTP % valid[1]	SOL % valid[1]	FLOW % valid[1]
North Cascades	Marblemount Ranger Station	88.1	—	90.6	93.3	98.9	98.9	98.3	98.4	98.9	98.4	99.0
Olympic	Visitor Center	97.8	95.5	100.0	100.0	100.0	94.1	99.5	99.6	100.0	100.0	100.0
Petrified Forest	Horse Barn	97.8	—	97.8	97.8	94.2	97.8	99.2	81.5	94.2	96.8	99.1
Pinnacles	East Entrance Station	99.3	—	95.7	99.5	99.6	99.6	99.0	98.9	99.6	96.1	99.6
Rocky Mountain	Longs Peak Ranger Station	99.4	—	99.5	99.5	98.2	96.3	99.2	87.5	98.2	99.9	100.0
Saguaro	Pima County	97.4	—	98.9	—	99.8	99.9	—	—	—	99.7	—
Sequoia and Kings Canyon	Ash Mountain	91.7	—	100.0	100.0	100.0	100.0	99.2	—	—	99.3	—
Sequoia and Kings Canyon	Lower Kaweah	91.4	—	94.3	94.3	97.8	97.8	90.9	—	—	90.5	—
Sequoia and Kings Canyon	Lookout Point	81.7	—	98.1	98.1	97.6	98.2	97.5	97.5	97.6	98.2	85.3
Shenendoah	Big Meadows	94.0	92.5	83.1	95.4	95.4	95.5	95.2	81.9	95.4	95.5	84.4
Theodore Roosevelt	Visitor Center	99.9	99.9	98.7	98.8	98.7	98.8	98.2	98.3	98.7	98.8	98.8
Virgin Islands	Lind Point	88.6	—	99.6	99.6	99.6	99.7	99.4	99.4	99.6	99.6	51.8
Voyageurs	Sullivan Bay	99.2	—	99.6	99.6	99.8	99.9	99.2	99.4	99.8	99.0	99.8
Yellowstone	Water Tank	91.0	—	99.6	99.6	99.6	99.6	99.2	—	99.6	89.2	99.6
Yosemite	Merced River	74.3	—	98.3	98.3	98.9	98.9	99.2	—	—	99.8	—
Yosemite	Turtleback Dome	99.5	—	95.3	95.3	99.7	88.3	99.1	88.9	97.0	99.7	99.8
Yukon Flats	Poker Flat	—	—	96.8	99.0	97.2	83.1	99.8	97.2	97.2	97.3	93.0
Average Network Data Collection		**94.5**	**96.9**	**95.9**	**97.6**	**97.7**	**96.5**	**96.2**	**93.5**	**95.2**	**97.6**	**94.4**

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 Radition
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, operator error, timing problems, flow issues, and other factors that affect instrument operation. When calculating percent valid for O_3 and SO_2, calibration events were removed from the number possible.

Table 3-2
Network Summary of Data Collections Statistics
2003
National Park Service Gaseous Pollutant Monitoring Program

Calendar Quarter	Network Data Collection Statistic[1]	Units	Parameter Code										
			O3	SO2	VWD	SWS	TMP	RH	RNF	WET	DTP	SOL	FLOW
Annual	Annual Network Average	%	94.5	96.9	95.9	97.6	97.7	96.5	95.2	93.5	95.2	96.7	94.4
	No. Sites>=75% Valid	No. Sites (%)	48 (96%)	6 (100%)	46 (96%)	47 (98%)	48 (98%)	47 (96%)	42 (96%)	28 (97%)	28 (93%)	46 (98%)	29 (94%)
	No. Sites <75% Valid	No. Sites (%)	2 (4%)	0 (0%)	2 (4%)	1 (2%)	1 (2%)	2 (4%)	2 (5%)	1 (3%)	2 (7%)	1 (2%)	2 (6%)
1	Quarterly Network Average	%	96.5	98.3	96.1	96.7	98.1	96.4	95.2	96.4	96.2	97.7	99.1
	No. Sites >=75% Valid	No. Sites (%)	39 (98%)	6 (100%)	39 (100%)	39 (100%)	40 (100%)	39 (98%)	34 (94%)	27 (93%)	29 (97%)	39 (100%)	30 (100%)
	No. Sites <75% Valid	No. Sites (%)	1 (2%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (2%)	2 (6%)	2 (7%)	1 (3%)	0 (0%)	0 (0%)
2	Quarterly Network Average	%	96.2	96.6	95.4	97.3	98.4	97.4	93.9	91.1	94.2	97.7	97.0
	No. Sites >=75% Valid	No. Sites (%)	48 (98%)	6 (100%)	45 (96%)	46 (98%)	48 (100%)	47 (98%)	41 (95%)	25 (86%)	29 (97%)	46 (100%)	30 (97%)
	No. Sites <75% Valid	No. Sites (%)	1 (2%)	0 (0%)	2 (4%)	1 (2%)	0 (0%)	1 (2%)	2 (5%)	4 (14%)	1 (3%)	0 (0%)	1 (3%)
3	Quarterly Network Average	%	91.5	96.6	95.4	97.8	95.9	95.7	95.3	89.9	92.7	95.7	92.5
	No. Sites >=75% Valid	No. Sites (%)	47 (94%)	6 (100%)	45 (94%)	47 (98%)	47 (96%)	48 (98%)	42 (96%)	26 (90%)	27 (90%)	45 (96%)	28 (90%)
	No. Sites <75% Valid	No. Sites (%)	3 (6%)	0 (0%)	3 (6%)	1 (2%)	2 (4%)	1 (2%)	2 (5%)	3 (10%)	3 (10%)	2 (4%)	3 (10%)
4	Quarterly Network Average	%	94.5	96.2	97.0	98.6	98.8	96.8	96.3	96.8	97.5	95.8	89.2
	No. Sites >=75% Valid	No. Sites (%)	40 (93%)	6 (100%)	41 (98%)	42 (98%)	43 (98%)	42 (98%)	38 (97%)	27 (93%)	29 (97%)	41 (95%)	26 (87%)
	No. Sites <75% Valid	No. Sites (%)	3 (7%)	0 (0%)	1 (2%)	1 (2%)	1 (2%)	1 (2%)	1 (3%)	2 (7%)	1 (3%)	2 (5%)	4 (13%)

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 Radition
FLOW = Filter Pack Flow Rate

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 oxides of nitrogen. 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 air quality standard.

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 thing 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, the SUM06, W126, and N100, are believed to be biologically relevant because they take into account both peak ozone concentrations and cumulative exposure to ozone. These indices are described further in Section 3.2.4.

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 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 that had exceedences during 2003 and the number that occurred.

Table 3-4 presents similar information for the non-EPA certified (portable) sites. Ozone summary statistics from portable stations 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 with 8-hour average ozone values greater than or equal to 85ppb 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)
2003
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]
Acadia	Cadillac Mountain	271	103	91	86	83	81	3
Acadia	McFarland Hill	363	91	88	84	80	78	2
Badlands	Visitor Center	149	71	69	69	67	67	0
Big Bend	K-Bar Ranch Road	351	67	65	64	63	63	0
Cape Cod	Cape Cod	170	110	94	94	89	88	8
Canyonlands	Island in the Sky	322	77	75	74	74	73	0
Chamizal	Chamizal	338	80	79	75	74	73	0
Chiricahua	Entrance Station	339	77	73	72	71	70	0
Channel Islands	Santa Rosa Island	339	68	67	64	64	63	0
Congaree Swamp	Congaree Bluff	344	79	76	76	74	71	0
Cowpens	Cowpens	362	87	82	79	79	76	1
Craters of the Moon	Visitor Center	337	79	74	70	70	70	0
Denali	Headquarters	361	61	54	54	54	54	0
Death Valley	Park Village	338	84	84	80	80	79	0
Everglades	Beard Center	310	79	69	68	67	65	0
Glacier	West Glacier Horse Stables	329	65	62	61	61	59	0
Great Basin	Maintenance Yard	356	79	74	73	71	70	0
Grand Canyon	The Abyss	359	78	76	74	73	71	0
Great Smoky Mountains	Cades Cove	214	88	81	71	71	70	1
Great Smoky Mountains	Clingmans Dome	165	98	91	91	84	83	3
Great Smoky Mountains	Cove Mountain	357	93	92	85	82	81	3
Great Smoky Mountains	Look Rock	359	96	96	93	90	88	9
Great Smoky Mountains	Purchase Knob	205	84	83	82	81	80	0
Hawaii Volcanoes	Thurston Lava Tubes	342	51	48	48	48	47	0
Joshua Tree	Yucca Valley	345	119	115	112	111	107	39
Lassen Volcanic	Monzanita Lake Maintenance Area	356	73	72	71	70	69	0
Mammoth Cave	Houchin Meadow	360	90	84	79	76	75	1
Mesa Verde	Maintenance Yard	352	78	70	68	67	67	0
Mount Rainier	Tahoma Woods	341	79	75	74	74	72	0
North Cascades	Marblemount Ranger Station	304	63	59	58	58	55	0
Olympic	Visitor Center	348	50	48	48	46	44	0
Petrified Forest	Horse Barn	343	77	75	74	74	73	0
Pinnacles	East Entrance Station	360	88	84	80	79	78	1
Rocky Mountain	Longs Peak Ranger Station	360	92	88	87	86	85	7
Saguaro	Pima County	355	87	84	78	76	76	1
Sequoia and Kings Canyon	Ash Mountain	224	115	111	110	110	109	72
Sequoia and Kings Canyon	Lower Kaweah	330	102	101	101	100	100	42
Sequoia and Kings Canyon	Lookout Point	283	109	108	106	104	104	53
Shenendoah	Big Meadows	330	104	100	91	86	86	6
Theodore Roosevelt	Visitor Center	364	73	68	68	64	62	0
Virgin Islands	Lind Point	281	44	44	44	43	41	0
Voyageurs	Sullivan Bay	358	69	69	68	68	68	0
Yellowstone	Water Tank	301	71	68	66	65	65	0
Yosemite	Merced River	272	70	63	62	60	60	0
Yosemite	Turtleback Dome	361	102	96	96	90	90	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.) Exceedances of the standard are highlighted here in orange or red.

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 Stations[1]
Highest Daily 8-Hour Average Maximum Concentrations (ppb)
2003
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	Valid Number of Days	1st Highest	2nd Highest	3rd Highest	4th Highest[2]	5th Highest	# Days with 8-Hour Average O3 Values >=85 ppb[2]
Big South Fork	Portable Ozone	80	76	65	65	64	64	0
Black Canyon of the Gunnison	Portable Ozone	111	72	72	70	67	67	0
Grand Canyon	Portable Ozone	134	77	68	68	67	66	0
Isle Royale	Portable Ozone	55	65	64	61	60	60	0
Lake Mead	Portable Ozone	113	87	78	77	77	76	1

1. The GPMP portable ozone stations do not meet EPA standards for regulatory monitoring. However, ozone summary statistics from portable stations 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.)

Table 3-5

Ozone Violation Summary
3-Year Average 4th Highest Daily Maximum 8-Hour Average Ozone Concentration[1] (ppb)
1996 - 2003
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	2001 - 2003	2000 - 2002	1999 - 2001	1998 - 2000	1997 - 1999	1996 - 1998	1995 - 1997	1994 - 1996
Acadia	Cadillac Mountain	94	93	89	87	(89)	(87)	(79)	(76)
Acadia	McFarland Hill	87	84	85	83	(90)	(88)	—	—
Badlands	Visitor Center	(67)	—	—	—	—	—	—	—
Big Bend	K-Bar Ranch Road	62	(62)	(63)	66	65	68	(67)	(69)
Cape Cod	Cape Cod	95	93	96	89	(95)	(93)	(100)	96
Canyonlands	Island in the Sky	70	(71)	(71)	73	70	70	68	68
Chamizal	Chamizal	79	81	75	(79)	(76)	(79)	77	(79)
Chiricahua	Entrance Station	69	69	70	70	68	68	(68)	(70)
Channel Islands	Santa Rosa Island	64	(65)	(66)	(66)	66	(64)	(63)	—
Congaree Swamp	Congaree Bluff	77	77	(74)	(73)	—	—	—	—
Cowpens	Cowpens	84	87	87	92	93	89	85	82
Craters of the Moon	Visitor Center	(65)	(63)	(63)	66	(64)	(63)	(60)	61
Denali	Headquarters	54	49	49	48	53	52	52	51
Death Valley	Park Village	81	81	79	80	79	79	(74)	(76)
Everglades	Beard Center	(60)	(60)	64	68	68	67	62	(61)
Glacier	West Glacier Horse Stables	53	49	48	51	47	50	47	52
Great Basin	Maintenance Yard	70	72	72	73	72	72	71	70
Grand Canyon	The Abyss	74	73	72	73	73	72	71	70
Great Smoky Mountains	Cades Cove	76	79	81	(85)	(83)	79	76	(76)
Great Smoky Mountains	Clingmans Dome	(92)	(98)	(98)	(102)	(98)	(94)	(88)	(84)
Great Smoky Mountains	Cove Mountain	92	96	96	101	(100)	97	93	91
Great Smoky Mountains	Look Rock	92	94	96	104	104	98	(95)	(93)
Great Smoky Mountains	Purchase Knob	86	88	87	90	90	(85)	(83)	(81)
Hawaii Volcanoes	Thurston Lava Tubes	42	(40)	(39)	(40)	(38)	—	—	—
Joshua Tree	Yucca Valley	99	94	92	102	109	112	109	108
Lassen Volcanic	Monzanita Lake Maintenance Area	72	74	77	78	76	72	(71)	(75)
Mammoth Cave	Houchin Meadow	80	84	88	94	(92)	(89)	(81)	—
Mesa Verde	Maintenance Yard	67	69	69	70	(66)	(67)	(65)	65
Mount Rainier	Tahoma Woods	61	56	60	57	51	52	56	65
North Cascades	Marblemount Ranger Station	50	46	48	46	43	(43)	(44)	(50)
Olympic	Visitor Center	39	39	44	43	43	44	45	43

Table 3-5 (cont.)

Ozone Violation Summary

3-Year Average 4th Highest Daily Maximum 8-Hour Average Ozone Concentration[1] (ppb)

1996 - 2003

National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	2001 - 2003	2000 - 2002	1999 - 2001	1998 - 2000	1997 - 1999	1996 - 1998	1995 - 1997	1994 - 1996
Petrified Forest	Horse Barn	(64)	(55)	—	—	—	—	—	—
Pinnacles	East Entrance Station	81	81	(79)	(82)	82	86	84	85
Rocky Mountain	Longs Peak Ranger Station	81	78	74	77	74	74	72	74
Saguaro	Pima County	73	72	69	73	74	77	79	79
Sequoia and Kings Canyon	Ash Mountain	(107)	(105)	(104)	(105)	(105)	—	—	—
Sequoia and Kings Canyon	Lower Kaweah	101	98	(94)	(93)	(96)	98	99	102
Sequoia and Kings Canyon	Lookout Point	(104)	(103)	(103)	(102)	(102)	(100)	(101)	—
Shenendoah	Big Meadows	87	85	87	93	96	92	85	83
Theodore Roosevelt	Visitor Center	61	59	58	(57)	(56)	(54)	—	—
Virgin Islands	Lind Point	(44)	(46)	47	(45)	(44)	(39)	—	—
Voyageurs	Sullivan Bay	65	(64)	67	68	70	(66)	(66)	(62)
Yellowstone	Water Tank	65	65	67	67	65	(62)	(61)	(61)
Yosemite	Merced River	(66)	(72)	—	—	—	—	—	—
Yosemite	Turtleback Dome	90	89	86	88	86	88	87	91
# Park Units with Violations:		**7**	**8**	**9**	**9**	**9**	**10**	**7**	**6**
# Sites with Violations:		**13**	**13**	**15**	**15**	**15**	**15**	**10**	**7**

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:

plain text = site operated by the National Park Service

italics = site operated by a state agency

Color shading key:

4th highest 8-hr. avg.

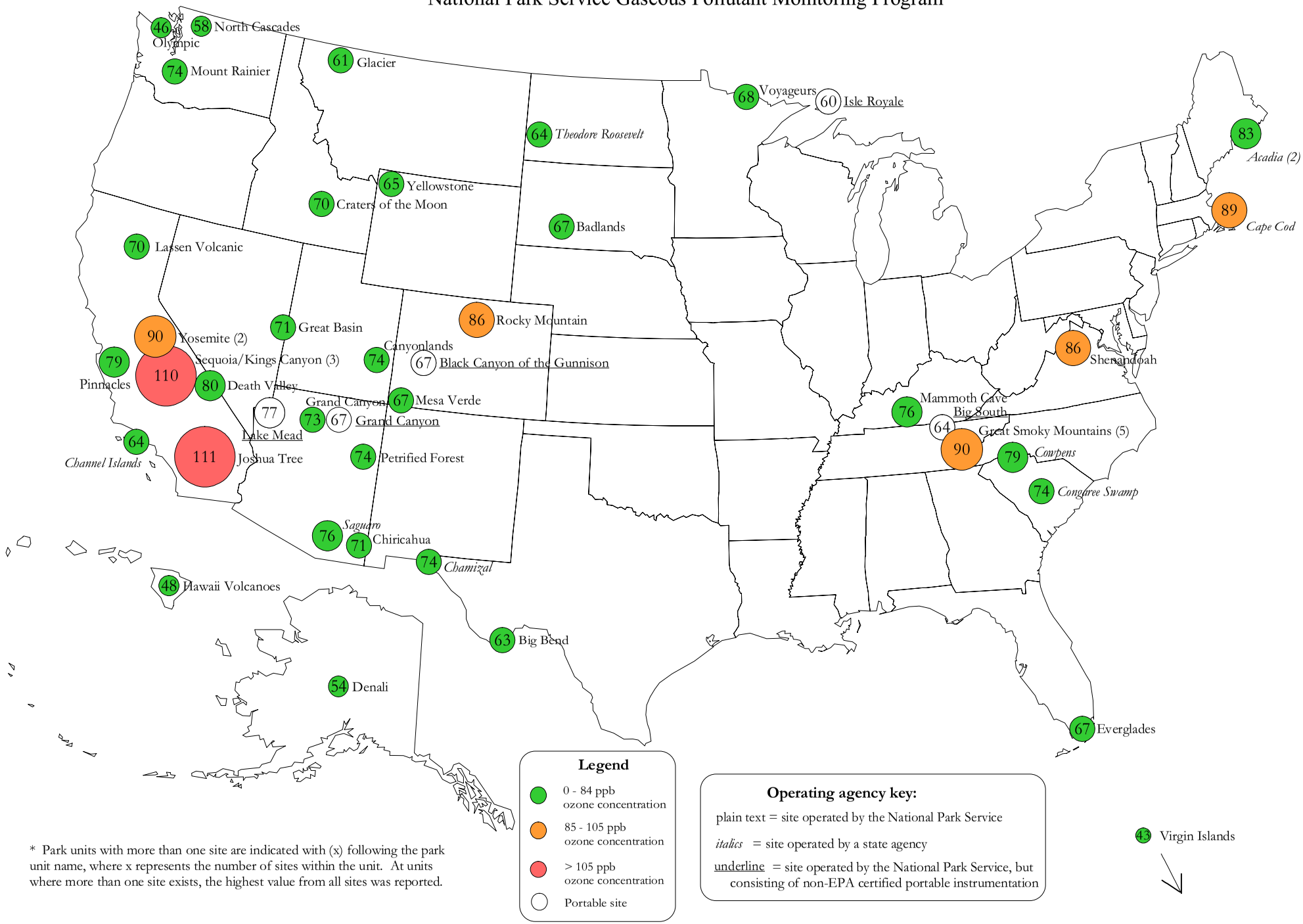
= 85 - 104 ppb ozone concentration

>=105 ppb ozone concentration

( ) 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 3-1

Annual Fourth Highest 8-Hour Average Ozone Concentrations (in ppb)
2003
National Park Service Gaseous Pollutant Monitoring Program



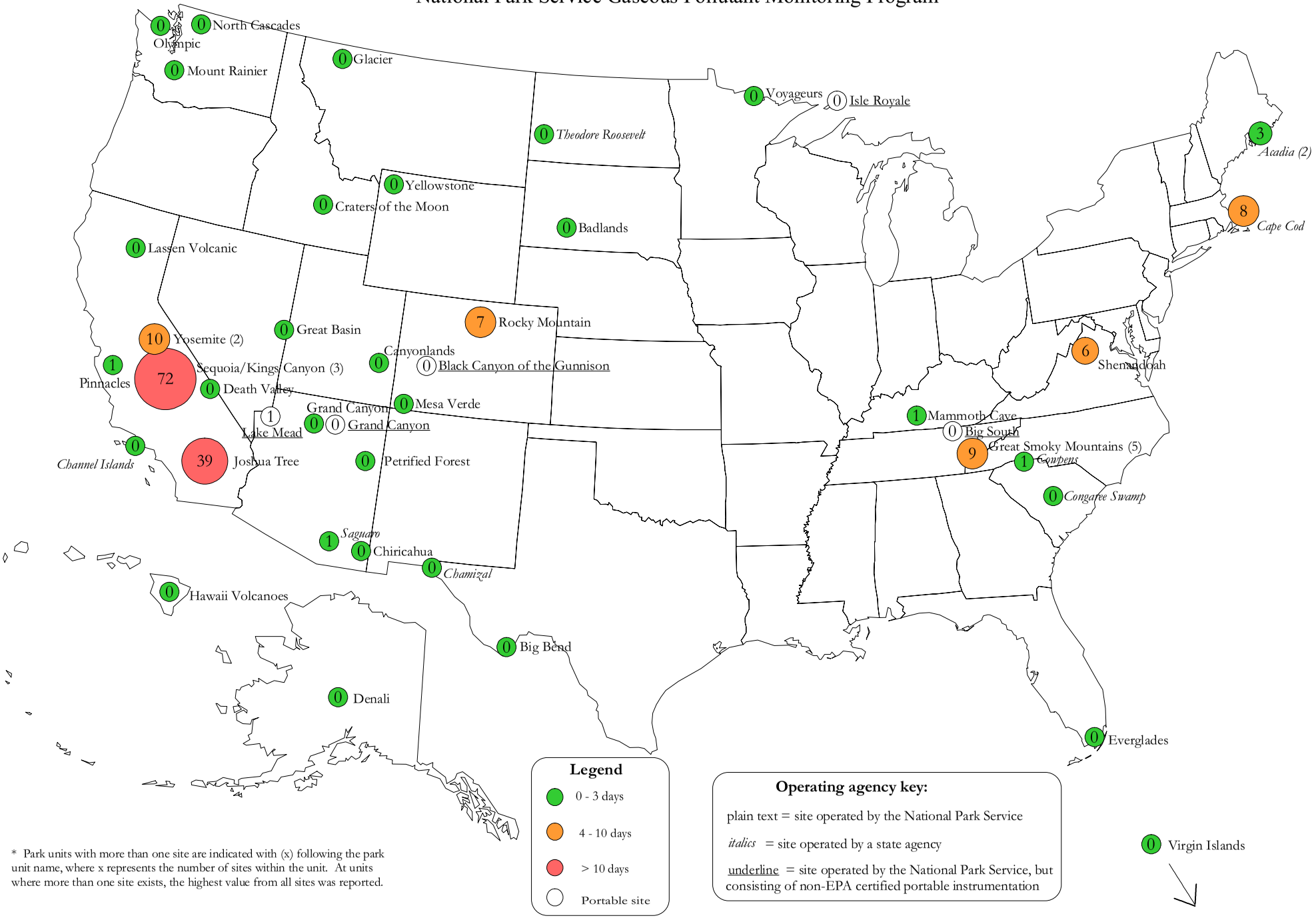
* Park units with more than one site are indicated with (x) following the park unit name, where x represents the number of sites within the unit. At units where more than one site exists, the highest value from all sites was reported.

Figure 3-2

Annual Number of Days with 8-Hour Average Ozone Values >= 85 ppb

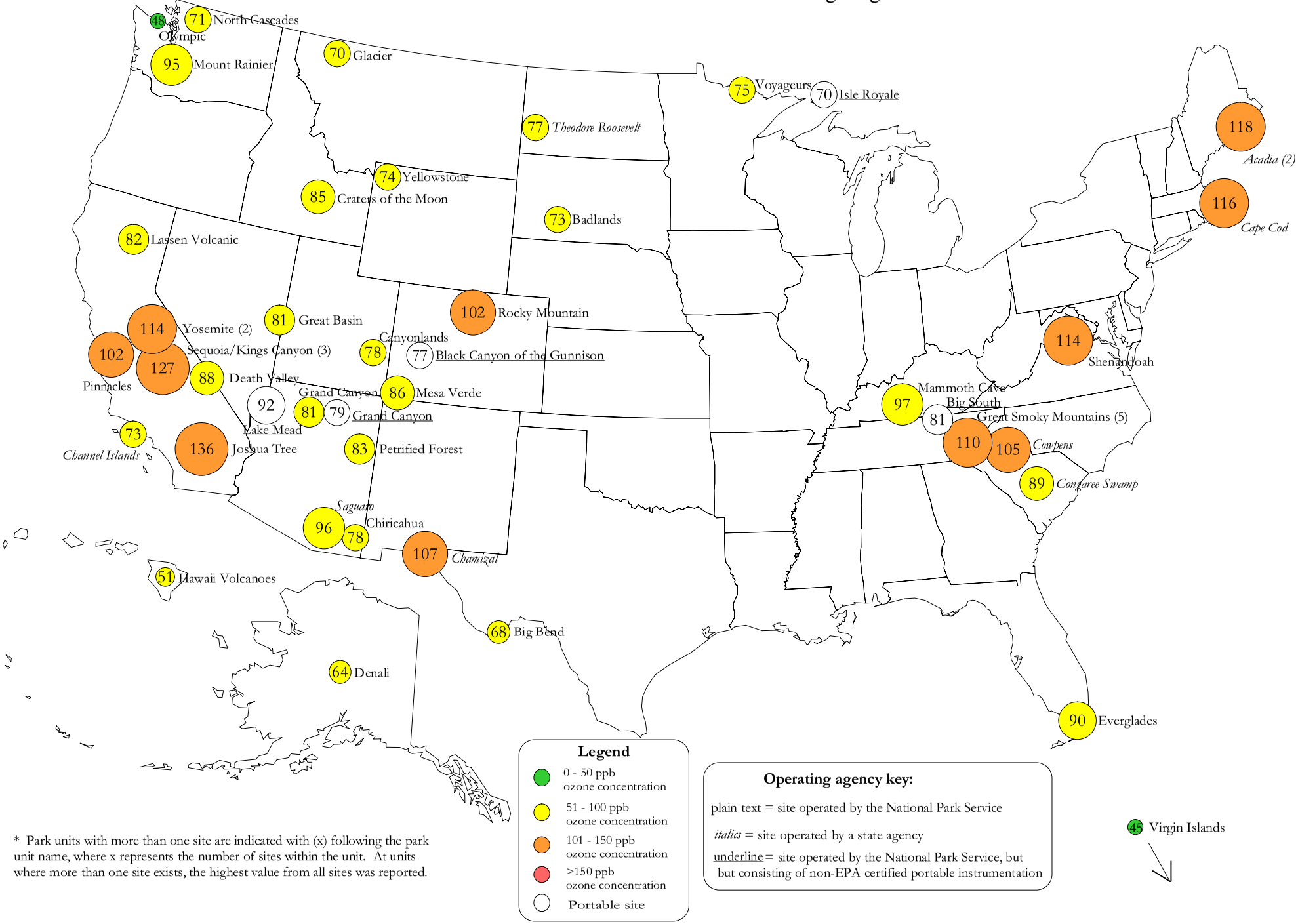
2003

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.

Figure 3-3
Annual Second Highest 1-Hour Average Ozone Concentrations (in ppb)
2003
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.

3.2.2 Ozone Violation Summaries

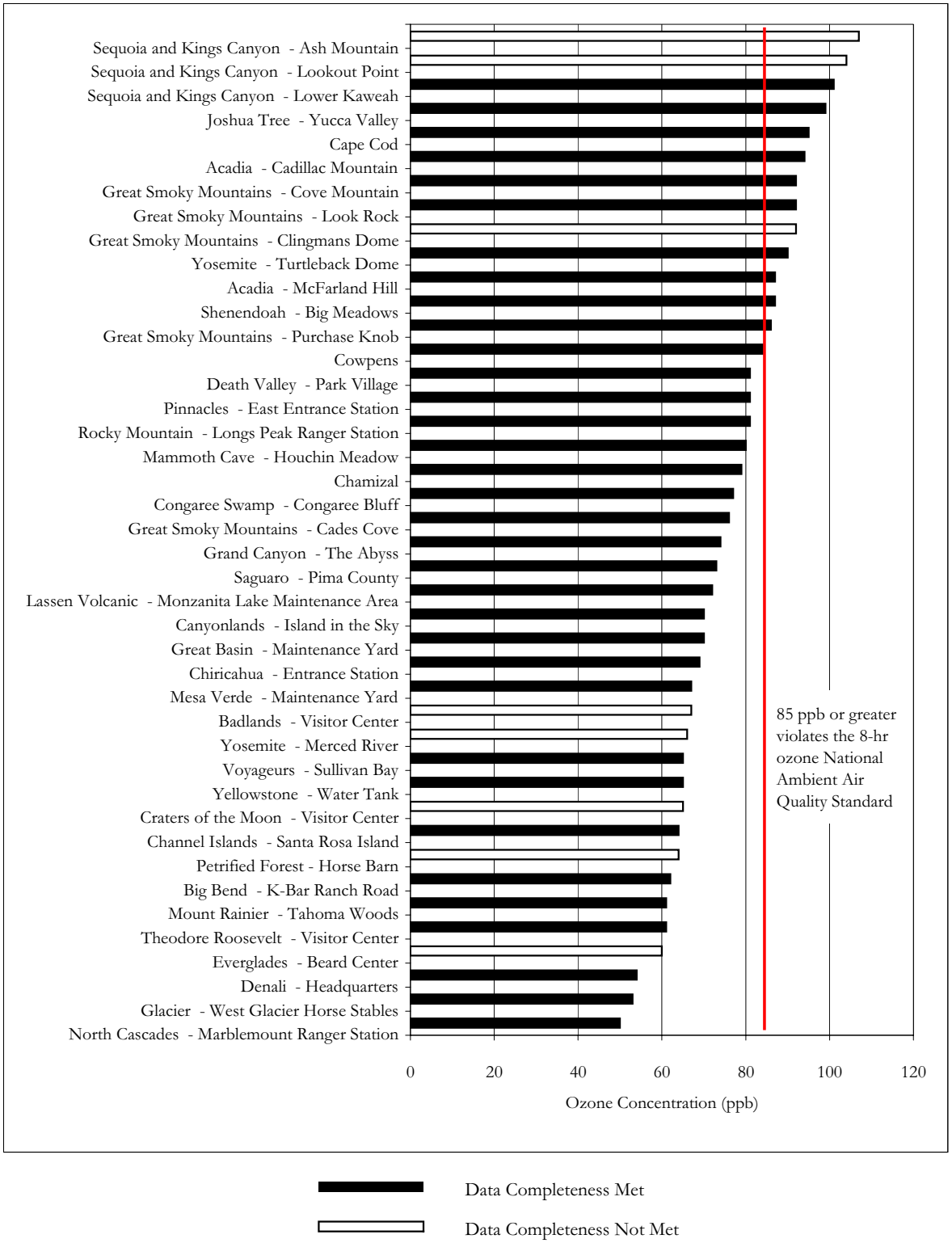
Table 3-5 presents an ozone violation summary for all 3-year periods over the last ten years, with violations indicated in orange and red. Table values in parentheses indicate that the EPA data completeness requirement for the 3-year period was not met. However, annual fourth highest daily maximum 8-hour 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.

Figure 3-4 presents a ranked list of sites based on the 2001 – 2003 ozone violation summary data presented in the first column of Table 3-5. Sites which met the EPA data completeness requirement are indicated with solid black bars, those which did not are indicated with open bars. Sites displaying an open bar with an ozone concentration greater than or equal to 85 ppb are in violation of the NAAQS.

Figure 3-4

Ozone Violation Summary Ranking

3-Year Average 4th Highest Daily Maximum 8-Hour Average Ozone Concentrations (ppb)
2001 - 2003
National Park Service Gaseous Pollutant Monitoring Program



The primary ozone 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.

3.2.3 Long-Term Ozone Trends

Determination of trends is an important monitoring network objective. It is also difficult because the definition of a trend is unclear, the pollutant emission rates are constantly changing, and annual climate variations can dominate over ozone production and transport factors. Several methods for trend determination have been explored, but only two will be presented here. The Thiel method is a non-parametric statistical technique used by the IMPROVE visibility program for trend determination. It is not dependant on a normal distribution, is tolerant of missing data, and handles outlier points well. A somewhat relaxed statistical significance level of 0.15 is used so that early warning of changes in ozone concentrations is possible from the network. Table 3-6 and Figures 3-5 and 3-6 present trend results using this method.

In Figure 3-5 the ozone trend for the 4th highest daily 8-hour maximum concentration relates most closely to the ozone standard. Over a 10-year period, the intermountain western parks and Congaree Swamp in South Carolina have shown increasing ozone. In Figure 3-6, ozone trends for the maximum annual 1-hour concentration also show increases in the intermountain west over the last 10 years.

A more commonly used trend technique is linear regression. This method has several problems, including the expectation of a consistent geometric progression. Comparisons of the linear trend and the time series plots of ozone can be helpful (Figures 3-7 and 3-8). At some monitoring sites progressions are evident while at other sites fluctuations are large and the trend line may have been dominated by a small number of points. Using information from both trend methods gives a richer understanding of the changes.

Figure 3-7 shows linear regression trends in the annual 4th highest daily maximum 8-hour average ozone values for selected western parks. Yellowstone, Rocky Mountain, Mesa Verde, and Grand Canyon National Parks have upward trends that are fairly consistent. The other parks have variations that make it much harder to be confident in the trend line. Figure 3-8 also displays linear regression trends for selected eastern parks. The upward trend at Congaree Swamp has an orderly progression. The upward linear trends at Shenandoah, Great Smoky Mountains, and Mammoth Cave have a strong downward swing that started in 1999.

Figure 3-5
Trends in Annual 4th Highest Daily Maximum 8-Hour Average Ozone Concentrations
1994 - 2003
National Park Service Gaseous Pollutant Monitoring Program

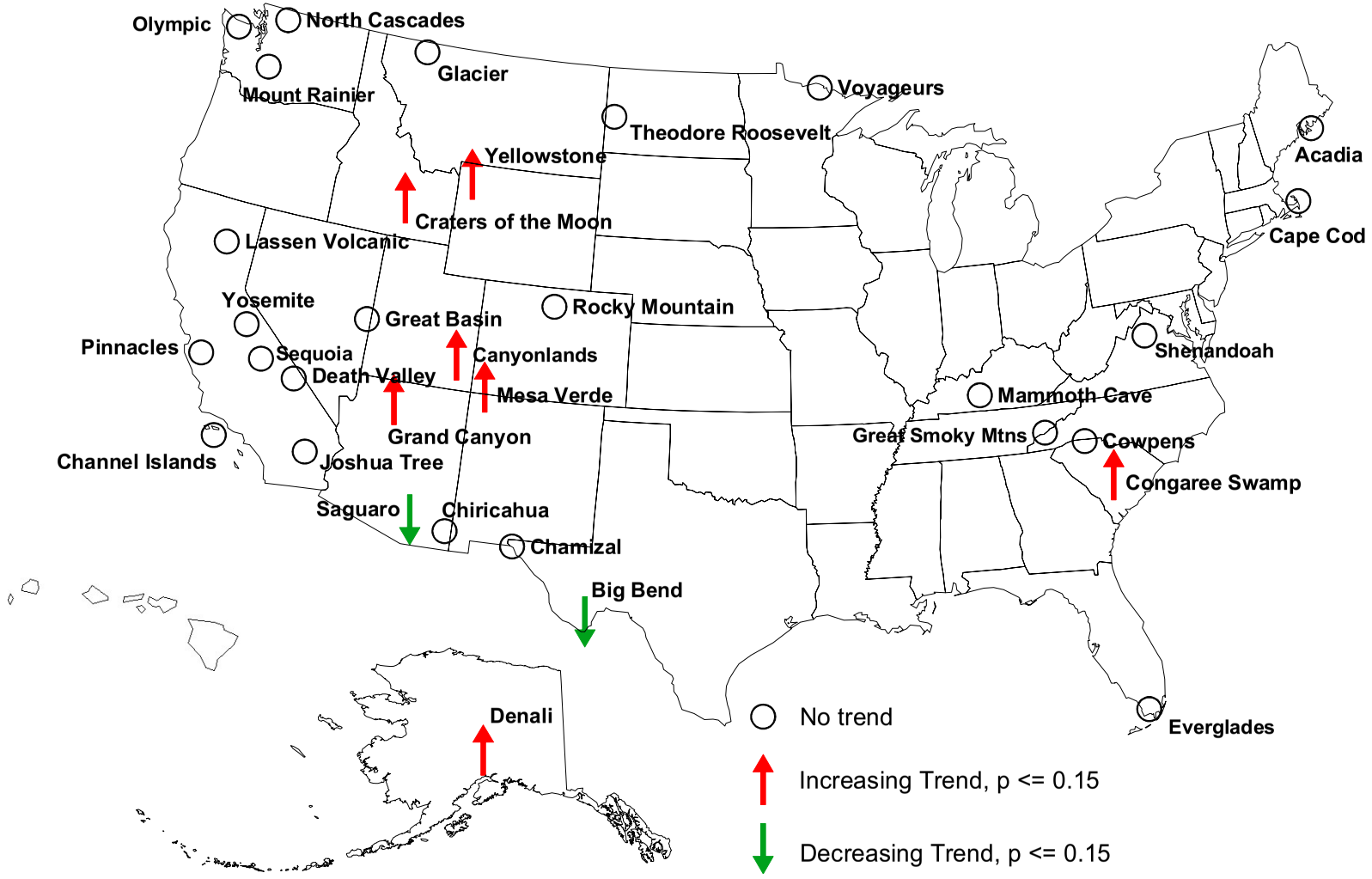


Figure 3-6
Trends in Average Daily Maximum 1-Hour Average Ozone Concentrations
1994 - 2003
National Park Service Gaseous Pollutant Monitoring Program

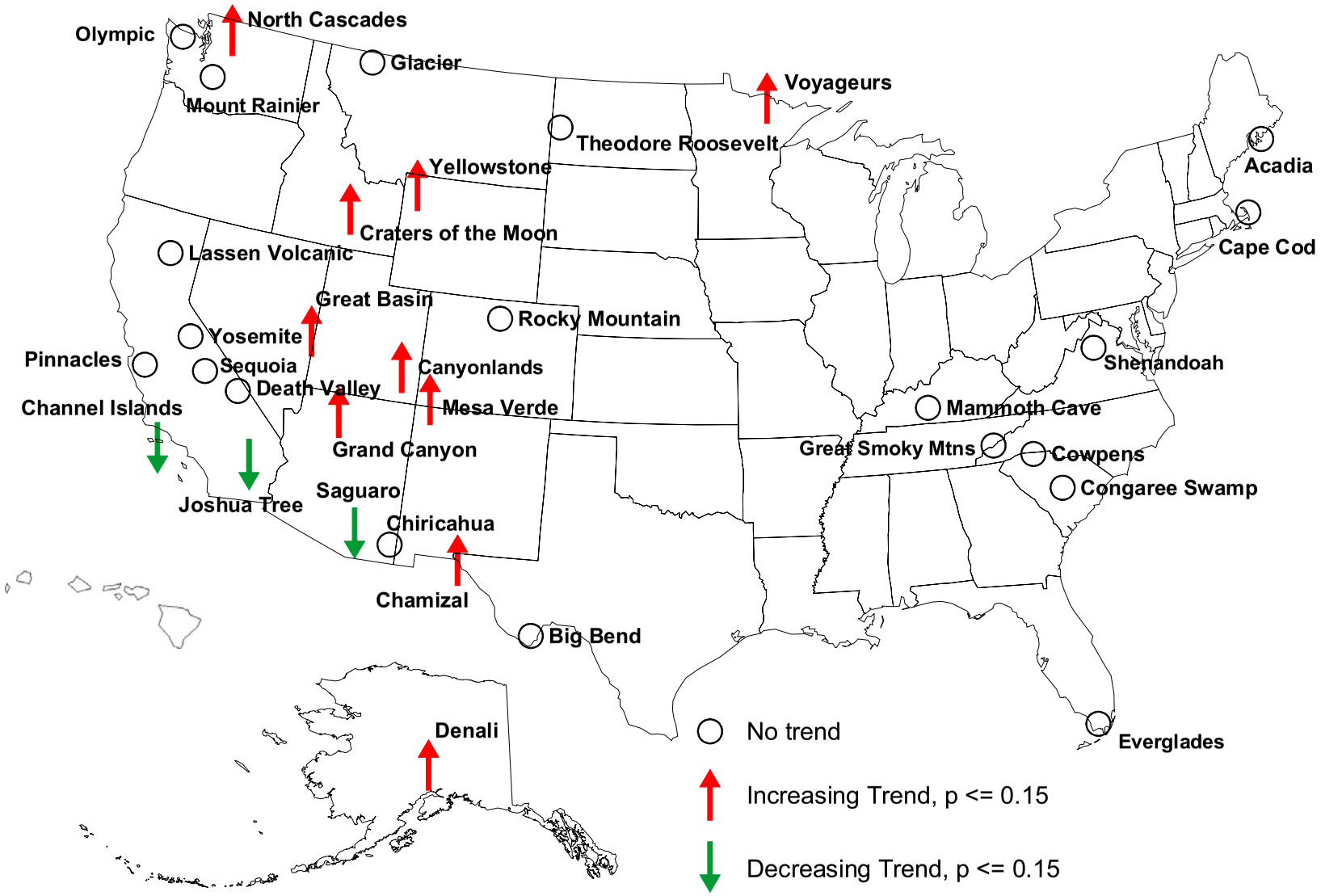


Table 3-6

Trends in Maximum Daily 1-Hour Average Ozone Concentrations
1994 - 2003
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	Ozone Slope (ppb/yr)	P-Value[1]
North Cascades	Marblemount Ranger Station	1.13	0.14
Sequoia/Kings Canyon	Lower Kaweah	0.98	0.30
Mesa Verde	Maintenance Yard	0.78	0.01
Chamizal	Chamizal	0.75	0.14
Congaree Swamp	Bluff	0.74	0.24
Rocky Mountain	Longs Peak Ranger Station	0.66	0.19
Sequoia/Kings Canyon	Lookout Point	0.61	0.19
Great Smoky Mountains	Clingmans Dome	0.55	0.30
Yellowstone	Water Tower	0.54	0.04
Voyageurs	Sullivan Bay	0.43	0.15
Grand Canyon	The Abyss	0.42	0.08
Acadia	McFarland Hill	0.38	0.36
Great Smoky Mountains	Cove Mountain	0.38	0.50
Denali	Headquarters	0.36	0.00
Canyonlands	Island in the Sky	0.31	0.05
Great Basin	Maintenance Yard	0.29	0.11
Chiricahua	Entrance Station	0.22	0.24
Craters of the Moon	Visitor Center	0.21	0.15
Glacier	Horse Stables	0.19	0.43
Cape Cod	Cape Cod	0.14	0.38
Great Smoky Mountains	Cades Cove	0.14	0.36
Yosemite	Turtleback Dome	0.13	0.43
Pinnacles	East Entrance Station	0.12	0.36
Everglades	Beard Center	0.10	0.46
Acadia	Cadillac Mountain	0.04	0.55
Great Smoky Mountains	Look Rock	-0.12	0.46
Death Valley	Park Village	-0.12	0.38
Shenandoah	Big Meadows	-0.14	0.43
Olympic	Visitor Center	-0.16	0.43
Big Bend	K-Bar	-0.27	0.36
Mammoth Cave	Houchin Meadow	-0.28	0.50
Lassen Volcanic	Manzanita Lake	-0.31	0.30
Cowpens	Cowpens	-0.35	0.43
Mount Rainier	Tahoma Woods	-0.44	0.36
Saguaro	Pima County	-0.55	0.11
Channel Islands	Channel Islands	-0.74	0.05
Joshua Tree	Yucca Valley	-1.41	0.08

1. Any P-value less than or equal to the defined significance level of 0.15 indicates a significant slope.

Operating agency key:

plain text = site operated by the National Park Service

italics = site operated by a state agency

Color shading key:

= ozone slope > 0

= ozone slope < 0

= P-value <= 0.15

Figure 3-7

Trends at Western Parks in Annual 4th Highest Daily Maximum
8-Hour Average Ozone Concentration

1994 - 2003

National Park Service Gaseous Pollutant Monitoring Program

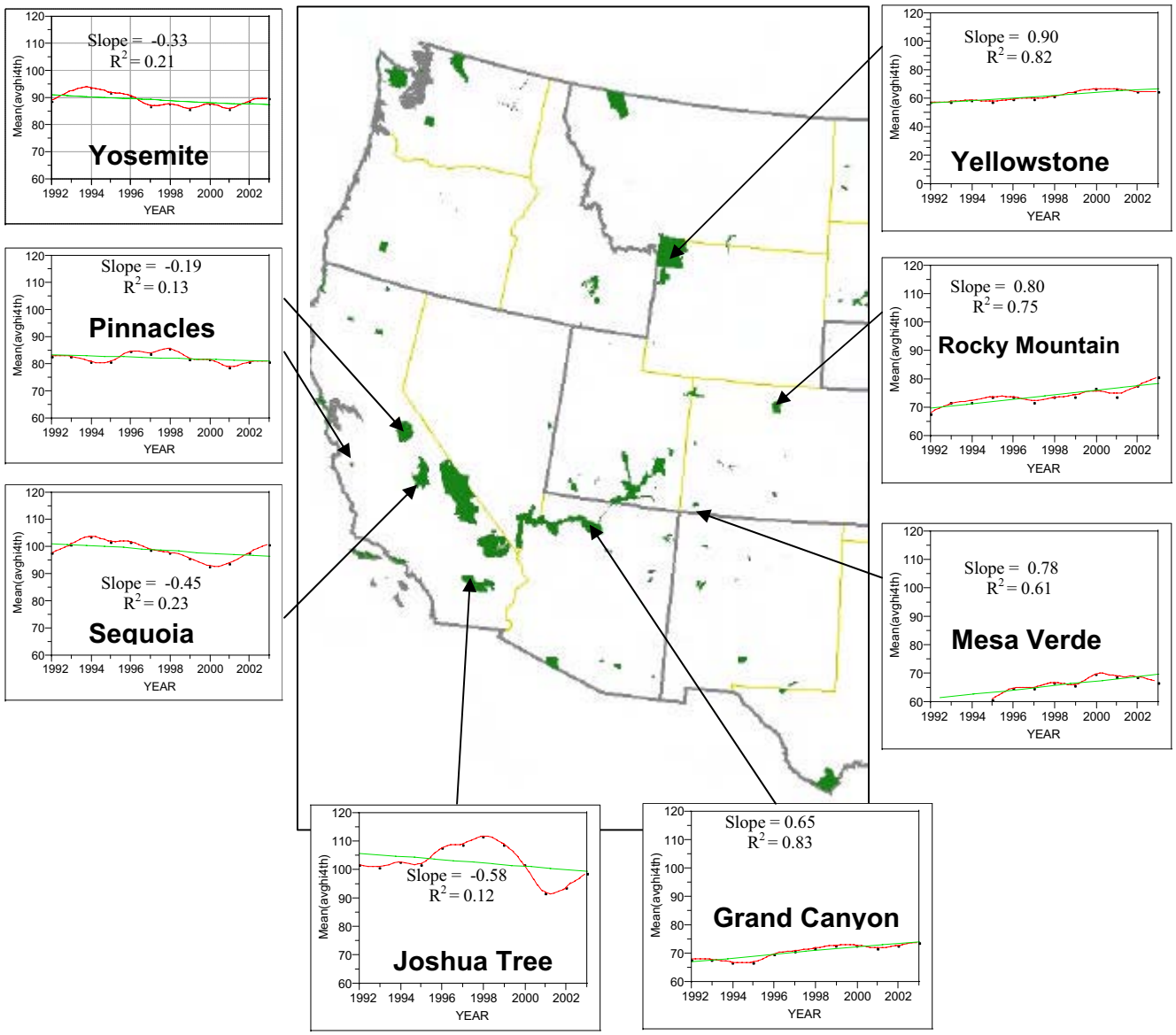
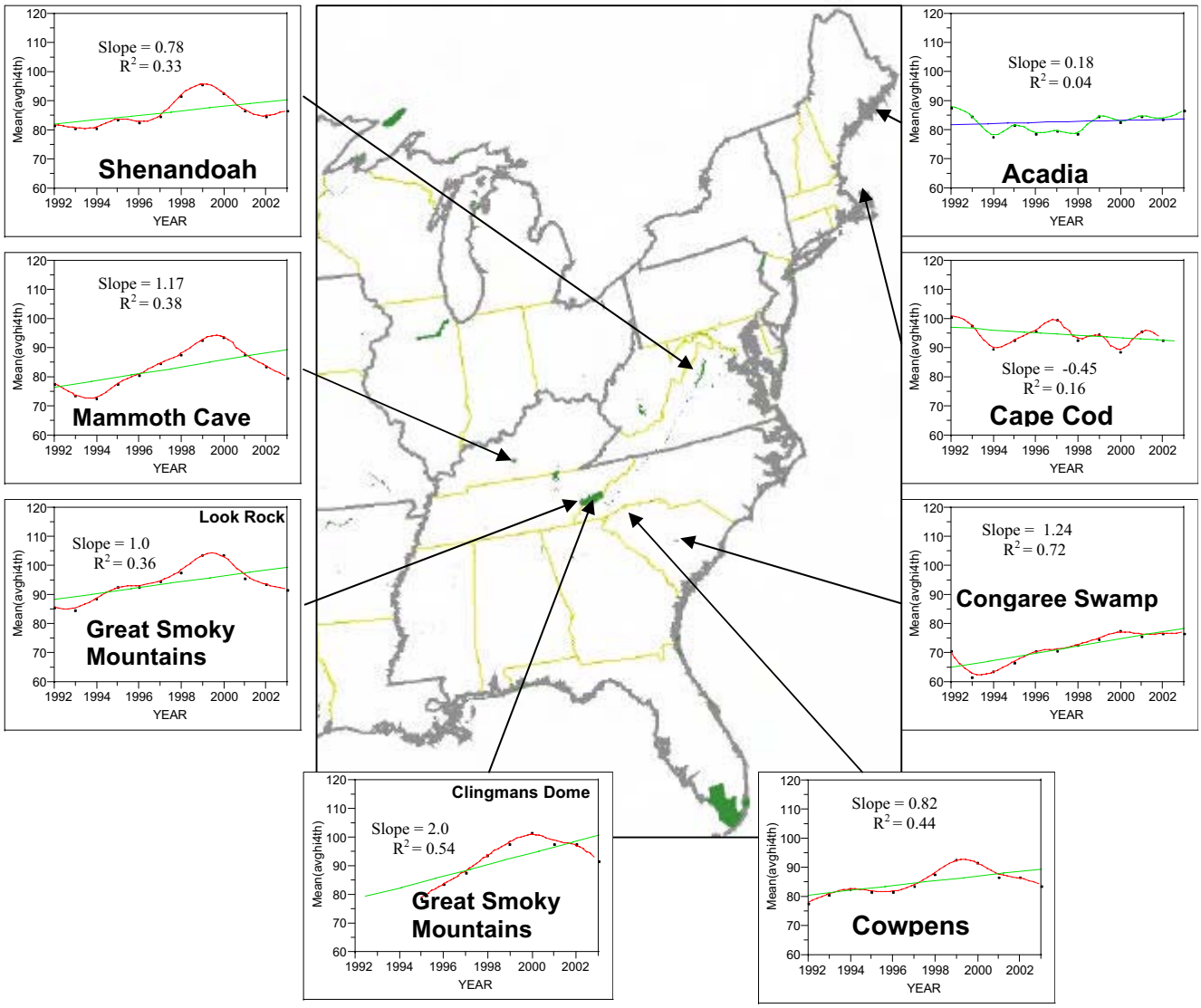


Figure 3-8

Trends at Eastern Parks in Annual 4th Highest Daily Maximum
8-Hour Average Ozone Concentration
1994 - 2003
National Park Service Gaseous Pollutant Monitoring Program



3.2.4 Resource Injury Indices

To quantify ozone exposure to plants, various indices other than the 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:

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:

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

Table 3-7 presents the resource injury summary statistics for 2003. 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.

The map in Figure 3-9 presents the annual 3 month maximum SUM06 exposure index for all network sites listed in Table 3-7. Index values are color-coded to represent three distinct levels of cumulative exposure. Data from portable sites (no color) are included for reference only.

Ozone sensitive plant species at sites with a cumulative SUM06 of 0-7 ppm-hr are unlikely to experience foliar injury or growth reduction because of ozone. Sites with a SUM06 of 8-16 ppm-hr have a higher risk to sensitive vegetation; sites with a SUM06 greater than 16 ppm-hr have the highest risk for ozone foliar injury or growth effects. These risks are relative and the thresholds are 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

SUM 06 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 both exposure indices are above thresholds for effects, the potential for injury increases.

Table 3-7

Summary of Indices for Resource Injury (SUM06, W126, and N100)
2003
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	O3 % Valid	SUM06[1] (ppm-hr)	W126[2] (ppm-hr)	N100[3]
Acadia	Cadillac Mountain	99.9	20.3	29.8	9
Acadia	McFarland Hill	99.4	14.8	21.7	0
Badlands	Visitor Center	99.5	0.0	8.9	0
Big Bend	K-Bar Ranch Road	98.1	9.8	24.2	0
Big South Fork	Portable Ozone	79.3	4.6	7.5	0
Black Canyon of the Gunnison	Portable Ozone	99.9	19.2	21.7	0
Cape Cod	Cape Cod	95.7	30.5	36.7	21
Canyonlands	Island in the Sky	89.0	58.1	66.7	0
Chamizal	Chamizal	96.0	13.9	22.6	5
Chiricahua	Entrance Station	94.2	31.2	50.5	0
Channel Islands	Santa Rosa Island	89.2	5.3	13.9	0
Congaree Swamp	Congaree Bluff	97.0	12.8	14.9	0
Cowpens	Cowpens	99.7	15.8	27.7	2
Craters of the Moon	Visitor Center	95.3	25.9	34.7	0
Denali	Headquarters	99.3	0.3	9.0	0
Death Valley	Park Village	97.6	80.2	77.7	0
Everglades	Beard Center	88.8	3.9	9.3	0
Glacier	West Glacier Horse Stables	91.2	2.3	8.6	0
Great Basin	Maintenance Yard	98.5	41.1	46.3	0
Grand Canyon	The Abyss	99.1	66.1	67.4	0
Grand Canyon	Portable Ozone	99.9	17.7	18.0	0
Great Smoky Mountains	Cades Cove	89.2	13.5	20.5	0
Great Smoky Mountains	Clingmans Dome	93.3	61.5	58.2	3
Great Smoky Mountains	Cove Mountain	98.6	45.3	76.7	1
Great Smoky Mountains	Look Rock	99.2	45.8	77.8	11
Great Smoky Mountains	Purchase Knob	93.5	45.5	52.5	0
Hawaii Volcanoes	Thurston Lava Tubes	95.4	0.0	1.9	0
Isle Royale	Portable Ozone	43.3	0.5	5.5	0
Joshua Tree	Yucca Valley	96.3	128.6	146.6	110
Lake Mead	Portable Ozone	87.4	40.4	34.3	0
Lassen Volcanic	Monzanita Lake Maintenance Area	98.8	12.9	24.4	0
Mammoth Cave	Houchin Meadow	99.0	22.2	31.7	0
Mesa Verde	Maintenance Yard	98.6	27.5	46.4	0
Mount Rainier	Tahoma Woods	97.6	7.9	9.8	0
North Cascades	Marblemount Ranger Station	88.1	1.1	4.1	0
Olympic	Visitor Center	97.8	0.0	1.8	0
Petrified Forest	Horse Barn	97.8	39.7	51.2	0
Pinnacles	East Entrance Station	99.3	27.3	39.3	4
Rocky Mountain	Longs Peak Ranger Station	99.4	53.0	81.3	4
Saguaro	Pima County	97.4	34.4	48.7	0
Sequoia and Kings Canyon	Ash Mountain	91.7	98.4	126.6	184
Sequoia and Kings Canyon	Lower Kaweah	91.4	105.4	112.4	83
Sequoia and Kings Canyon	Lookout Point	81.7	63.8	109.4	118
Shenendoah	Big Meadows	94.0	45.4	61.1	14

Table 3-7 (cont.)

Summary of Indices for Resource Injury (SUM06, W126, and N100)
2003
National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	O3 % Valid	SUM06[1] (ppm-hr)	W126[2] (ppm-hr)	N100[3]
Theodore Roosevelt	Visitor Center	99.9	1.2	15.2	0
Virgin Islands	Lind Point	88.6	0.0	1.4	0
Voyageurs	Sullivan Bay	99.2	8.1	19.2	0
Yellowstone	Water Tank	91.0	15.5	32.9	0
Yosemite	Merced River	74.3	2.9	8.1	0
Yosemite	Turtleback Dome	99.5	84.1	109.5	15

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 concntrations 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

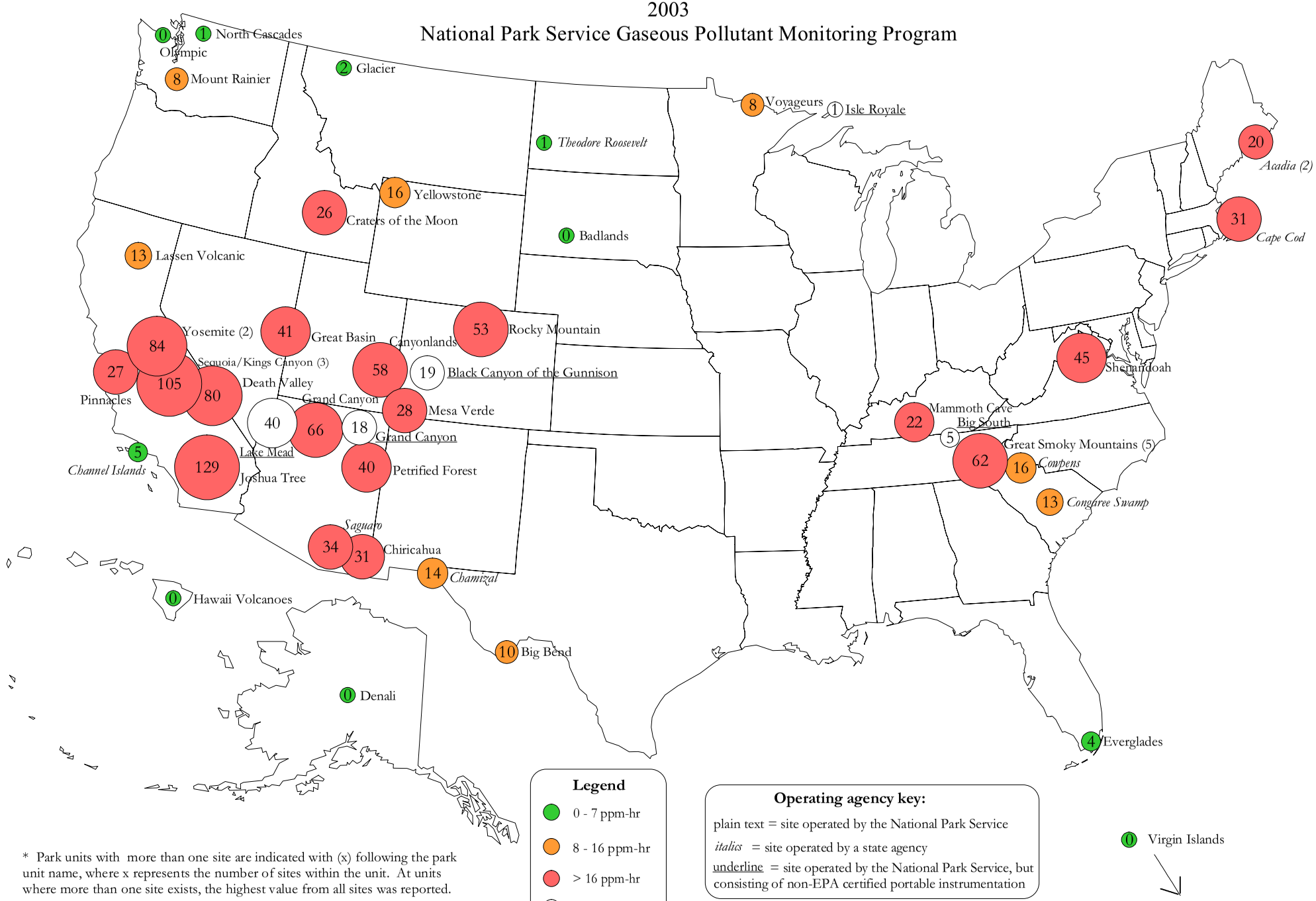
3. N100 represents the number of hourly ozone concentrations greater than or equal to 0.100 ppm (100 ppb).

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 protable instrumentation

Figure 3-9

Annual 3 Month Maximum Sum06 Exposure Index
2003
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 is a criteria pollutant that alone, and after chemical transformation into particulate sulfate, is responsible for health and environmental impacts. Both sulfur dioxide and sulfate can cause respiratory problems. Sulfur dioxide can react with other chemicals and water in the air to form acid rain which is detrimental to plant and watershed resources. Sulfate is one of the particulate species responsible for visibility degradation and regional haze.

There are several National Ambient Air Quality Standards for sulfur dioxide. The primary annual NAAQS is an annual arithmetic mean of 0.03 ppm (34 ppb). The primary daily NAAQS is a 24-hour mean of 0.14 ppm (144 ppb). The secondary NAAQS is a 3-hour mean of 0.50 ppm (549 ppb). Table 3-8 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.

Table 3-8

Summary of Sulfur Dioxide Data by Site

2003

National Park Service Gaseous Pollutant Monitoring Program

National Park Unit	Site Name	Annual Arithmetic Mean	Highest Daily 24-Hour Average Concentrations[2] (ppb)					Highest Daily Maximum 3-Hour Average Concentration[3] (ppb)					Highest Daily Maximum 1-Hour Average Concentration (ppb)			
			1st Highest	2nd Highest	3rd Highest	4th Highest	No. of days with 24-Hour Average >=145 ppb	1st Highest	2nd Highest	3rd Highest	4th Highest	No. of days with 3-Hour Maximum >= 550 ppb	1st Highest	2nd Highest	3rd Highest	4th Highest
Congaree Swamp	Congaree Bluff	1	9	8	7	6	0	32	30	30	24	0	80	50	48	45
Hawaii Volcanoes	Observatory	20	250	212	160	137	3	591	561	518	513	2	867	858	804	733
Hawaii Volcanoes	Visitor Center	14	173	162	141	129	2	554	512	477	475	1	839	732	724	689
Olympic	Visitor Center	1	4	4	3	3	0	12	12	10	10	0	20	19	16	16
Shenendoah	Big Meadows	2	9	9	8	7	0	15	15	15	15	0	24	21	20	18
Theodore Roosevelt	Visitor Center	1	4	4	3	3	0	9	7	7	6	0	20	11	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.)

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 causes and impacts of air pollution. In addition, meteorological data are essential for air quality modeling efforts.

Table 3-9 presents a summary of selected meteorological data for all sites. The parameters included are wind speed, ambient temperature, relative humidity, and precipitation.

Figure 3-10 presents annual wind roses, a graphical representation of summarized wind speed and wind direction data for all sites.

Table 3-9
Summary of Selected Meteorological Data by Site
2003
National Park Service Gaseous Pollutant Monitoring Program

		Wind Speed (Scalar) (m/s)	Ambient Temperature (degrees C)			Relative Humidity (%)			Precipitation (mm)
National Park Unit	Site Name	Average	Average	Maximum	Minimum	Average	Maximum	Minimum	Accumulated during period
Acadia	Cadillac Mountain	5.9	14.4	27.8	-0.8	80	100	16	—
Acadia	McFarland Hill	3.3	6.2	27.6	-25.7	67	100	8	856.8
Badlands	Visitor Center	3.9	11.2	39.7	-19.4	54	96	9	—
Big Bend	K-Bar Ranch Road	3.6	20.3	38.3	-4.5	42	100	2	306.1
Big South Fork	Portable Ozone	0.6	21.4	33.2	1.1	82	99	34	405.0
Black Canyon of the Gunnison	Portable Ozone	2.3	17.5	32.3	-4.6	38	99	6	95.6
Cape Cod	Cape Cod	2.8	8.9	29.9	-14.2	78	100	10	—
Canyonlands	Island in the Sky	2.8	13.0	36.5	-10.9	37	99	3	116.7
Chamizal	Chamizal	3.4	19.8	39.9	-5.1	33	99	4	—
Chiricahua	Entrance Station	3.2	16.4	37.5	-10.7	38	100	5	118.5
Craters of the Moon	Visitor Center	3.6	7.8	35.0	-20.0	49	99	5	—
Denali	Headquarters	1.4	-0.3	26.0	-31.7	67	99	13	326.8
Death Valley	Park Village	3.6	26.4	49.5	5.0	22	100	1	72.1
Everglades	Beard Center	2.0	23.3	32.2	2.2	79	100	29	1404.9
Glacier	West Glacier Horse Stables	1.1	1.8	32.5	-24.3	77	100	13	554.5
Great Basin	Maintenance Yard	2.7	9.9	33.6	-15.6	42	96	4	42.6
Grand Canyon	The Abyss	2.9	11.3	33.2	-10.7	40	100	3	254.0
Grand Canyon	Portable Ozone	2.7	25.0	41.4	8.3	29	96	4	75.1
Great Smoky Mountains	Cades Cove	1.3	13.0	33.2	-17.3	78	100	10	1436.7
Great Smoky Mountains	Clingmans Dome	3.7	10.8	20.5	-4.1	90	101	6	960.8
Great Smoky Mountains	Cove Mountain	4.6	9.9	24.9	-21.6	75	100	5	1215.7
Great Smoky Mountains	Look Rock	2.5	12.6	27.0	-18.7	75	100	13	1603.1
Hawaii Volcanoes	Observatory	4.9	16.6	28.5	8.0	81	100	9	854.9
Hawaii Volcanoes	Thurston Lava Tubes	1.7	15.0	24.0	7.1	89	100	17	2522.3
Hawaii Volcanoes	Visitor Center	3.7	15.4	26.0	7.4	90	100	20	1750.3
Isle Royale	Portable Ozone	5.4	15.9	28.3	1.2	71	100	8	107.5
Joshua Tree	Yucca Valley	3.7	16.6	37.4	-2.3	37	100	4	315.5
Lake Mead	Portable Ozone	3.7	31.2	43.5	16.2	21	94	4	36.7
Lassen Volcanic	Monzanita Lake Maintenance Area	2.0	7.8	31.5	-13.6	62	98	6	937.3
Mammoth Cave	Houchin Meadow	1.8	13.5	32.2	-19.7	71	99	16	1239.3
Mesa Verde	Maintenance Yard	2.9	10.1	33.1	-14.5	37	100	1	239.2
Mount Rainier	Tahoma Woods	1.1	9.1	34.3	-6.2	77	100	16	1347.7

Table 3-9 (cont.)
Summary of Selected Meteorological Data by Site
2003
National Park Service Gaseous Pollutant Monitoring Program

		Wind Speed (Scalar) (m/s)	Ambient Temperature (degrees C)			Relative Humidity (%)			Precipitation (mm)
National Park Unit	**Site Name**	**Average**	**Average**	**Maximum**	**Minimum**	**Average**	**Maximum**	**Minimum**	**Accumulated during period**
North Cascades	Marblemount Ranger Station	1.5	10.1	34.4	-6.0	79	98	17	2127.1
Olympic	Visitor Center	1.0	8.9	29.3	-2.8	79	100	19	803.5
Petrified Forest	Horse Barn	4.0	14.3	36.9	-11.1	38	99	0	103.1
Pinnacles	East Entrance Station	2.1	14.7	41.1	-5.9	61	98	4	283.2
Rocky Mountain	Longs Peak Ranger Station	2.9	4.5	26.4	-23.8	49	99	5	450.7
Sequoia and Kings Canyon	Ash Mountain	2.6	20.8	40.2	-1.1	47	99	6	238.6
Sequoia and Kings Canyon	Lower Kaweah	1.5	9.8	28.3	-10.9	60	100	5	711.8
Sequoia and Kings Canyon	Lookout Point	4.0	13.2	33.6	-5.8	56	99	8	551.8
Shenendoah	Big Meadows	2.7	7.5	25.6	-20.1	76	100	12	1736.0
Theodore Roosevelt	Visitor Center	5.1	6.7	37.5	-27.8	63	100	10	379.8
Virgin Islands	Lind Point	3.9	26.7	31.8	20.3	70	96	39	1219.5
Voyageurs	Sullivan Bay	2.7	4.0	35.3	-30.5	68	99	14	435.2
Yellowstone	Water Tank	1.7	2.7	29.7	-31.1	65	100	6	421.3
Yosemite	Merced River	0.5	10.7	36.1	-8.1	69	99	6	665.0
Yosemite	Turtleback Dome	3.8	11.5	30.7	-9.0	47	99	0	758.1
Yukon Flats	Poker Flat	3.1	-0.7	26.5	-32.6	67	100	12	367.8

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

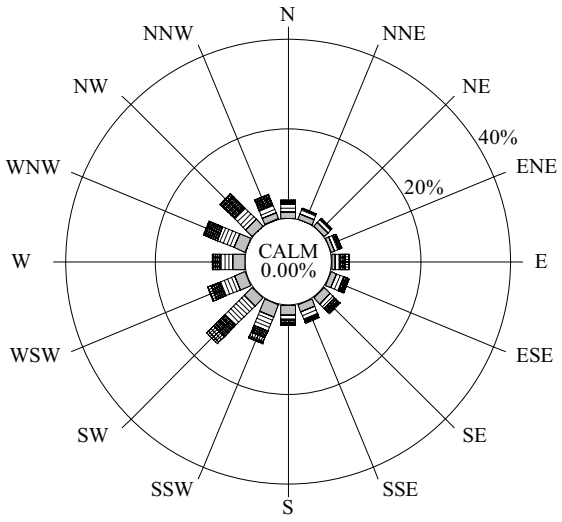
Note: Dashed lines represent no data available for that particular parameter at that site.

Figure 3-10

Annual Wind Rose by Site

2003

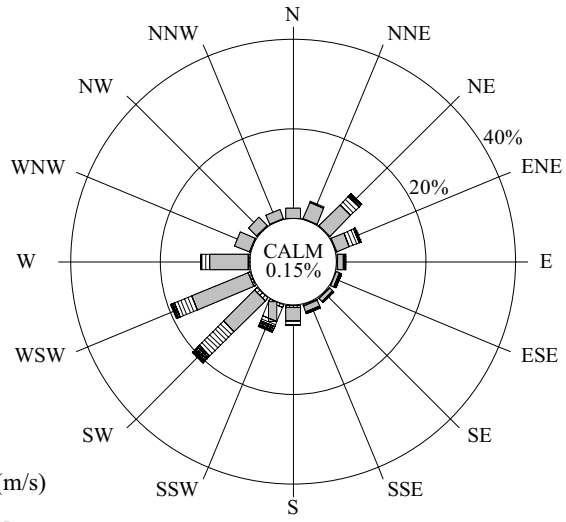
Acadia National Park
Cadillac Mountain



99.6% Collected 99.6% Valid
3853 Possible /3839 Collected /3839 Valid
(includes WS and WD)

Final Validation

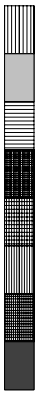
Acadia National Park
McFarland Hill



99.8% Collected 99.2% Valid
8760 Possible /8741 Collected /8689 Valid
(includes WS and WD)

Final Validation

Scalar Wind Speed (m/s)



CALM < -5

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1.0-3.9

4.0-6.9

7.0-9.9

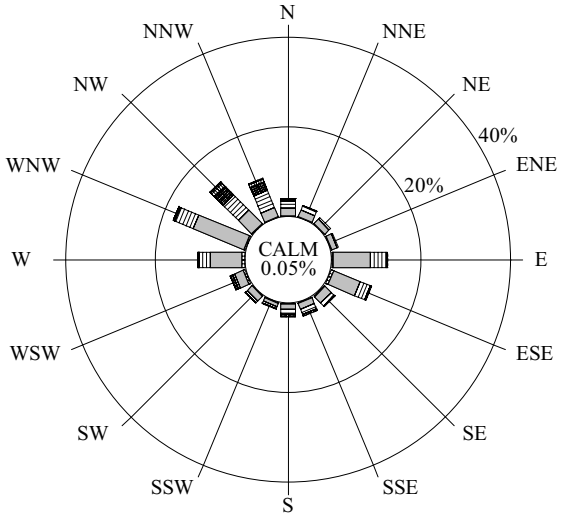
10.0-12.9

13.0-15.9

16.0-18.9

19.0+

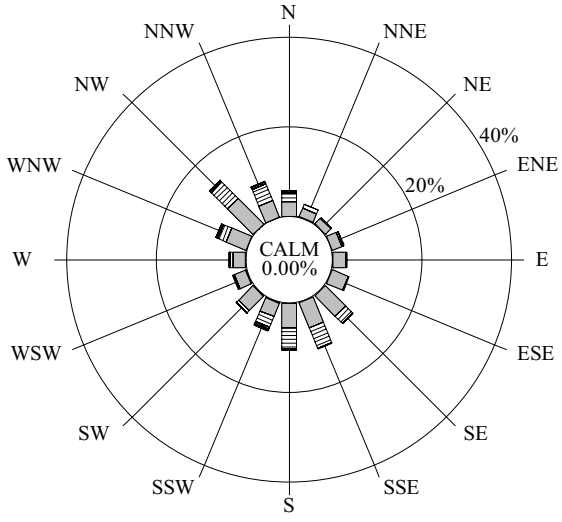
Badlands National Park
Visitor Center



100.0% Collected 100.0% Valid
3672 Possible /3671 Collected /3671 Valid
(includes WS and WD)

Final Validation

Big Bend National Park
K-Bar Ranch Road



99.2% Collected 99.2% Valid
8760 Possible /8692 Collected /8692 Valid
(includes WS and WD)

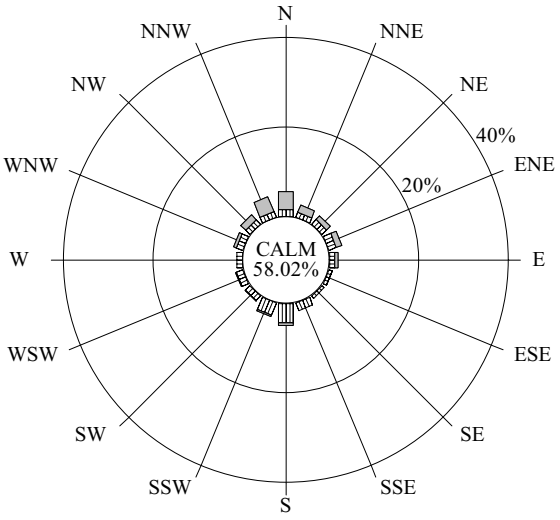
Final Validation

Figure 3-10 (cont.)

Annual Wind Rose by Site

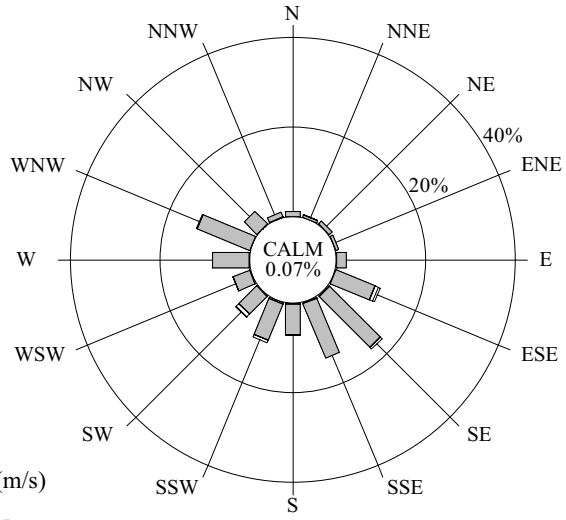
2003

Big South Fork
National River and Recreation Area
Portable Ozone



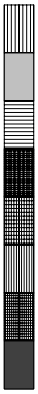
99.2% Collected 99.2% Valid
2506 Possible /2487 Collected /2487 Valid
(includes WS and WD)
Final Validation

Black Canyon
of the Gunnison National Park
Portable Ozone



100.0% Collected 100.0% Valid
2673 Possible /2673 Collected /2673 Valid
(includes WS and WD)
Final Validation

Scalar Wind Speed (m/s)



CALM < -5
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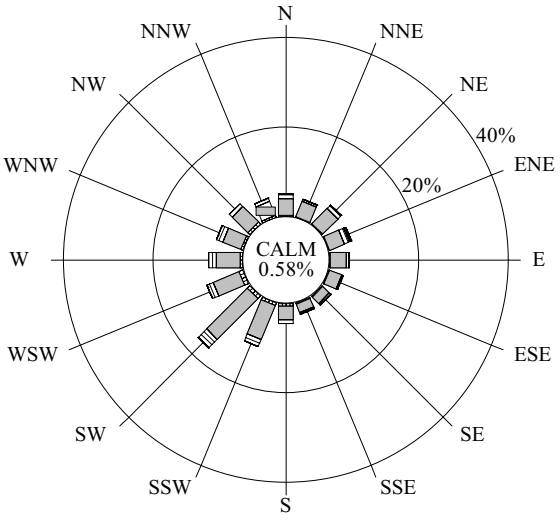
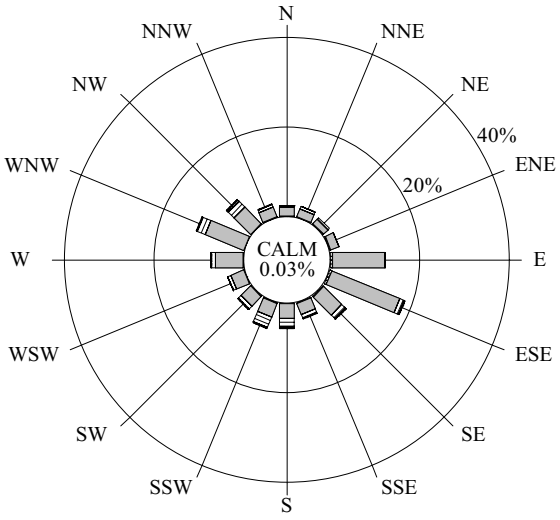
1.0-3.9
4.0-6.9
7.0-9.9
10.0-12.9
13.0-15.9
16.0-18.9
19.0+

Cape Cod National
Seashore



99.8% Collected 99.8% Valid
8760 Possible /8745 Collected /8745 Valid
(includes WS and WD)
Final Validation

Canyonlands National Park
Island in the Sky



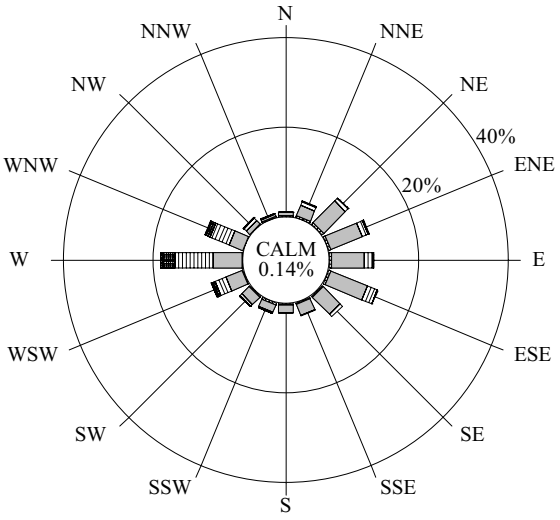
99.8% Collected 99.5% Valid
8760 Possible /8743 Collected /8718 Valid
(includes WS and WD)
Final Validation

Figure 3-10 (cont.)

Annual Wind Rose by Site

2003

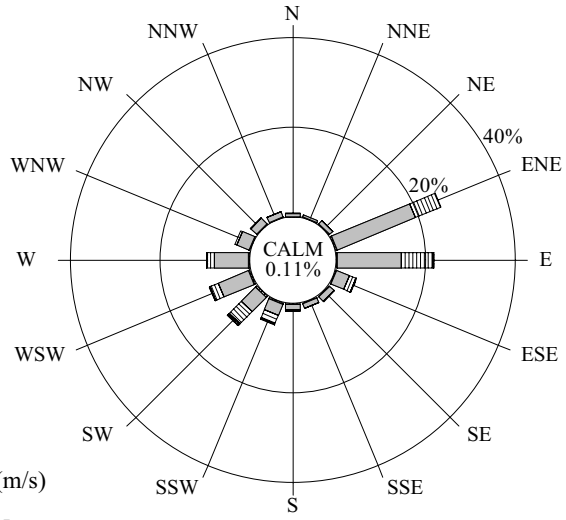
Chamizal National Memorial



98.8% Collected 98.7% Valid
8760 Possible /8659 Collected /8649 Valid
(includes WS and WD)

Final Validation

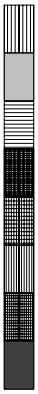
Chiricahua National Monument Entrance Station



99.7% Collected 99.7% Valid
8760 Possible /8738 Collected /8738 Valid
(includes WS and WD)

Final Validation

Scalar Wind Speed (m/s)



CALM < -5

0.0-0.9

1.0-3.9

4.0-6.9

7.0-9.9

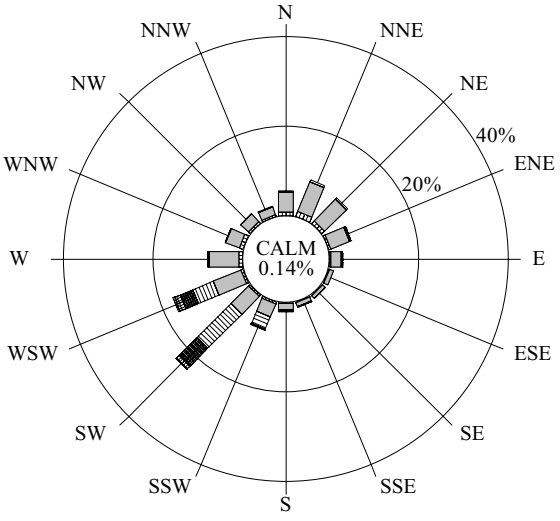
10.0-12.9

13.0-15.9

16.0-18.9

19.0+

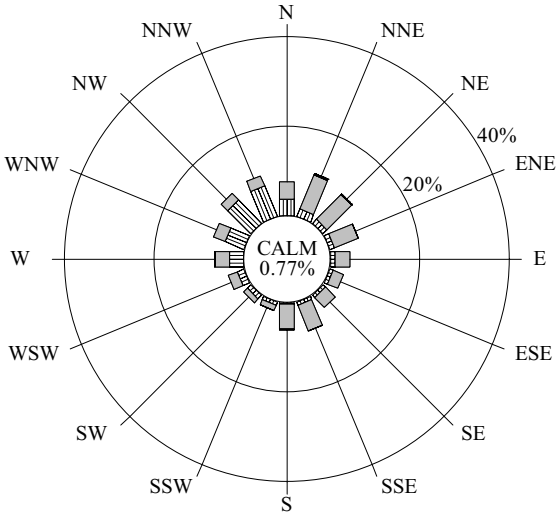
Craters of the Moon National Monument Visitor Center



99.2% Collected 99.2% Valid
8760 Possible /8694 Collected /8694 Valid
(includes WS and WD)

Final Validation

Denali National Park Headquarters



99.6% Collected 99.3% Valid
8760 Possible /8725 Collected /8699 Valid
(includes WS and WD)

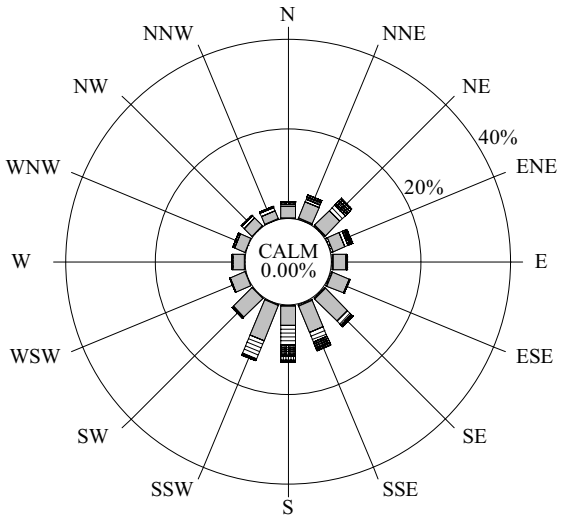
Final Validation

Figure 3-10 (cont.)

Annual Wind Rose by Site

2003

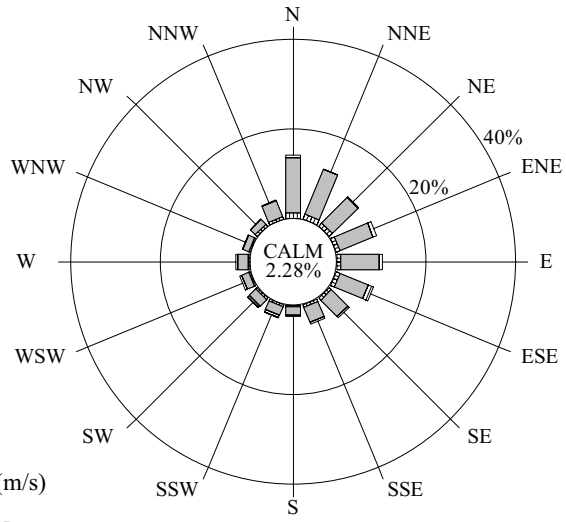
Death Valley
National Park
Park Village



99.7% Collected 97.8% Valid
8760 Possible /8732 Collected /8564 Valid
(includes WS and WD)

Final Validation

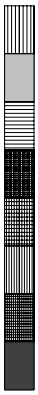
Everglades National Park
Beard Center



92.0% Collected 91.6% Valid
8760 Possible /8056 Collected /8025 Valid
(includes WS and WD)

Final Validation

Scalar Wind Speed (m/s)



CALM < -5

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1.0-3.9

4.0-6.9

7.0-9.9

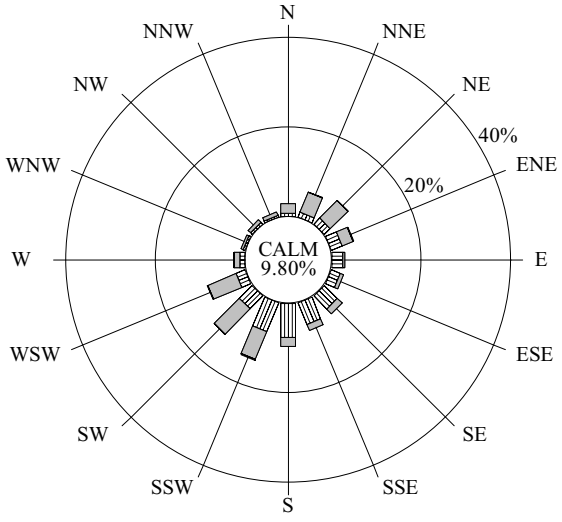
10.0-12.9

13.0-15.9

16.0-18.9

19.0+

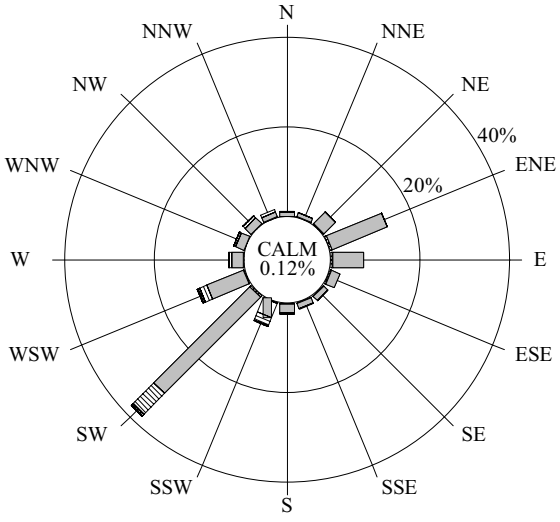
Glacier National Park
West Glacier Horse Stables



98.8% Collected 95.5% Valid
8760 Possible /8656 Collected /8364 Valid
(includes WS and WD)

Final Validation

Great Basin National Park
Maintenance Yard



99.2% Collected 96.0% Valid
8760 Possible /8689 Collected /8410 Valid
(includes WS and WD)

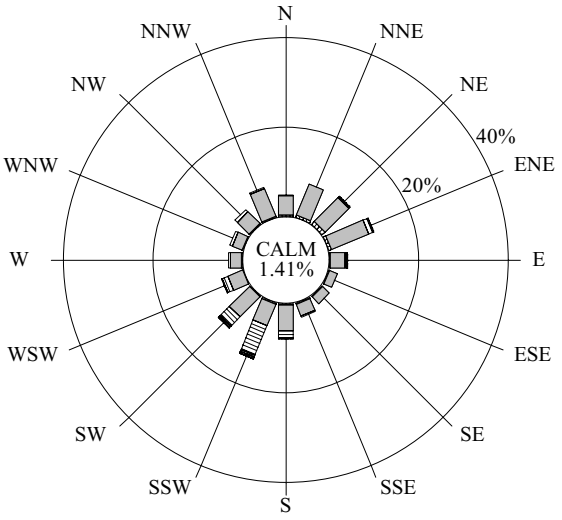
Final Validation

Figure 3-10 (cont.)

Annual Wind Rose by Site

2003

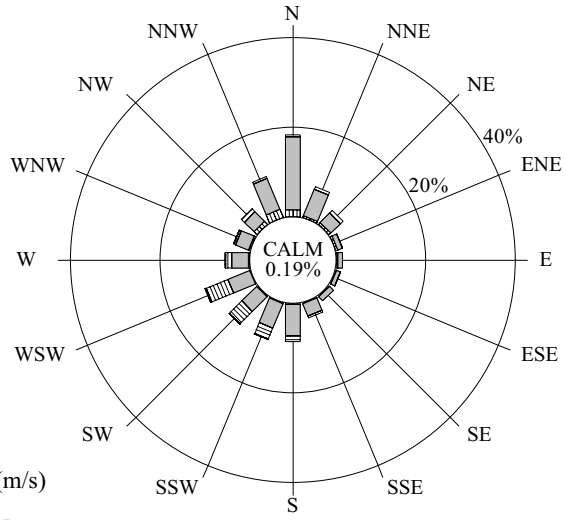
Grand Canyon
National Park
The Abyss



98.9% Collected 59.1% Valid
8760 Possible /8667 Collected /5174 Valid
(includes WS and WD)

Final Validation

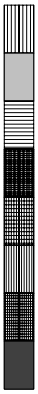
Grand Canyon
National Park
Portable Ozone



100.0% Collected 100.0% Valid
3223 Possible /3222 Collected /3222 Valid
(includes WS and WD)

Final Validation

Scalar Wind Speed (m/s)



CALM < -5

0.0-0.9

1.0-3.9

4.0-6.9

7.0-9.9

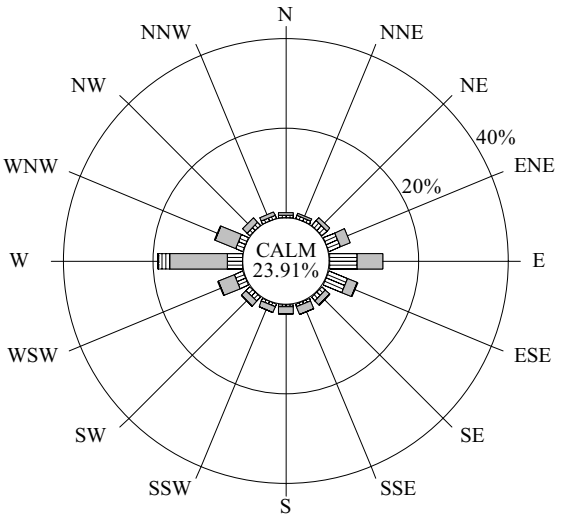
10.0-12.9

13.0-15.9

16.0-18.9

19.0+

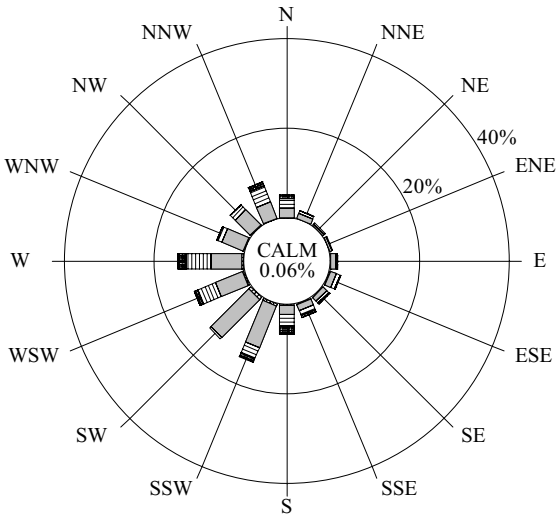
Great Smoky Mountains
National Park
Cades Cove



99.9% Collected 99.9% Valid
8760 Possible /8747 Collected /8747 Valid
(includes WS and WD)

Final Validation

Great Smoky Mountains
National Park
Clingmans Dome



74.6% Collected 73.3% Valid
4416 Possible /3295 Collected /3235 Valid
(includes WS and WD)

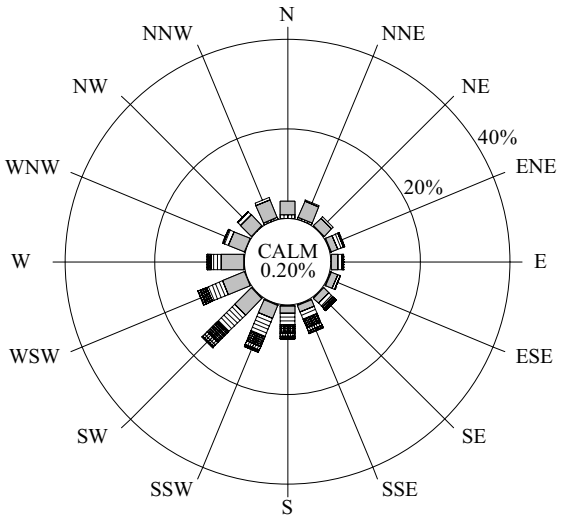
Final Validation

Figure 3-10 (cont.)

Annual Wind Rose by Site

2003

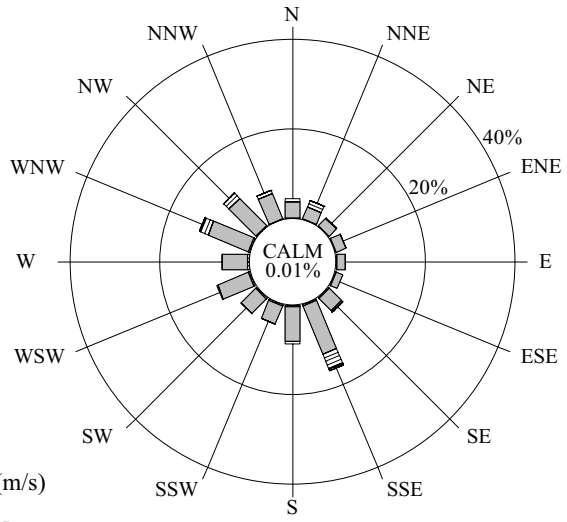
Great Smoky Mountains
National Park
Cove Mountain



99.6% Collected 97.5% Valid
8760 Possible /8728 Collected /8537 Valid
(includes WS and WD)

Final Validation

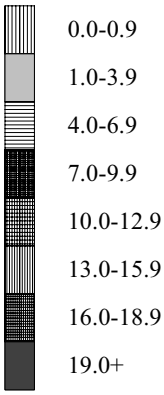
Great Smoky Mountains
National Park
Look Rock



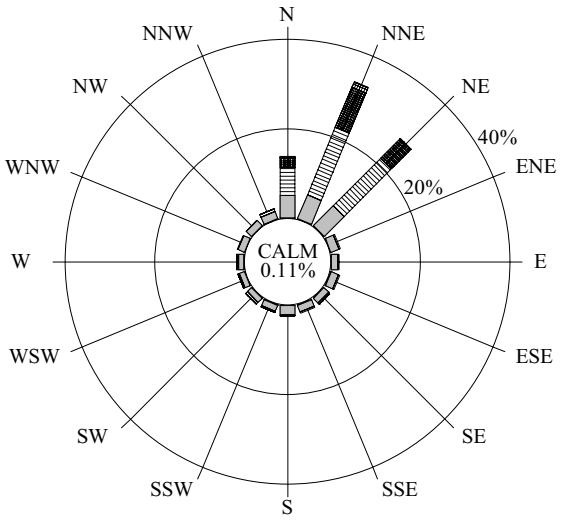
98.4% Collected 98.4% Valid
8760 Possible /8621 Collected /8621 Valid
(includes WS and WD)

Final Validation

Scalar Wind Speed (m/s)



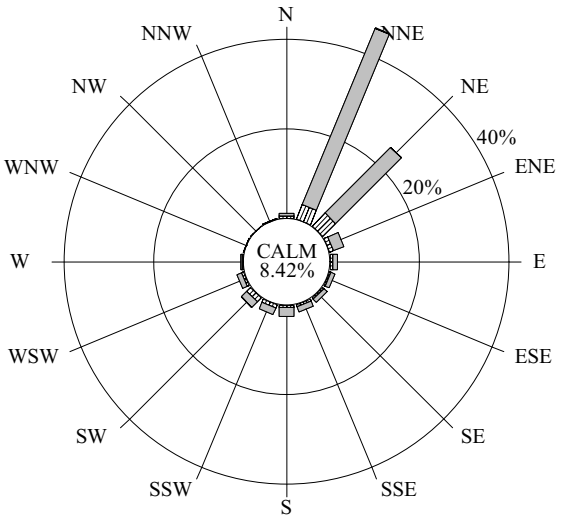
Hawaii Volcanoes
National Park
Observatory



100.0% Collected 100.0% Valid
8760 Possible /8759 Collected /8758 Valid
(includes WS and WD)

Final Validation

Hawaii Volcanoes
National Park
Thurston Lava Tubes



99.8% Collected 99.8% Valid
8760 Possible /8744 Collected /8744 Valid
(includes WS and WD)

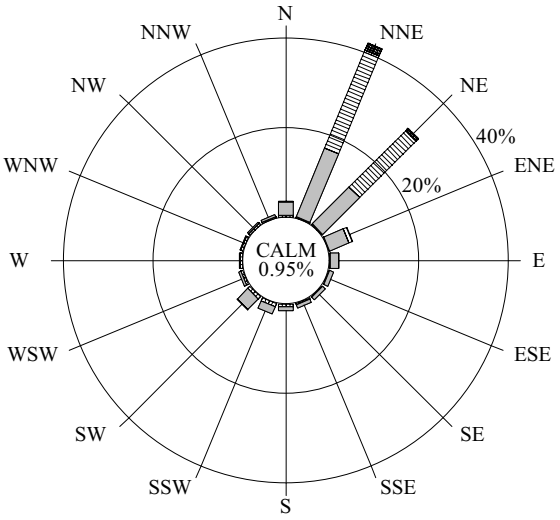
Final Validation

Figure 3-10 (cont.)

Annual Wind Rose by Site

2003

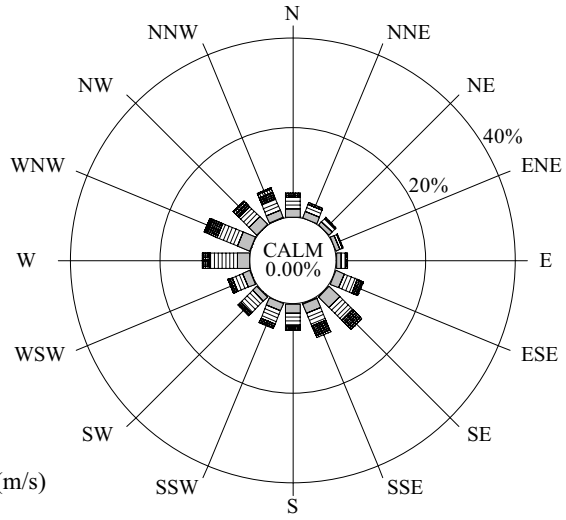
Hawaii Volcanoes
National Park
Visitor Center



99.8% Collected 99.8% Valid
8760 Possible /8744 Collected /8744 Valid
(includes WS and WD)

Final Validation

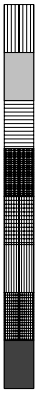
Isle Royale National Park
Portable Ozone



99.9% Collected 91.2% Valid
3475 Possible /3473 Collected /3170 Valid
(includes WS and WD)

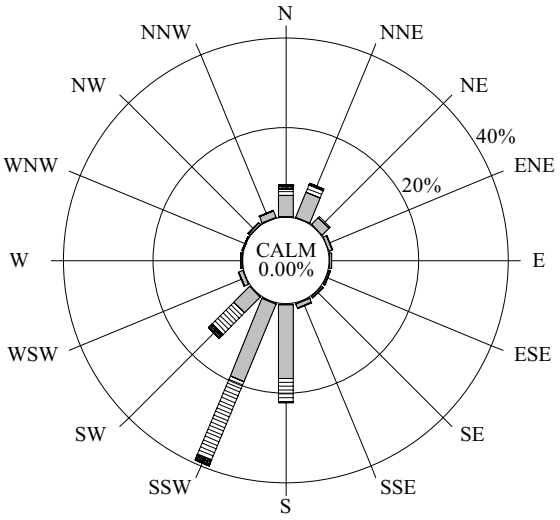
Final Validation

Scalar Wind Speed (m/s)



CALM < -5
0.0-0.9
1.0-3.9
4.0-6.9
7.0-9.9
10.0-12.9
13.0-15.9
16.0-18.9
19.0+

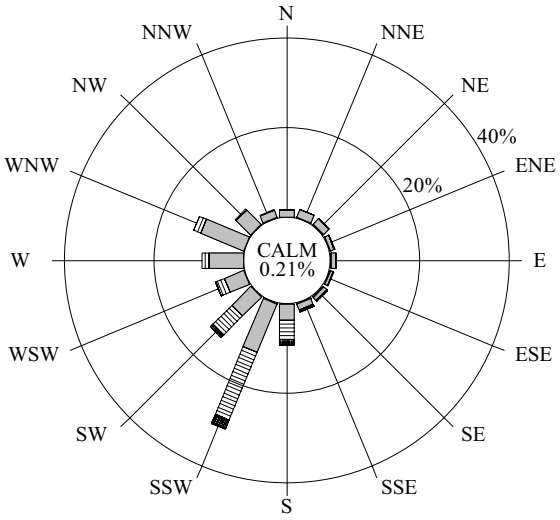
Joshua Tree National Park
Yucca Valley



99.5% Collected 98.8% Valid
8760 Possible /8715 Collected /8657 Valid
(includes WS and WD)

Final Validation

Lake Mead National
Recreation Area
Portable Ozone



92.0% Collected 92.0% Valid
3157 Possible /2904 Collected /2904 Valid
(includes WS and WD)

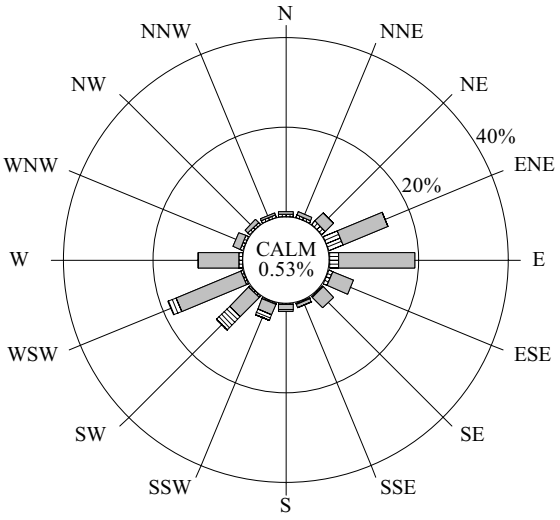
Final Validation

Figure 3-10 (cont.)

Annual Wind Rose by Site

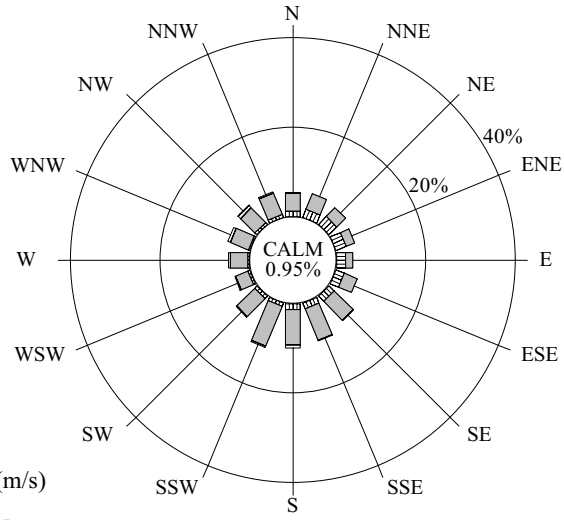
2003

Lassen Volcanic
National Park
Monzanita Lake Maintenance Area



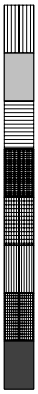
97.3% Collected 92.2% Valid
8760 Possible /8520 Collected /8075 Valid
(includes WS and WD)
Final Validation

Mammoth Cave
National Park
Houchin Meadow



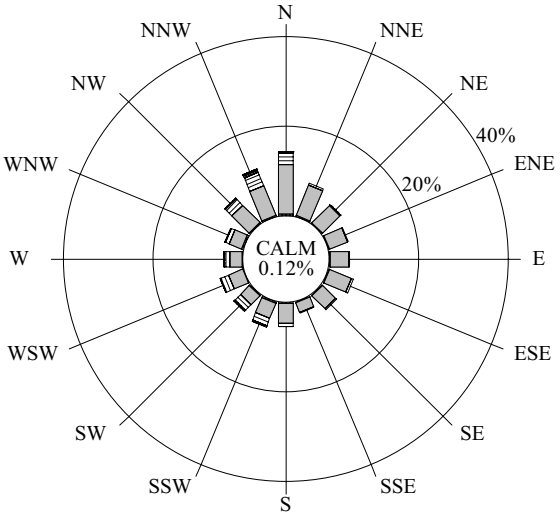
99.6% Collected 99.5% Valid
8760 Possible /8723 Collected /8715 Valid
(includes WS and WD)
Final Validation

Scalar Wind Speed (m/s)



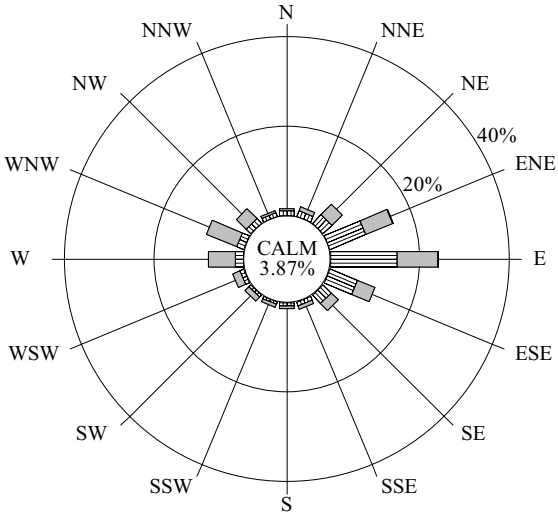
CALM < -5
0.0-0.9
1.0-3.9
4.0-6.9
7.0-9.9
10.0-12.9
13.0-15.9
16.0-18.9
19.0+

Mesa Verde National Park
Maintenance Yard



99.4% Collected 88.5% Valid
8760 Possible /8706 Collected /7756 Valid
(includes WS and WD)
Final Validation

Mount Rainier
National Park
Tahoma Woods

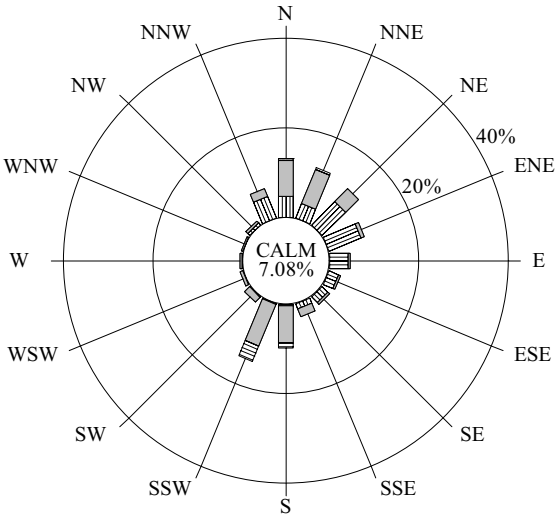


98.6% Collected 88.4% Valid
8660 Possible /8542 Collected /7654 Valid
(includes WS and WD)
Final Validation

Figure 3-10 (cont.)

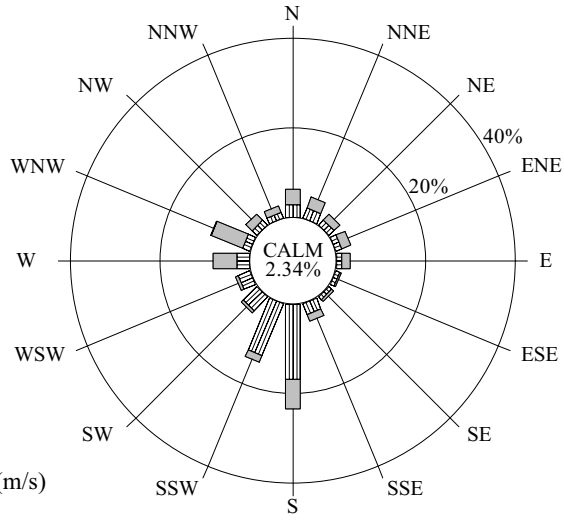
Annual Wind Rose by Site
2003

North Cascades
National Park
Marblemount Ranger Station



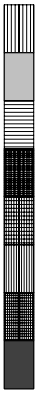
98.1% Collected 90.6% Valid
8760 Possible /8597 Collected /7933 Valid
(includes WS and WD)
Final Validation

Olympic National Park
Visitor Center



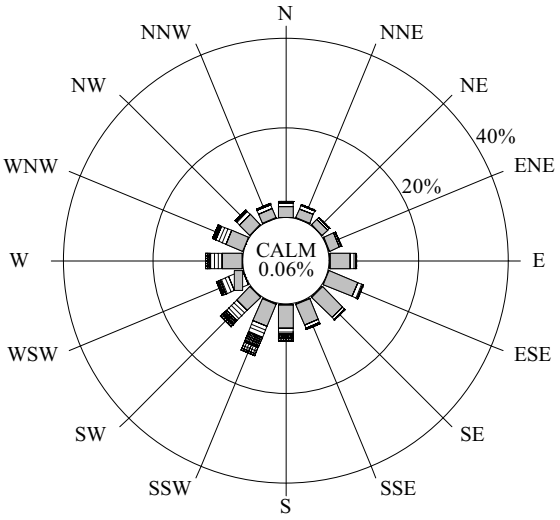
100.0% Collected 100.0% Valid
8760 Possible /8757 Collected /8757 Valid
(includes WS and WD)
Final Validation

Scalar Wind Speed (m/s)



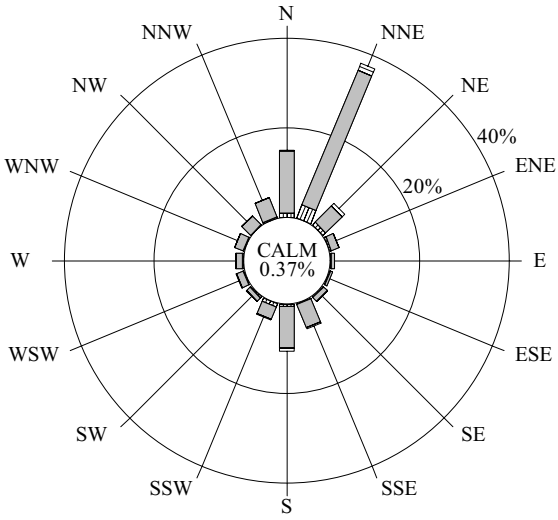
CALM < -5
0.0-0.9
1.0-3.9
4.0-6.9
7.0-9.9
10.0-12.9
13.0-15.9
16.0-18.9
19.0+

Petrified Forest
National Park
Horse Barn



97.8% Collected 97.8% Valid
8760 Possible /8563 Collected /8563 Valid
(includes WS and WD)
Final Validation

Pinnacles National
Monument
East Entrance Station

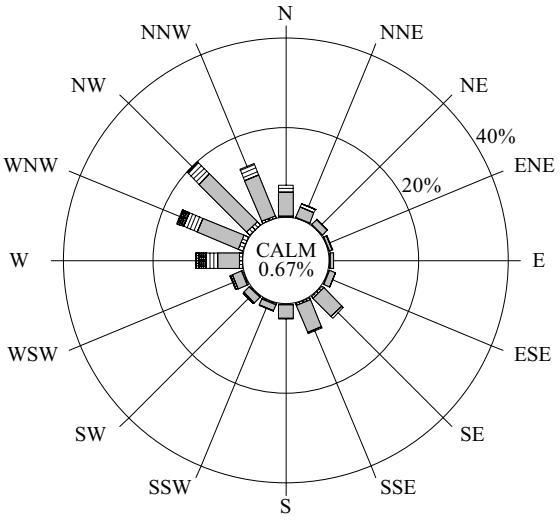


99.5% Collected 95.6% Valid
8760 Possible /8719 Collected /8372 Valid
(includes WS and WD)
Final Validation

Figure 3-10 (cont.)

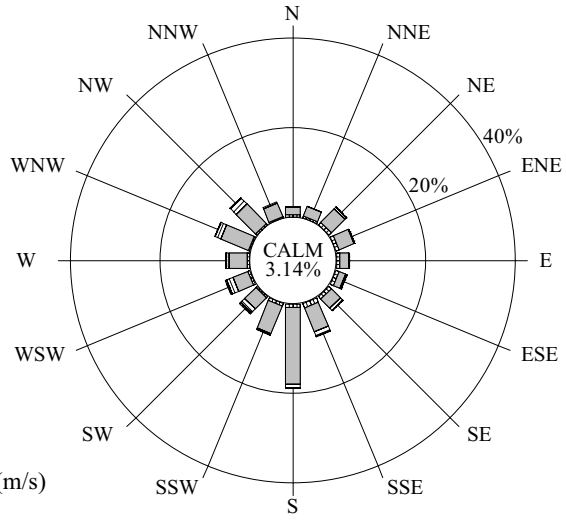
Annual Wind Rose by Site
2003

Rocky Mountain
National Park
Longs Peak Ranger Station



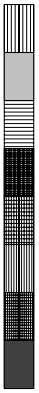
99.5% Collected 99.5% Valid
8760 Possible /8719 Collected /8719 Valid
(includes WS and WD)
Final Validation

Saguaro National Park
Pima County



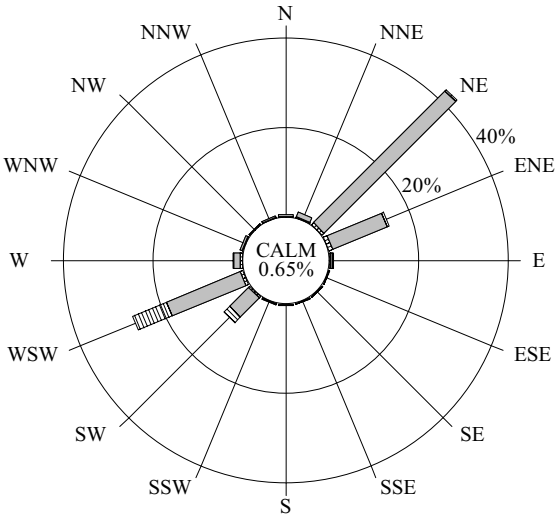
100.0% Collected 98.9% Valid
8750 Possible /8749 Collected /8656 Valid
(includes WS and WD)
Final Validation

Scalar Wind Speed (m/s)



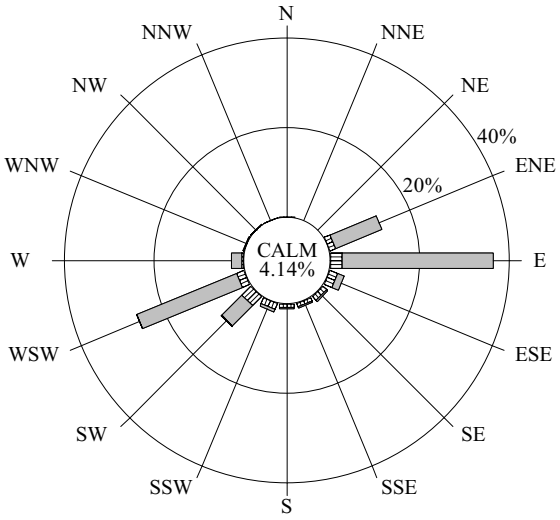
CALM < -5
0.0-0.9
1.0-3.9
4.0-6.9
7.0-9.9
10.0-12.9
13.0-15.9
16.0-18.9
19.0+

Sequoia and Kings
Canyon National Parks
Ash Mountain



100.0% Collected 100.0% Valid
5880 Possible /5878 Collected /5878 Valid
(includes WS and WD)
Final Validation

Sequoia and Kings
Canyon National Parks
Lower Kaweah



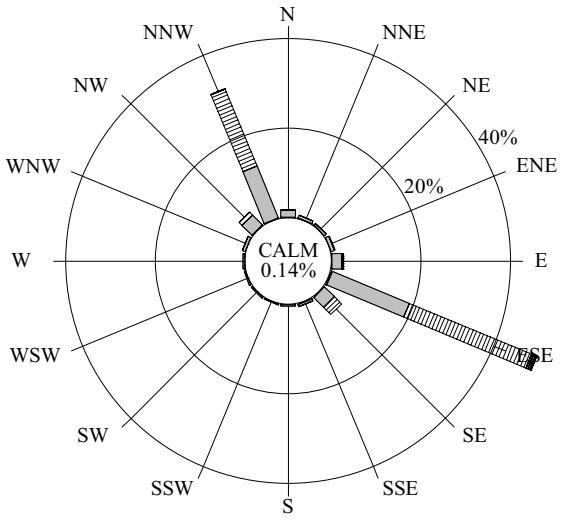
97.2% Collected 94.3% Valid
8760 Possible /8512 Collected /8259 Valid
(includes WS and WD)
Final Validation

Figure 3-10 (cont.)

Annual Wind Rose by Site

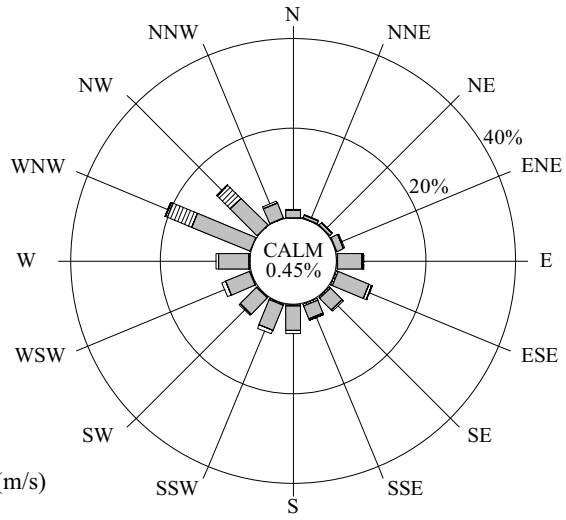
2003

Sequoia and Kings
Canyon National Parks
Lookout Point



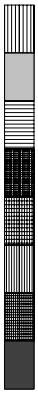
98.1% Collected 98.1% Valid
8760 Possible /8597 Collected /8597 Valid
(includes WS and WD)
Final Validation

Shenendoah National Park
Big Meadows



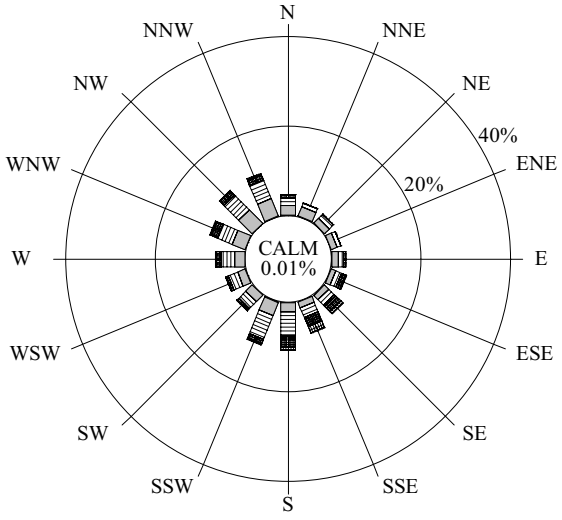
90.2% Collected 83.1% Valid
8760 Possible /7901 Collected /7279 Valid
(includes WS and WD)
Final Validation

Scalar Wind Speed (m/s)



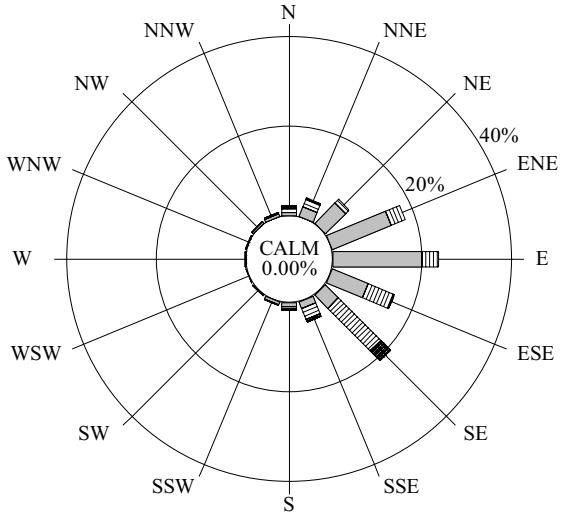
CALM < -5
0.0-0.9
1.0-3.9
4.0-6.9
7.0-9.9
10.0-12.9
13.0-15.9
16.0-18.9
19.0+

Theodore Roosevelt
National Park
Visitor Center



98.7% Collected 98.7% Valid
8760 Possible /8650 Collected /8650 Valid
(includes WS and WD)
Final Validation

Virgin Islands
National Park
Lind Point

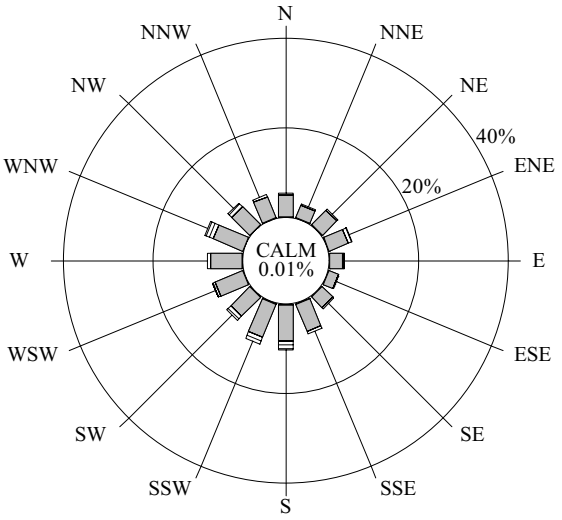


99.6% Collected 99.6% Valid
8759 Possible /8726 Collected /8726 Valid
(includes WS and WD)
Final Validation

Figure 3-10 (cont.)

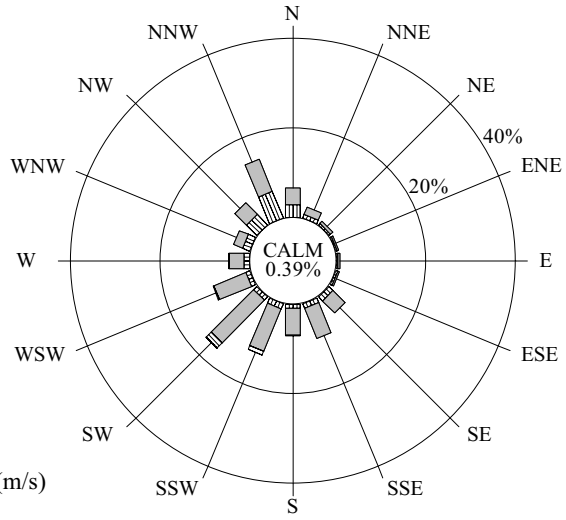
Annual Wind Rose by Site
2003

Voyageurs National Park
Sullivan Bay



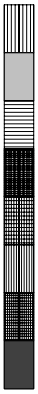
99.6% Collected 99.6% Valid
8760 Possible /8726 Collected /8726 Valid
(includes WS and WD)
Final Validation

Yellowstone National Park
Water Tank



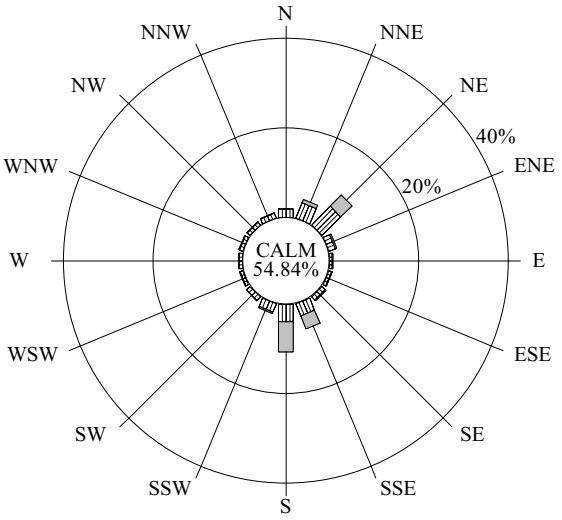
99.6% Collected 99.6% Valid
8760 Possible /8725 Collected /8725 Valid
(includes WS and WD)
Final Validation

Scalar Wind Speed (m/s)



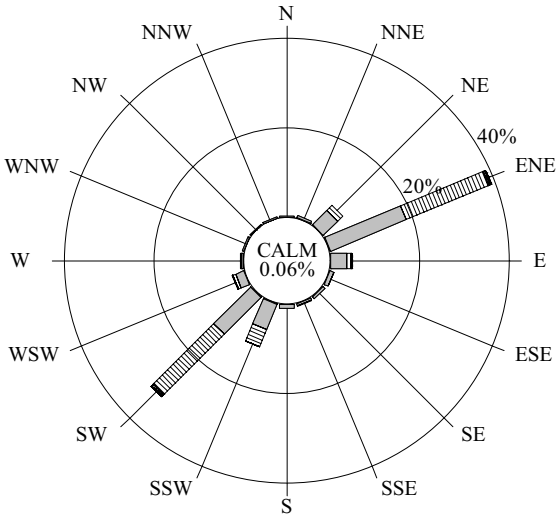
CALM < -5
0.0-0.9
1.0-3.9
4.0-6.9
7.0-9.9
10.0-12.9
13.0-15.9
16.0-18.9
19.0+

Yosemite National Park
Merced River



98.3% Collected 98.3% Valid
8760 Possible /8609 Collected /8609 Valid
(includes WS and WD)
Final Validation

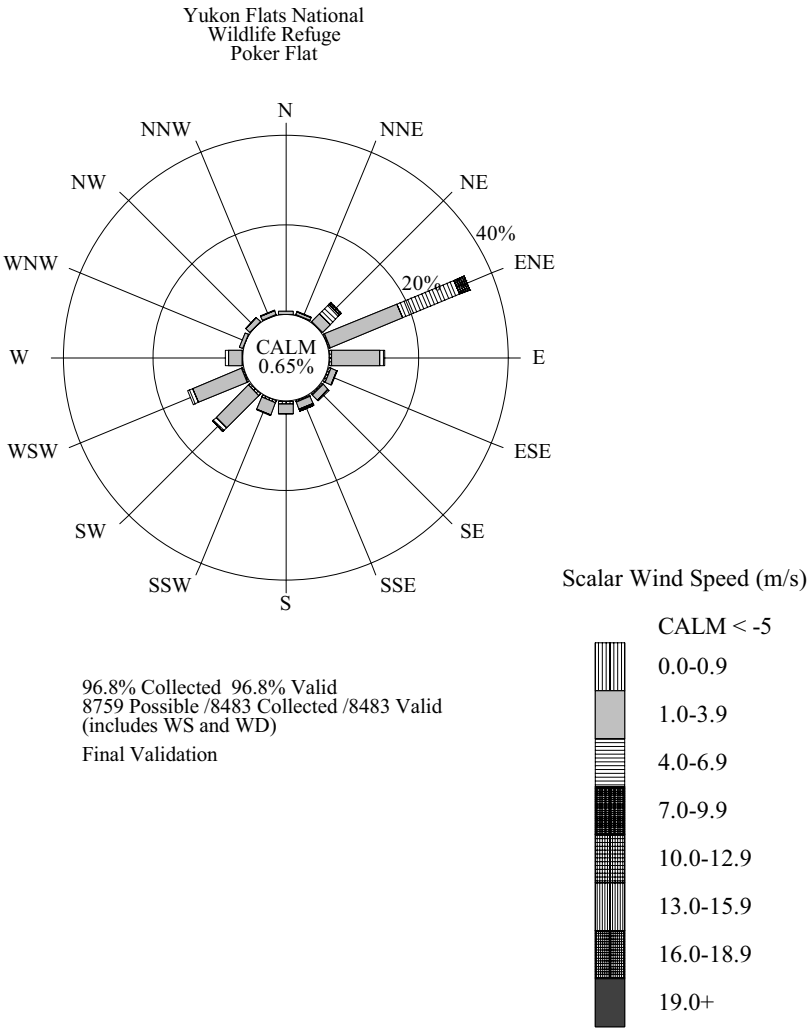
Yosemite National Park
Turtleback Dome



99.7% Collected 95.3% Valid
8760 Possible /8735 Collected /8351 Valid
(includes WS and WD)
Final Validation

Figure 3-10 (cont.)

Annual Wind Rose by Site
2003



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 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 +/- 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 +/- 10% of the transfer standard gas concentrations.

Table 4-1 presents a summary of ozone analyzer precision results and semi-annual accuracy results, by quarter, for 2003. 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 2003. Included in the table are the number of sites whose precision and accuracy checks fell within +/- 5%, +/- 10%, and outside of +/- 10%.

Table 4-1

Ozone Analyzer Precision and Accuracy Summary
2003
National Park Service Gaseous Pollutant Monitoring Program

			Precision				Accuracy		
National Park Unit	**Site Name**	**Calendar Quarter**	**Required No. of Precision Checks Met?[1]**	**Average Absolute Percent Difference[3,4]**	**Lower 95% Probability Limit[6]**	**Upper 95% Probability Limit[6]**	**Accuracy Check Performed During the Quarter?[2]**	**Average Absolute Percent Difference[3,4]**	**Maximum Percent Difference[5]**
Acadia	Cadillac Mountain	1	N	0.7	-1.0	2.5	N	—	—
		2	Y	0.1	-1.5	1.4	N	—	—
		3	N	0.2	-2.1	1.6	N	—	—
		4	—	—	—	—	—	—	—
Acadia	McFarland Hill	1	Y	3.8	1.1	6.6	N	—	—
		2	Y	0.5	-4.6	3.5	N	—	—
		3	Y	0.7	-3.4	4.8	N	—	—
		4	N	0.1	-4.8	4.6	N	—	—
Badlands	Visitor Center	1	—	—	—	—	—	—	—
		2	—	—	—	—	—	—	—
		3	Y	1.4	-6.1	3.3	N	—	—
		4	Y	0.9	-3.8	2.0	N	—	—
Big Bend	K-Bar Ranch Road	1	Y	0.5	-2.4	3.4	Y	1.3	1.9
		2	Y	0.7	-3.5	2.0	N	—	—
		3	Y	0.7	-4.1	2.6	Y	14.4	15.2
		4	Y	0.5	-4.4	3.4	N	—	—
Cape Cod	Cape Cod	1	—	—	—	—	—	—	—
		2	Y	1.9	-2.6	-1.1	N	—	—
		3	Y	3.0	-3.0	-3.0	N	—	—
		4	—	—	—	—	—	—	—
Canyonlands	Island in the Sky	1	Y	1.5	-3.1	0.2	N	—	—
		2	Y	0.1	-1.3	1.0	Y	2.5	2.9
		3	Y	0.4	-0.6	1.5	N	—	—
		4	N	0.0	-1.9	2.0	Y	0.4	1.2
Chamizal	Chamizal	1	Y	2.0	-4.8	0.9	N	—	—
		2	Y	5.4	-11.3	0.4	N	—	—
		3	N	1.2	-3.4	5.9	N	—	—
		4	Y	1.6	-8.5	5.3	N	—	—
Chiricahua	Entrance Station	1	Y	2.4	1.2	3.6	N	—	—
		2	Y	0.4	-2.5	3.3	Y	1.3	-2.7
		3	Y	0.8	-1.9	0.3	N	—	—
		4	Y	0.0	-1.5	1.4	Y	0.8	1.4
Channel Islands	Santa Rosa Island	1	Y	0.7	-1.8	0.3	N	—	—
		2	Y	0.5	-1.6	0.7	N	—	—
		3	N	0.4	-1.5	0.7	N	—	—
		4	Y	0.5	-1.6	0.6	N	—	—
Congaree Swamp	Congaree Bluff	1	Y	2.0	-8.4	12.5	N	—	—
		2	Y	2.7	-3.8	9.2	N	—	—
		3	Y	3.7	-0.4	7.8	N	—	—
		4	N	3.8	-0.7	8.4	N	—	—

Table 4-1 (cont.)

Ozone Analyzer Precision and Accuracy Summary

2003

National Park Service Gaseous Pollutant Monitoring Program

			Precision				Accuracy		
National Park Unit	**Site Name**	**Calendar Quarter**	**Required No. of Precision Checks Met?[1]**	**Average Absolute Percent Difference[3,4]**	**Lower 95% Probability Limit[6]**	**Upper 95% Probability Limit[6]**	**Accuracy Check Performed During the Quarter?[2]**	**Average Absolute Percent Difference[3,4]**	**Maximum Percent Difference[5]**
Cowpens	Cowpens	1	Y	2.0	-0.9	4.9	N	—	—
		2	Y	0.8	-3.0	4.6	N	—	—
		3	N	0.2	-4.5	4.8	N	—	—
		4	Y	4.3	-6.0	14.6	N	—	—
Craters of the Moon	Visitor Center	1	N	0.4	-7.0	6.2	Y	1.9	-3.0
		2	Y	1.8	-0.5	4.1	N	—	—
		3	Y	2.3	-1.9	6.5	Y	1.1	1.4
		4	Y	2.2	-4.2	-0.3	N	—	—
Denali	Headquarters	1	N	1.3	-7.6	5.0	Y	1.5	-4.3
		2	Y	0.1	-0.8	0.6	N	—	—
		3	Y	0.5	-1.6	0.6	Y	1.4	4.3
		4	Y	0.2	-1.0	0.6	N	—	—
Death Valley	Park Village	1	Y	0.6	-3.3	2.2	N	—	—
		2	Y	1.0	-3.6	1.5	N	—	—
		3	Y	2.1	-6.8	2.6	Y	0.6	-1.4
		4	Y	4.4	-9.6	0.8	N	—	—
Everglades	Beard Center	1	Y	0.9	-0.2	2.0	N	—	—
		2	Y	0.6	-3.0	4.3	N	—	—
		3	N	5.0	-11.8	1.9	N	—	—
		4	Y	0.5	-5.6	6.6	N	—	—
Glacier	West Glacier Horse Stables	1	Y	2.9	-5.4	-0.3	Y	2.6	-5.7
		2	Y	2.5	-6.8	1.7	N	—	—
		3	Y	4.9	-10.3	0.5	N	—	—
		4	Y	1.1	-6.5	4.4	Y	0.3	-1.2
Great Basin	Maintenance Yard	1	Y	4.1	1.6	6.6	N	—	—
		2	Y	4.9	1.9	8.0	N	—	—
		3	N	5.7	-10.2	-1.2	Y	2.2	3.0
		4	Y	4.4	-7.1	-1.7	N	—	—
Grand Canyon	The Abyss	1	Y	1.5	-3.9	0.9	N	—	—
		2	Y	0.5	-3.4	2.5	Y	1.4	-2.8
		3	Y	0.9	-0.1	1.9	Y	0.6	1.4
		4	Y	0.4	-1.8	1.1	N	—	—
Great Smoky Mountains	Cades Cove	1	Y	4.5	-11.1	2.1	N	—	—
		2	Y	0.0	-6.9	6.8	Y	1.6	2.2
		3	Y	2.5	-3.0	8.0	N	—	—
		4	Y	1.5	-4.8	1.8	Y	3.3	4.1
Great Smoky Mountains	Clingmans Dome	1	—	—	—	—	—	—	—
		2	N	0.1	-7.1	7.3	N	—	—
		3	N	1.7	-3.0	6.4	N	—	—
		4	Y	3.6	-13.8	6.5	Y	2.3	2.9
Great Smoky Mountains	Cove Mountain	1	Y	0.6	-4.5	5.6	N	—	—
		2	Y	2.4	-3.7	8.6	Y	6.5	-7.1
		3	Y	3.4	-1.0	7.8	N	—	—
		4	Y	1.3	-5.3	2.8	Y	0.2	-0.6

Table 4-1 (cont.)

Ozone Analyzer Precision and Accuracy Summary

2003

National Park Service Gaseous Pollutant Monitoring Program

			Precision				Accuracy		
National Park Unit	Site Name	Calendar Quarter	Required No. of Precision Checks Met?[1]	Average Absolute Percent Difference[3,4]	Lower 95% Probability Limit[6]	Upper 95% Probability Limit[6]	Accuracy Check Performed During the Quarter?[2]	Average Absolute Percent Difference[3,4]	Maximum Percent Difference[5]
Great Smoky Mountains	Look Rock	1	Y	0.6	-2.0	3.1	N	—	—
		2	Y	1.1	-3.4	1.2	Y	1.7	4.4
		3	Y	0.4	-4.8	4.1	N	—	—
		4	Y	0.2	-2.0	1.6	Y	0.5	-1.3
Great Smoky Mountains	Purchase Knob	1	—	—	—	—	—	—	—
		2	Y	1.6	0.4	2.8	N	—	—
		3	Y	0.6	-1.1	2.2	N	—	—
		4	Y	0.0	0.0	0.0	N	—	—
Hawaii Volcanoes	Thurston Lava Tubes	1	Y	3.2	-2.7	9.1	N	—	—
		2	Y	1.2	-6.5	8.9	N	—	—
		3	Y	0.7	-4.5	5.9	Y	1.5	2.8
		4	Y	2.2	-4.8	9.2	N	—	—
Joshua Tree	Yucca Valley	1	Y	0.1	-1.9	2.1	Y	2.3	3.5
		2	Y	0.8	-3.1	4.8	N	—	—
		3	Y	1.5	0.3	2.7	N	—	—
		4	Y	0.2	-3.8	3.4	Y	1.6	1.8
Lassen Volcanic	Monzanita Lake Maintenance Area	1	Y	1.2	-4.4	6.8	N	—	—
		2	Y	2.7	-7.0	1.5	Y	1.4	-2.9
		3	Y	5.6	-8.2	-3.1	N	—	—
		4	Y	6.6	-10.5	-2.8	Y	3.1	-7.1
Mammoth Cave	Houchin Meadow	1	Y	0.5	-1.6	2.5	Y	1.0	1.4
		2	Y	1.8	-1.2	4.9	Y	1.6	1.9
		3	Y	1.4	-1.7	4.5	N	—	—
		4	Y	1.0	-1.1	3.1	N	—	—
Mesa Verde	Maintenance Yard	1	Y	4.0	-14.7	6.7	N	—	—
		2	Y	6.0	-9.9	-2.1	Y	1.4	-4.3
		3	N	3.4	-6.6	-0.1	Y	0.8	-2.9
		4	Y	1.7	-5.3	2.0	N	—	—
Mount Rainier	Tahoma Woods	1	Y	3.8	-9.2	1.7	Y	2.1	3.0
		2	Y	4.6	-7.3	-1.8	N	—	—
		3	Y	5.3	-9.9	-0.7	N	—	—
		4	Y	2.2	-6.6	2.1	N	—	—
North Cascades	Marblemount Ranger Station	1	Y	4.4	-7.9	-0.9	Y	1.5	2.7
		2	Y	3.5	-5.5	-1.5	N	—	—
		3	N	4.6	-8.8	-0.4	Y	1.2	-2.8
		4	N	7.1	-11.1	-3.0	N	—	—
Olympic	Visitor Center	1	Y	0.6	-8.6	7.5	Y	0.8	-2.0
		2	Y	5.1	0.4	9.8	N	—	—
		3	Y	1.0	-8.0	5.9	N	—	—
		4	Y	2.7	-9.4	4.0	Y	0.9	-1.8
Petrified Forest	Horse Barn	1	Y	0.6	-2.4	1.3	Y	2.8	3.2
		2	Y	0.8	-2.5	0.9	N	—	—
		3	Y	0.6	-1.9	0.7	Y	0.2	-0.4
		4	Y	0.8	-2.4	0.7	N	—	—

Table 4-1 (cont.)

Ozone Analyzer Precision and Accuracy Summary
2003
National Park Service Gaseous Pollutant Monitoring Program

			Precision				Accuracy		
National Park Unit	**Site Name**	**Calendar Quarter**	**Required No. of Precision Checks Met?[1]**	**Average Absolute Percent Difference[3,4]**	**Lower 95% Probability Limit[6]**	**Upper 95% Probability Limit[6]**	**Accuracy Check Performed During the Quarter?[2]**	**Average Absolute Percent Difference[3,4]**	**Maximum Percent Difference[5]**
Pinnacles	East Entrance Station	1	Y	0.3	-0.9	1.5	N	—	—
		2	Y	1.6	-3.8	0.6	Y	2.4	2.9
		3	Y	0.5	-2.2	1.2	N	—	—
		4	Y	1.0	-3.8	1.8	Y	1.6	4.2
Rocky Mountain	Longs Peak Ranger Station	1	Y	0.2	-1.5	1.2	Y	1.2	1.4
		2	Y	0.1	-1.0	1.3	N	—	—
		3	Y	0.2	-1.1	1.5	Y	2.6	2.9
		4	Y	0.4	-3.4	2.6	N	—	—
Saguaro	Pima County	1	Y	0.2	-4.5	4.8	N	—	—
		2	Y	0.4	-2.9	3.6	N	—	—
		3	Y	0.3	-1.7	2.4	N	—	—
		4	N	0.6	-0.6	1.7	N	—	—
Sequoia and Kings Canyon	Ash Mountain	1	—	—	—	—	—	—	—
		2	Y	0.4	-6.4	5.5	Y	5.7	10.1
		3	Y	1.8	-2.9	6.5	N	—	—
		4	Y	0.0	-1.5	1.4	N	—	—
Sequoia and Kings Canyon	Lower Kaweah	1	Y	1.8	-6.8	10.3	N	—	—
		2	Y	2.4	-0.2	4.9	Y	5.5	8.7
		3	Y	2.5	-5.9	1.0	N	—	—
		4	Y	0.0	-6.6	6.6	N	—	—
Sequoia and Kings Canyon	Lookout Point	1	N	2.4	-10.1	5.2	N	—	—
		2	Y	1.5	-8.5	11.5	Y	2.1	3.0
		3	Y	2.6	-14.4	9.2	N	—	—
		4	N	1.0	-6.6	4.7	N	—	—
Shenendoah	Big Meadows	1	Y	0.8	-2.6	0.9	N	—	—
		2	Y	0.7	-2.2	0.9	Y	1.2	2.9
		3	Y	0.5	-1.9	1.0	N	—	—
		4	Y	1.3	-5.2	2.6	Y	2.3	2.9
Theodore Roosevelt	Visitor Center	1	Y	0.0	-2.7	2.7	N	—	—
		2	Y	1.9	-0.7	4.4	N	—	—
		3	N	0.4	-0.8	1.7	N	—	—
		4	Y	1.3	-3.3	0.8	N	—	—
Virgin Islands	Lind Point	1	Y	0.7	-3.1	1.7	Y	3.8	4.2
		2	Y	1.5	-5.7	2.6	N	—	—
		3	Y	0.3	-8.2	7.6	Y	1.5	-1.8
		4	Y	0.6	-5.2	4.0	N	—	—
Voyageurs	Sullivan Bay	1	Y	2.8	-4.1	-1.5	N	—	—
		2	Y	4.9	-6.7	-3.1	N	—	—
		3	Y	4.7	-6.7	-2.7	N	—	—
		4	Y	2.8	-4.5	-1.1	Y	1.0	-1.8
Yellowstone	Water Tank	1	Y	2.0	0.2	3.7	N	—	—
		2	Y	1.6	-0.4	3.7	Y	2.2	2.8
		3	Y	1.0	-1.6	3.7	Y	0.8	-1.4
		4	Y	1.0	-2.8	0.8	N	—	—

Table 4-1 (cont.)

Ozone Analyzer Precision and Accuracy Summary
2003
National Park Service Gaseous Pollutant Monitoring Program

			Precision				Accuracy		
National Park Unit	**Site Name**	**Calendar Quarter**	**Required No. of Precision Checks Met?[1]**	**Average Absolute Percent Difference[3,4]**	**Lower 95% Probability Limit[6]**	**Upper 95% Probability Limit[6]**	**Accuracy Check Performed During the Quarter?[2]**	**Average Absolute Percent Difference[3,4]**	**Maximum Percent Difference[5]**
Yosemite	Merced River	1	N	0.8	-1.8	3.5	N	—	—
		2	Y	0.0	-2.1	2.0	Y	1.5	1.8
		3	Y	1.8	0.6	3.1	N	—	—
		4	Y	1.9	0.7	3.2	N	—	—
Yosemite	Turtleback Dome	1	Y	0.2	-1.8	1.3	N	—	—
		2	Y	0.6	-2.0	0.8	Y	2.1	2.5
		3	Y	0.4	-2.0	1.2	N	—	—
		4	Y	0.4	-2.1	1.2	N	—	—

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%

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.[3] According to NPS Standard Operating Procedures, the pollutant analyzer must respond within 10% of the transfer

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.[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.

3. Percent Difference = ((analyzer - transfer std)/transfer std)x100

4. 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.

5. Maximum Percent Difference is the highest percent difference from the points of a multipoint (or accuracy) calibration. A positive value indicates the anlyzer read high, a negative value indicates the anlyzer read low.

6. 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
2003
National Park Service Gaseous Pollutant Monitoring Program

		Precision[1] Average Absolute Percent Difference			Accuracy[2] Average Absolute Percent Difference		
Calendar Quarter	# Operational Sites	# Sites within +/- 5%	# Sites within +/- 5.1 - 10%	# Sites > +/- 10%	# Sites within +/- 5%	# Sites within +/- 5.1 - 10%	# Sites > +/- 10%
1	40	40	0	0	12	0	0
2	49	46	3	0	14	3	0
3	50	46	4	0	12	0	1
4	43	41	2	0	13	0	0

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

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.