



Annual Data Summary 2010

Gaseous Pollutant Monitoring Program

Natural Resource Data Series NPS/NRSS/ARD/NRDS—2011/192



ON THE COVER

Dinosaur National Monument (Split Mountain and the Green River), Colorado.
Photograph courtesy of the National Park Service.

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John D. Ray, Ph.D.
National Park Service Air Resources Division
Gaseous Pollutant Monitoring Program
PO BOX 25287
Denver, CO, 80225

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The National Park Service, Natural Resource Stewardship and Science Denver office publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

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Introduction

This report focuses on the gaseous air pollutant concentrations measured in national parks during 2010 as part of the National Park Service, Air Resources Division (NPS ARD) monitoring program. It is mostly a statistical summary and feedback for park staff. The primary air pollutants reported, including ozone (O₃), sulfur dioxide (SO₂), and inhalable particulate matter (PM_{2.5}), are known to cause human health problems and to injure natural resources. The U.S. Environmental Protection Agency (EPA) sets standards to which we can compare the monitored data. More information on air quality conditions and trends in the parks can be found in the Division's annual performance reports (<http://www.nature.nps.gov/air/index.cfm>).

In recent years ozone pollution at surface monitoring sites in the national parks has been decreasing. In 2010, only 7 parks with monitors within the park had ozone concentrations that exceeded the National Ambient Air Quality Standard (NAAQS), which is currently at 75 ppb for an 8-hour average. Parks with high ozone are listed below with NAAQS relevant statistics.

Most of these parks are in California and have air pollutants transported into them from more populated areas to the west. A fourth park unit, Mojave National Preserve, has been found to have high ozone based on portable ozone monitors, with the 4th highest 8-hour concentration of 77 ppb and 4 exceedance days. The Mojave station had higher ozone concentrations than

the nearby Death Valley station, which had a 4th highest 8-hour average ozone concentration of 69 ppb.

Other gaseous pollutants are measured in fewer parks. PM_{2.5} is now being measured with continuous monitors in 15 park or park-supported units. Unhealthy conditions, as defined by the NAAQS for PM_{2.5}, occur in 2 park units: Hawaii Volcanoes and Indiana Dunes. SO₂ is measured by the National Park Service in Hawaii Volcanoes, Great Smoky Mountains, and Mammoth Cave, but only Hawaii Volcanoes has extreme SO₂ concentrations that far exceed the current NAAQS of 75 ppb as a daily 1-hour maximum.

Both current and past data from NPS monitoring sites is available on the Web:

- Current air quality (<http://www.nature.nps.gov/air/data/current/index.cfm>).
- Interactive data and report products access to validated archive database (<http://ard-request.air-resource.com/data.aspx>).
- AirNow has current air quality conditions and forecasts for national parks and urban locations (http://airnow.gov/index.cfm?action=airnow.national_summary).
- Maps of air quality concentrations and monitoring locations can be obtained from the interactive Web site "Air Atlas" (<http://www.nature.nps.gov/air/Maps/AirAtlas/index.cfm>).

Park	2010 4 th high 8-hr	Exceedances	3-yr avg 4 th high 8-hr
Joshua Tree	97 ppb	53 days	98 ppb
Sequoia and Kings Canyon	94 ppb	66 days	101 ppb
Great Smoky Mountains	81 ppb	11 days	77 ppb
Cape Cod	78 ppb	4 days	75 ppb
Rocky Mountain	77 ppb	6 days	73 ppb
Yosemite	77 ppb	7 days	83 ppb
Acadia	76 ppb	4 days	74 ppb

Monitoring Results

The NPS ARD issues this annual data summary for their Gaseous Pollutant Monitoring Program (GPMP). These summaries present only O₃, SO₂, PM, and meteorological data from continuous monitors that report hourly data. Other gas, particulate, and precipitation monitoring is performed under the visibility and deposition programs and is reported separately.

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

GPMP Network Monitoring

The locations of monitoring sites that operated during 2010 are presented on the map in Figure 1. The parameters monitored at each park unit are indicated with colored flags. The CASTNet flag identifies sites where the NPS operates Clean Air Status and Trends Network monitoring systems in cooperation with EPA to estimate dry atmospheric deposition. The enhanced gaseous and/or particulates flag indicates that the NPS sponsors additional or high-resolution gaseous or particulate monitoring at that park unit. 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 1.

In addition to monitoring for regulatory compliance, the NPS added portable ozone monitoring systems (POMS) to the GPMP in 2003. The POMS monitors have recently been designated by the EPA as a federal equivalency method (FEM) to measure certifiable ozone data. Although the POMS are not currently operated according to this protocol, the data are equivalent to the certified monitors and can be used for survey monitoring to obtain air quality baseline information. POMS site names in tables and figures have been underlined to distinguish them from monitoring sites meeting all EPA guidelines.

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 O₃, SO₂, PM, and meteorological data submitted by states to the EPA AQS are retrieved for inclusion in this report.

Annual Ozone Summaries

In 2008 the primary National Ambient Air Quality Standard (NAAQS) for ozone changed from 0.08 ppm (85 ppb equivalent) over an 8-hour period to 0.075 ppm (75 ppb equivalent) over an 8-hour period (http://www.epa.gov/ttn/naaqs/standards/ozone/s_o3_index.html). The ozone standard is again under review and a new standard between 0.060 and 0.070 ppm is expected to be set by 2011. According to the current standard, an exceedance of the standard occurs when an 8-hour average ozone concentration is greater than or equal to 76 ppb. An exceedance of the standard is not the same as a violation. A violation occurs when the 3-year average of the fourth highest daily maximum 8-hour average ozone concentration equals or exceeds 76 ppb. The secondary ozone standard defined by the EPA, which is intended to protect the environment, is the same as the primary standard. In this report, ozone concentrations are compared to the NAAQS that was in place during the period reported.

Table 2 summarizes O₃ measurements with respect to the daily maximum 8-hour average concentrations at each NPS monitoring site. The five highest daily maximum 8-hour average ozone concentrations are listed, as well as the total number of days with exceedances of the 8-hour standard. At each site with an EPA-certified monitor, the fourth highest value column and the number of days column are both color-coded to identify sites where the fourth highest daily maximum 8-hour average ozone value exceeded the standard during 2010. Note that other sites may have experienced fewer than four exceedances of the standard, and are not color coded. Ozone summary statistics for POMS are highlighted bold where exceedances occurred. These sites should be compared to EPA standards for reference purposes only.

The map in Figure 2 presents the annual fourth highest 8-hour average ozone concentrations for all network sites listed in Table 2. Ozone values for EPA-certified sites are color-coded to represent values below (green) and above (orange and red) the national standard. Values from portable sites (no color) are included for reference only.

The map in Figure 3 presents the annual number of days which exceeded the 8-hour standard for all network sites listed in Table 2. 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.

The map in Figure 4 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 four distinct levels. Ozone values from portable sites (no color) are included for reference only.

Ozone Violation Summaries

Table 3 presents ozone violation summaries for NPS-operated and cooperating sites for all 3-year periods over the last 10 years. Violations of the (old) 85 ppb standard are indicated in orange and red. Values that violate the new standard of 75 ppb are outlined with a black box.

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 76 ppb. Table values in parentheses indicate that EPA data completeness requirements for the 3-year period were not met. However, annual fourth highest daily maximum 8-hour ozone concentrations greater than or equal to 76 ppb for calendar years not meeting EPA data completeness requirements are included in the NAAQS violation computation.

Resource Injury Indices

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

- W126 – A cumulative index that is calculated as the maximum 3-month sum of the 0800-2000 hourly average 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 0.04 ppm (40 ppb), and no weight to concentrations below 0.04 ppm (40 ppb). Units of this index are ppm-hr.
- SUM06 – A cumulative index that is calculated as the maximum 3-month sum of the 0800-2000 hourly average ozone concentrations during the ozone season that are equal to or greater than 0.06 ppm (60 ppb). The units of this index are ppm-hr. Several thresholds have been developed for SUM06¹.

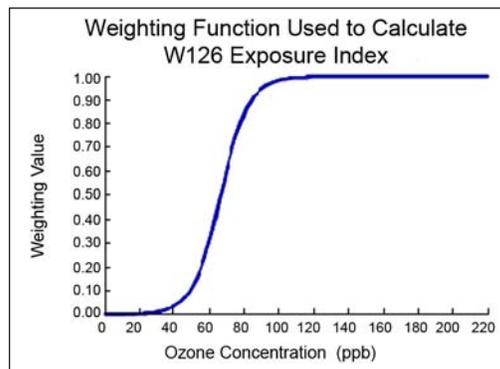
The W126 is expressed as a 3-month sum of all hourly ozone concentrations where each concentration is weighted by a sigmoidal function that gives greater emphasis to the higher hourly concentrations while still including the lower ones. In the latest use of W126, only the daytime hours of 8 am to 8 pm (12 hours) are used in the expression. This weighting function provides a weighting value that is unique for each hourly ozone concentration. The weighting function, as described by Lefohn, Laurence, and Kohut² is:

$$w_i = \frac{1}{1 + 4403 \exp^{- (126c_i)}}$$

where

w_i = weighting value for hourly concentration c_i , and c_i = hourly concentration i in ppb.

W126 and SUM06 thresholds for ozone effects to vegetation		
Growth Reduction	W126	SUM06
Tree seedlings - natural forest stands	7-13 ppm-hrs	10-15 ppm-hrs
Tree seedlings/saplings - plantations	9-14 ppm-hrs	12-16 ppm-hrs
Visible Foliar Injury		
Plants in natural ecosystems	5-9 ppm-hrs	8-12 ppm-hrs



The graph of weighting value versus ozone concentration, in the figure above, illustrates the greater weights given to higher hourly ozone concentrations. Each hour's weighting value is multiplied by its corresponding hourly concentration. This product is summed over all the valid daytime hours in each month to calculate the monthly W126 exposure. Thus, the monthly W126 exposure is:

$$W126 = \sum_{i=1}^n w_i * c_i$$

where

W126 = monthly W126 exposure index,

w_i = weighting value for hourly concentration i ,

c_i = hourly concentration i in ppb, and

n = number of hours in the month with valid ozone concentrations.

EPA is considering the maximum daytime consecutive 3-month value of the W126 for the secondary standard. The exposure units are ppb-hr.

Because each hour contributes to this exposure index, the number of hours with valid observations (n) is an important factor in calculating the W126. The EPA usually considers air quality statistics to be "valid" (i.e., representative of the parameter being estimated for the time interval in question) only if 75% or more of the total possible observations have been measured during that time interval. Therefore, one should exercise caution when comparing these statistics between months and sites, particularly those that are not averages (e.g., maxima and exposures) whenever the number of valid observations is less than 75% of the total possible. EPA is developing fill-in rules for missing hourly data that may be issued when the revision to the ozone standard is announced in 2011³.

Table 4 presents the ozone exposure indices summary statistics for 2010. Summaries for POMS are included for comparison only. Since portable sites are deployed for seasonal use, there may be significant biases in W126 and SUM06 exposure indices calculated from their data.

Figure 5 presents the 3-month maximum W126 exposure index for all network sites listed in Table 4. Figure 6 presents the annual 3-month maximum SUM06 exposure index for the same sites. Index values are color-coded to represent three distinct levels of cumulative exposure. Data from portable sites (no color) are included for reference only.

¹Heck, W.W. and E.B. Cowling, 1997. The Need for a Long-term Cumulative Secondary Ozone Standard - An Ecological Perspective. *Environmental Management*. January: 23-33.

²Lefohn, A.S.; Lawrence, J.A.; Kohut, R.J. (1988). A comparison of indices that describe the relationship between exposure to ozone and reduction in the yield of agricultural crops. *Atmospheric Environment*. 22:1229-1240.

³U.S. EPA, 2010, Proposed Rule, National Ambient Air Quality Standards for Ozone, *Federal Register/Vol. 75, No. 11/Tuesday, January 19, 2010*.

Sulfur Dioxide Summaries

During 2010, the primary NAAQS for sulfur dioxide was a 24-hour mean of 0.14 ppm not to be exceeded more than once per year, and a daily maximum 1-hour average of 75 ppb. The secondary NAAQS was a 3-hour mean of 0.50 ppm, not to be exceeded more than once per year. The EPA revised the SO₂ standard in June 2010 to add the primary 1-hour average standard. Table 5 summarizes sulfur dioxide measurements for comparison to the standards that were in place during 2010 and lists the number of exceedances for each.

Kilauea Volcano is the source of sulfur dioxide in Hawaii Volcanoes National Park. Sulfur dioxide data are collected in the park using a lower range and an upper range. The lower range does not capture values higher than 1 ppm (1,000 ppb), but is considered to be an EPA equivalency method. The upper range captures values above 1 ppm accurately, but is not an EPA equivalent range. The Hawaii Volcanoes

National Park data presented in this report were collected using the upper range to give a more accurate representation of sulfur dioxide values.

PM_{2.5} Data Summaries

The primary NAAQS for PM_{2.5} are an annual arithmetic mean of 15 µg/m³ and a daily arithmetic mean of 35 µg/m³. An exceedance of the standard occurs when either an annual arithmetic mean is greater than 15.0 µg/m³ or a daily arithmetic mean is greater than 35 µg/m³. An exceedance of the standard is not the same as a violation. A violation occurs when either the 3-year average of the annual mean is greater than 15.0 µg/m³ or the 3-year average of the 98th percentile daily mean concentrations is greater than 35 µg/m³.

Table 6 summarizes PM_{2.5} measurements with respect to both the daily 24-hour average maximum concentrations and the annual arithmetic mean. The four highest and 98th percentile 24-hour average concentrations are listed, as well as the total number of days with 24-hour average PM_{2.5} concentrations greater than 35 µg/m³. No violation summaries for PM_{2.5} data are presented.

PM₁₀ Data Summaries

The primary NAAQS for PM₁₀ is a daily arithmetic mean of 150 µg/m³. An exceedance of the standard occurs when a daily arithmetic mean is greater than 150 µg/m³. An exceedance of the standard is not the same as a violation. A violation occurs when a 24-hour average

concentration greater than 150 µg/m³ occurs more than once per year on average over three years.

Table 7 summarizes PM₁₀ measurements with respect to both the daily 24-hour average maximum concentrations and the annual arithmetic mean. The four highest 24-hour average concentrations are listed, as well as the total number of days with exceedances of the NAAQS 24-hour standard. The number of days column is color-coded to identify sites where an exceedance of the 24-hour standard occurred.

Table 8 presents the same summaries for sites that collected PM₁₀ using non-equivalency methods.

Table 9 presents a PM₁₀ violation summary based on the 24-hour average standard for one-year periods over the last three years, with violations indicated in red. Table values in parentheses indicate that the EPA data completeness requirement was not met. However, calendar quarters not meeting EPA data completeness requirements were included in the NAAQS violation computation if the resulting 24-hour average exceeds the standard.

Meteorological Data Summaries

Table 10 presents a summary of selected meteorological data for all sites. The parameters included are wind speed, ambient temperature, relative humidity, and precipitation.



View of the Halema'uma'u vent within the Kilauea caldera. (USGS photo)

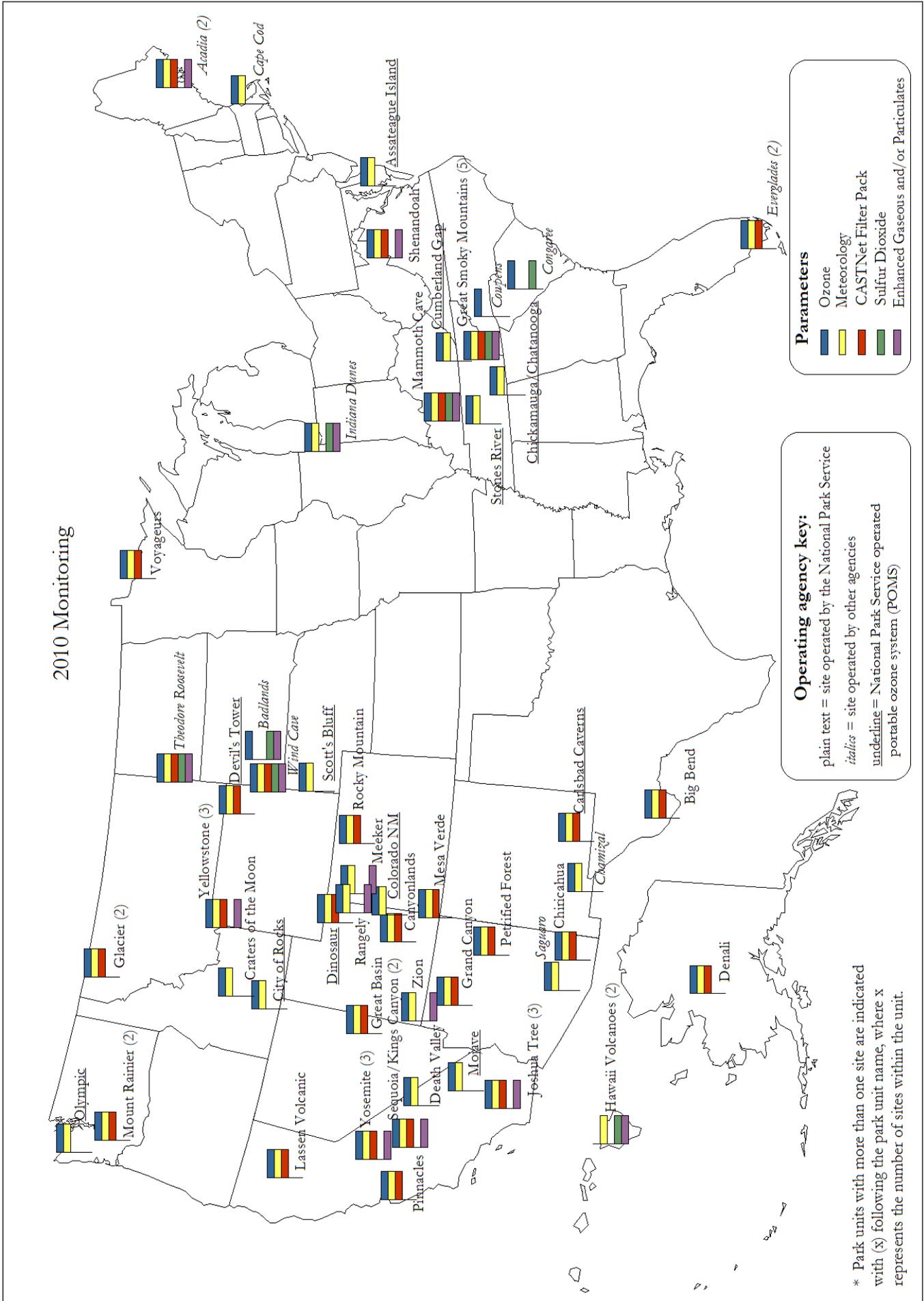


Figure 1. 2010 Air quality monitoring in or nearby park units.

Table 1. 2010 Site specifications.

National Park Unit	Site Name	State	NPS Abbr.	CASTNet Abbr.	AQS ID Number	Latitude (degrees north)	Longitude (degrees west)	Elev. (m)	O ₃ Years ^a	SO ₂	PM	WD	WS	TMP	RH	RNF	WET	DTP	SOL	Filter Pack ^b
Sites operated by the National Park Service (Gaseous Pollutant Monitoring Program)																				
<u>Assateague Island</u>	Maintenance Area	MD	ASIS-MA	---	24-047-1001	38.2511	75.1594	3	6	---	---	X	X	X	X	X	X	---	---	X
<u>Big Bend</u>	K-Bar Ranch Road	TX	BIBE-KB	BBE401	48-043-0101	29.3022	103.1772	1052	21	---	---	X	X	X	X	X	X	X	X	X
<u>Canyonlands</u>	Island in the Sky	UT	CANY-HS	CAN407	49-037-0101	38.4586	109.8211	1809	19	---	---	X	X	X	X	X	X	X	X	X
<u>Carrisbad Caverns</u>	Maintenance Area	NM	CAVE-MA	---	35-015-3001	32.1783	104.4406	1349	5	---	---	X	X	X	X	X	X	---	---	X
<u>Chickamauga/Chatanooga</u>	Lookout Mountain	TN	CHCH-LM	---	---	34.9183	85.27	237	1	---	---	X	X	X	X	X	X	---	---	---
<u>Chiricahua</u>	Entrance Station	AZ	CHIR-ES	CHA467	04-003-8001	32.0092	109.3892	1570	20	---	---	X	X	X	X	X	X	X	X	X
<u>City of Rocks</u>	Juniper Campground	ID	CIRO-JC	---	16-031-001	42.0289	113.7292	1914	1	---	---	X	X	X	X	X	X	---	---	X
<u>Colorado</u>	Maintenance Yard	CO	COLM-MY	---	08-077-1001	39.1067	108.7411	1740	5	---	---	X	X	X	X	X	X	---	---	X
<u>Craters of the Moon</u>	Visitor Center	ID	CRMO-VC	---	16-023-0101	43.4606	113.5622	1815	19	---	---	X	X	X	X	X	X	---	---	X
<u>Cumberland Gap</u>	Hensley Settlement	TN	CUGA-HS	---	21-013-1002	36.6719	83.5264	1013	5	---	---	X	X	X	X	X	X	---	---	X
<u>Death Valley</u>	Park Village	CA	DEVA-PV	---	06-027-0101	36.5092	116.8481	125	18	---	---	X	X	X	X	X	X	---	---	X
<u>Denali</u>	Headquarters	AK	DENA-HQ	DEN417	02-068-0003	63.7258	148.9633	661	24	---	---	X	X	X	X	X	X	X	X	X
<u>Devils Tower</u>	Joyner Ridge Trail	WY	DETO-JR	---	56-011-1013	44.5969	104.7047	1200	3	---	---	X	X	X	X	X	X	---	---	X
<u>Dinosaur</u>	West Entrance Housing	UT	DINO-WE	---	49-047-1002	40.2917	108.9417	2072	6	---	---	X	X	X	X	X	X	---	---	X
<u>Everglades</u>	Beard Center	FL	EVER-BC	EVE419	12-086-0030	25.3911	80.6806	2	---	---	---	X	X	X	X	X	X	---	---	X
<u>Glacier</u>	Saint Mary's Ranger District	MT	GLAC-SM	---	30-035-1001	48.7408	113.4333	1388	2	---	---	X	X	X	X	X	X	---	---	X
<u>Glacier</u>	West Glacier Horse Stables	MT	GLAC-WG	GLR468	30-029-8001	48.5103	113.9956	976	19	---	---	X	X	X	X	X	X	X	X	X
<u>Grand Canyon</u>	The Abyss	AZ	GRCA-AS	GRC474	04-005-8001	36.0597	112.1822	2073	18	---	---	X	X	X	X	X	X	X	X	X
<u>Great Basin</u>	Maintenance Yard	NV	GRBA-MY	GRB411	32-033-0101	39.0053	114.2158	2060	18	---	---	X	X	X	X	X	X	X	X	X
<u>Great Smoky Mountains</u>	Clingmans Dome	TN	GRSM-CD	---	47-155-0102	35.5619	83.4981	2021	18	---	---	X	X	X	X	X	X	---	---	X
<u>Great Smoky Mountains</u>	Cove Mountain	TN	GRSM-CM	---	47-155-0101	35.6967	83.6086	1243	23	X	---	X	X	X	X	X	X	---	---	---
<u>Great Smoky Mountains</u>	Look Rock	TN	GRSM-LR	GRS420	47-009-0101	35.6331	83.9422	793	23	X	X	X	X	X	X	X	X	---	---	X
<u>Hawaii Volcanoes</u>	Observatory/Jaggar Museum	HI	HAVO-OB	---	15-001-0007	19.4203	155.2881	1123	---	X	X	X	X	X	X	X	X	---	---	---
<u>Hawaii Volcanoes</u>	Visitor Center	HI	HAVO-VC	---	15-001-0005	19.4308	155.2578	1215	---	X	X	X	X	X	X	X	X	---	---	X
<u>Joshua Tree</u>	Black Rock	CA	JOTR-BR	JOT403	06-071-9002	34.0714	116.3906	1244	18	---	---	X	X	X	X	X	X	X	X	X
<u>Joshua Tree</u>	Cottonwood Canyon	CA	JOTR-CC	---	06-065-0008	33.7411	115.8206	984	6	---	X	X	X	X	X	X	X	---	---	X
<u>Joshua Tree</u>	Pinto Wells	CA	JOTR-PW	---	06-065-1004	33.9397	115.4108	326	5	---	---	X	X	X	X	X	X	---	---	X
<u>Lassen Volcanic</u>	Manzanita Lake Fire Station	CA	LAVO-ML	LAV410	06-089-3003	40.5403	121.5764	1756	23	---	---	X	X	X	X	X	X	X	X	X
<u>Mammoth Cave</u>	Houchin Meadow	KY	MACA-HM	MAC426	21-061-0501	37.1319	86.1478	243	15	X	---	X	X	X	X	X	X	X	X	X
<u>Mesa Verde</u>	Resource Management Area	CO	MEVE-RM	MEV405	08-083-0101	37.1983	108.4903	2165	18	---	---	X	X	X	X	X	X	X	X	X
<u>Mojave</u>	Kelso Mountains	CA	MOJA-KM	---	06-071-1001	35.1019	115.7767	1212	5	---	---	X	X	X	X	X	X	---	---	X

Table 1. 2010 Site specifications (continued).

National Park Unit	Site Name	State	NPS Abbr.	CASTNet Abbr.	AQS ID Number	Latitude (degrees north)	Longitude (degrees west)	Elev. (m)	O ₃ Years ^a	SO ₂	PM	WD	WS	TMP	RH	RNF	WET	DTP	SOL	Filter Pack ^b
Sites operated by the National Park Service (Gaseous Pollutant Monitoring Program)																				
Mount Rainier	Tahoma Woods	WA	MORA-TW	MOR409	53-053-1010	46.7583	122.1244	415	20	---	---	X	X	X	X	X	X	X	X	X
Olympic	Deer Park	WA	OLYM-DP	---	53-009-0016	47.9492	123.2653	1607	2	---	---	X	X	X	X	X	---	---	X	---
Petrified Forest	South Entrance	AZ	PEFO-SE	PET427	04-017-0119	34.8225	109.8919	1723	9	---	---	X	X	X	X	X	X	X	X	X
Pinnacles	SW of East Entrance Station	CA	PINN-ES	PIN414	06-069-0003	36.485	121.1556	335	24	---	---	X	X	X	X	X	X	X	X	X
Rocky Mountain	Long's Peak	CO	ROMO-LP	ROM406	08-069-0007	40.2778	105.5453	2743	26	---	---	X	X	X	X	X	X	X	X	X
Scotts Bluff	Visitor Center	NE	SCBL-VC	---	31-157-0005	41.8294	103.708	1255	1	---	---	X	X	X	X	X	---	---	X	---
Sequoia and Kings Canyon	Ash Mountain	CA	SEKI-AS	SEK430	06-107-0009	36.4894	118.8292	457	12	---	X	X	X	X	X	X	X	X	X	X
Sequoia and Kings Canyon	Lower Kaweah	CA	SEKI-HK	---	06-107-0006	36.5658	118.7772	1890	27	---	---	X	X	X	X	X	---	---	X	---
Shenandoah	Big Meadows	VA	SHEN-BM	SHN418	51-113-0003	38.5231	78.4347	1073	28	---	X	X	X	X	X	X	X	X	X	X
Stones River	Beasley Field	TN	STRI-BF	---	---	35.8814	86.4353	176	1	---	---	X	X	X	X	X	---	---	X	---
Voyagers	Sullivan Bay	MN	VOYA-SB	VOY413	27-137-0034	48.4128	92.8292	429	15	---	---	X	X	X	X	X	X	X	X	X
Yellowstone	Old Faithful	WY	YELL-OF	---	56-039-1012	44.4569	110.8314	2246	---	---	X	X	X	X	X	---	---	---	---	---
Yellowstone	Water Tank	WY	YELL-WT	YEL408	56-039-1011	44.5597	110.4006	2400	15	---	---	X	X	X	X	X	X	X	X	X
Yosemite	School Yard	CA	YOSE-SY	---	06-043-1004	37.7478	119.5917	1234	5	---	---	X	X	X	X	X	---	---	X	---
Yosemite	Turtleback Dome	CA	YOSE-TD	YOS404	06-043-0003	37.7133	119.7061	1605	18	---	---	X	X	X	X	X	X	X	X	X
Zion	Dalton's Wash	UT	ZION-DW	---	49-053-0130	37.1983	113.1506	1213	7	---	X	X	X	X	X	X	---	---	X	---
# active park units: 38 # active park sites: 47																				
Sites operated by the Bureau of Land Management																				
Meekeer	Plant Science Center	CO	MEEK-PS	---	08-103-0005	40.0039	107.8475	1994	1	---	X	X	X	X	X	X	X	X	X	X
Rangely	Golf Course	CO	RANG-GC	---	08-103-0006	40.0869	108.7614	1655	1	---	X	X	X	---	X	X	---	---	X	---
# active units: 2 # active sites: 2																				
Sites operated by cooperating state agencies																				
Acadia	Cadillac Mountain	ME	ACAD-CM	---	23-009-0102	44.3472	68.2278	466	16	---	---	X	X	X	X	---	---	---	---	---
Acadia	McFarland Hill	ME	ACAD-MH	ACA416	23-009-0103	44.3769	68.2608	158	13	---	X	X	X	X	X	X	X	X	X	X
Badlands	Visitor Center	SD	BADL-VC	---	46-071-0001	43.7436	101.9414	739	13	---	X	---	---	---	---	---	---	---	---	---
Cape Cod	Cape Cod	MA	CACO-XX	---	25-001-0002	41.9758	70.0247	41	24	---	---	X	X	X	X	---	---	---	X	---
Chamizal	Chamizal	TX	CHAM-XX	---	48-141-0044	31.7656	106.455	1128	19	---	---	X	X	X	X	---	---	---	X	---
Congaree	Congaree Bluff	SC	COSW-BL	---	45-079-0021	33.8147	80.7811	34	11	X	---	---	---	---	---	---	---	---	---	---
Cowpens	State Monitor	SC	COWP-SM	---	45-021-0002	35.1303	87.8164	297	23	---	---	---	---	---	---	---	---	---	---	---
Everglades	Cutler Road	FL	EVER-CR	---	12-086-0029	25.5861	80.3269	4	26	---	---	---	---	---	---	---	---	---	---	---

Table 1. 2010 Site specifications (continued).

National Park Unit	Site Name	State	NPS Abbr.	CASTNet Abbr.	AQS ID Number	Latitude (degrees north)	Longitude (degrees west)	Elev. (m)	O ₃ Years ^a	SO ₂	PM	WD	WS	TMP	RH	RNF	WET	DTP	SOL	Filter Pack ^b
Sites operated by cooperating state agencies																				
<i>Great Smoky Mountains</i>	Cades Cove	TN	GRSM-CC	---	47-009-0102	35.6042	83.7831	564	18	---	---	X	X	X	X	X	---	---	---	X
<i>Great Smoky Mountains</i>	Purchase Knob	NC	GRSM-PK	---	37-087-0036	35.59	83.0775	1500	14	---	---	---	---	---	---	---	---	---	---	---
<i>Indiana Dunes</i>	Ammunition Bunker	IN	INDU-AB	---	18-089-0022	41.5733	87.3047	183	18	---	X	X	X	X	X	---	---	---	---	X
<i>Mount Rainier</i>	Jackson Visitor's Center	WA	MORA-IV	---	53-053-0012	46.7853	121.7378	1615	13	---	---	---	---	---	---	---	---	---	---	---
<i>Saguaro</i>	Pima County	AZ	SAGU-PC	---	04-019-0021	32.1744	110.7364	938	19	---	---	---	---	---	---	---	---	---	---	---
<i>Theodore Roosevelt</i>	Painted Canyon Visitor Cntr	ND	THRO-VC	THR422	38-007-0002	46.8947	103.3778	850	13	X	X	X	X	X	X	X	X	X	X	X
<i>Wind Cave</i>	Visitor Center	SD	WICA-VC	WNC429	46-033-0132	43.5578	103.4839	1292	7	---	X	X	X	X	X	X	X	X	X	X
<i>Yellowstone</i>	West Yellowstone	MT	YELL-WS	---	30-031-0017	44.6569	111.0894	2030	---	---	X	X	X	X	---	---	---	---	---	---
<i>Yosemite</i>	Village	CA	YOSE-VI	---	06-043-1001	37.7458	119.6028	1216	---	---	X	---	---	---	---	---	---	---	---	---
# active park units: 15 # active park sites: 17																				

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

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

Operating agency key: plain text = site operated by the National Park Service

italics = site operated by a state agency

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

Parameter key: O₃ = ozone analyzer (ppb)

SO₂ = sulfur dioxide analyzer (ppb)

PM = particulate matter (µg/m³)

WD = wind direction (degrees)

WS = wind speed (m/s)

TMP = ambient temperature (degrees C)

RH = relative humidity (%)

RNF = precipitation (mm/hr)

WET = wetness (% on)

DTP = delta temperature (degrees C)

SOL = solar radiation (watts/m²)

Note: Dashed lines indicate parameter not measured at that site.

2010 GPMP Data Summary

Table 2. 2010 Summary of 8-hour average ozone concentrations (ppb).

National Park Unit	Site Name	Valid Number of Days	1 st Highest	2 nd Highest	3 rd Highest	4 th Highest ^a	5 th Highest	# Days with 8-Hour Average O ₃ Values ≥76 ppb ^a
Sites operated by the National Park Service (Gaseous Pollutant Monitoring Program)								
Big Bend	K-Bar Ranch Road	349	69	67	65	64	64	0
Canyonlands	Island in the Sky	344	76	71	68	68	68	1
Chiricahua	Entrance Station	358	74	72	72	71	67	0
Craters of the Moon	Visitor Center	311	63	63	63	62	62	0
Death Valley	Park Village	324	76	75	70	69	69	1
Denali	Headquarters	361	53	53	53	52	52	0
Glacier	West Glacier Horse Stables	355	58	58	57	55	54	0
Grand Canyon	The Abyss	358	73	72	70	69	68	0
Great Basin	Maintenance Yard	338	77	69	69	69	68	1
Great Smoky Mountains	Clingmans Dome	176	84	80	78	77	76	7
Great Smoky Mountains	Cove Mountain	361	81	81	80	79	78	11
Great Smoky Mountains	Look Rock	354	84	83	83	81	80	11
Joshua Tree	Black Rock	363	105	101	99	97	94	53
Joshua Tree	Cottonwood Canyon	319	80	78	78	78	77	8
Lassen Volcanic	Manzanita Lake Fire Station	358	72	70	65	65	64	0
Mammoth Cave	Houchin Meadow	354	78	77	75	75	75	2
Mesa Verde	Resource Management Area	352	77	68	68	66	66	1
Mount Rainier	Tahoma Woods	349	69	59	55	54	52	0
Petrified Forest	South Entrance	360	74	73	68	68	68	0
Pinnacles	SW of East Entrance Station	338	77	74	72	71	71	1
Rocky Mountain	Long's Peak	349	82	79	78	77	77	6
Sequoia and Kings Canyon	Ash Mountain	359	99	98	97	94	94	66
Sequoia and Kings Canyon	Lower Kaweah	358	79	78	78	77	77	9
Shenandoah	Big Meadows	298	82	77	76	74	72	3
Voyageurs	Sullivan Bay	344	71	69	67	67	66	0
Yellowstone	Water Tank	355	67	67	67	66	65	0
Yosemite	Turtleback Dome	354	85	81	79	77	76	7
Zion	Dalton's Wash	354	73	73	72	72	72	0
Sites operated by the Bureau of Land Management								
Meeker	Plant Science Center	343	73	72	67	66	64	0
Rangely	Golf Course	142	67	64	59	58	58	0
Sites operated by cooperating state agencies								
Acadia	Cadillac Mountain	207	89	81	79	76	74	4
Acadia	McFarland Hill	346	87	77	72	70	69	2
Badlands	Visitor Center	364	62	61	60	58	56	0
Cape Cod	Cape Cod	216	86	80	79	78	73	4
Chamizal	Chamizal	354	76	72	72	72	71	1
Congaree	Congaree Bluff	341	73	69	66	65	64	0
Cowpens	State Monitor	338	78	75	75	72	70	1
Everglades	Cutler Road	354	75	69	67	65	65	0
Great Smoky Mountains	Cades Cove	241	78	75	74	74	73	1
Great Smoky Mountains	Purchase Knob	209	74	74	72	72	72	0
Indiana Dunes	Ammunition Bunker	146	80	67	65	64	64	1
Mount Rainier	Jackson Visitor's Center	346	61	55	54	53	53	0

Table 2. 2010 Summary of 8-hour average ozone concentrations (ppb) (continued).

National Park Unit	Site Name	Valid Number of Days	1 st Highest	2 nd Highest	3 rd Highest	4 th Highest ^a	5 th Highest	# Days with 8-Hour Average O ₃ Values ≥76 ppb ^a
Sites operated by cooperating state agencies								
<i>Saguaro</i>	Pima County	362	75	73	70	68	68	0
<i>Theodore Roosevelt</i>	Painted Canyon Visitor Cntr	350	67	62	61	61	59	0
<i>Wind Cave</i>	Visitor Center	329	63	61	60	59	58	0
Portable ozone monitoring systems (POMS)^b								
<u>Assateague Island</u>	Maintenance Area	169	100	84	76	75	69	3
<u>Carlsbad Caverns</u>	Maintenance Area	146	69	68	67	63	62	0
<u>Chickamauga/Chatanooga</u>	Lookout Mountain	111	83	83	81	80	78	8
<u>City of Rocks</u>	Juniper Campground	166	65	64	64	61	61	0
<u>Colorado</u>	Maintenance Yard	257	66	66	66	65	64	0
<u>Cumberland Gap</u>	Hensley Settlement	155	74	74	73	72	70	0
<u>Devil's Tower</u>	Joyner Ridge Trail	152	71	60	59	58	58	0
<u>Dinosaur</u>	West Entrance Housing	245	71	70	68	68	66	0
<u>Glacier</u>	Saint Mary's Ranger District	153	62	60	59	59	58	0
<u>Joshua Tree</u>	Pinto Wells	221	81	80	77	76	76	6
<u>Mojave</u>	Kelso Mountains	168	80	80	78	77	75	4
<u>Olympic</u>	Deer Park	113	60	56	55	54	49	0
<u>Scotts Bluff</u>	Visitor Center	149	64	63	61	59	59	0
<u>Stones River</u>	Beasley Field	138	62	60	60	59	59	0
<u>Yosemite</u>	School Yard	156	66	65	64	64	64	0

^a The primary and secondary National Ambient Air Quality Standard for ozone is 0.075 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 76 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 76 ppb.) Exceedances of the standard are highlighted here in orange or red.

^b The Gaseous Pollutant Monitoring Program Portable Ozone Monitoring Systems (POMS) do not meet EPA standards for regulatory monitoring. However, ozone summary statistics from portable systems can be compared to EPA standards for reference purposes.

Note: The color coding break points follow the color categories used on the EPA's AIRNow Web Site (<http://www.airnow.gov>).

Operating agency key: plain text = site operated by the National Park Service

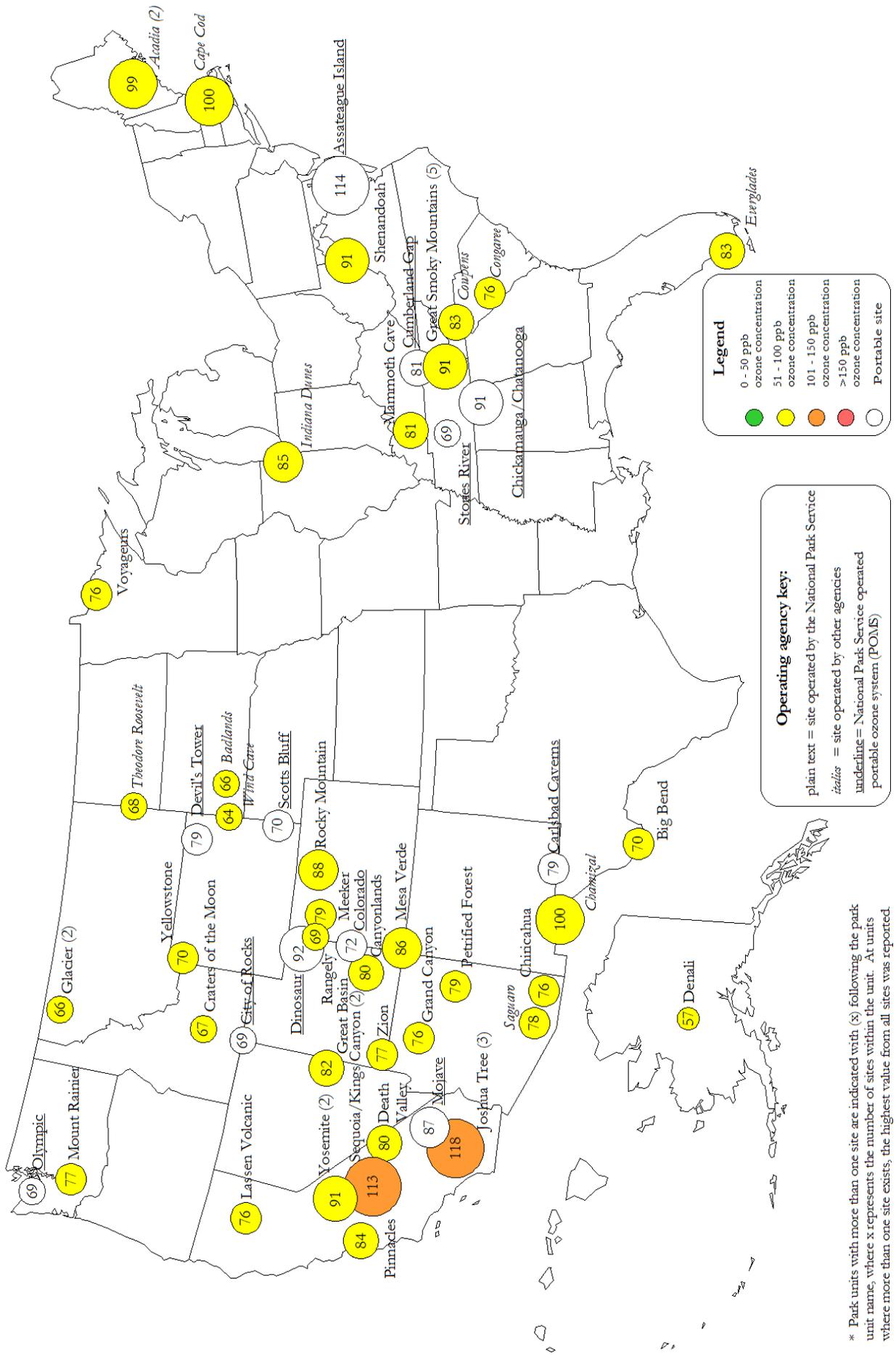
italics = site operated by a state agency

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

Bold = Ozone summary statistics for POMS are highlighted bold where exceedances occurred. These sites should be compared to EPA standards for reference purposes only.

Color shading key: 4th highest 8-hour average  = 76 - 104 ppb ozone concentration # days with 8-hour average ≥76 ppb  = 4 - 10 days
 ≥ 105 ppb ozone concentration  > 10 days

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



* 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 4. 2010 Annual second highest 1-hour average ozone concentrations (in ppb).

Table 3. 2010 Ozone violation summary - primary standard^{a,b}.

National Park Unit	Site Name	2008–2010	2007-2009	2006-2008	2005–2007	2004–2006	2003–2005	2002–2004	2001–2003
Sites operated by the National Park Service (Gaseous Pollutant Monitoring Program)									
Big Bend	K-Bar Ranch Road	64	66	66	66	63	63	62	62
Canyonlands	Island in the Sky	68	70	71	70	70	71	72	70
Chiricahua	Entrance Station	68	66	69	71	72	71	71	70
Craters of the Moon	Visitor Center	62	(64)	(67)	(67)	---	---	67	(65)
Death Valley	Park Village	72	77	81	84	82	81	80	81
Denali	Headquarters	58	58	58	52	51	52	53	54
Glacier	West Glacier Horse Stables	51	51	53	55	54	56	55	53
Grand Canyon	The Abyss	68	68	70	72	73	74	74	74
Great Basin	Maintenance Yard	69	71	72	73	72	72	72	70
Great Smoky Mountains	Clingmans Dome	(76)	(79)	(84)	(83)	(80)	(79)	(87)	(92)
Great Smoky Mountains	Cove Mountain	76	79	82	82	77	78	86	92
Great Smoky Mountains	Look Rock	77	79	85	86	84	86	91	92
Joshua Tree	Black Rock	98	100	104	103	103	105	106	(98)
Joshua Tree	Cottonwood Canyon	(81)	(80)	(79)	(66)	(62)	(45)	---	---
Lassen Volcanic	Manzanita Lake Fire Station	70	74	77	72	69	68	71	72
Mammoth Cave	Houchin Meadow	70	72	74	76	72	73	77	80
Mesa Verde	Resource Management Area	68	69	71	73	73	70	68	67
Mount Rainier	Tahoma Woods	55	(56)	58	(56)	(58)	(61)	63	61
Petrified Forest	South Entrance	67	(67)	(70)	(70)	(70)	(71)	(66)	(64)
Pinnacles	SW of East Entrance Station	76	77	79	74	75	76	81	81
Rocky Mountain	Long's Peak	73	74	76	76	74	78	82	81
Sequoia and Kings Canyon	Ash Mountain	(101)	(103)	(105)	(103)	(103)	(105)	(105)	(107)
Sequoia and Kings Canyon	Lower Kaweah	86	90	96	95	96	97	101	101
Shenandoah	Big Meadows	74	73	76	77	77	(80)	82	87
Voyageurs	Sullivan Bay	(62)	(61)	(61)	(65)	64	66	64	65
Yellowstone	Water Tank	64	64	66	64	63	61	63	65
Yosemite	Turtleback Dome	83	87	(89)	86	86	88	90	90
Zion	Dalton's Wash	69	69	71	78	79	(82)	(74)	---
# park units with violations (0.08 ppm standard):			3	4	4	3	4	4	5
# sites with violations:			4	5	5	4	5	7	8
# park units with violations (0.075 ppm standard):			5						
# sites with violations:			9						
Sites operated by the Bureau of Land Management									
Meeker	Plant Science Center	(66)	---	---	---	---	---	---	---
Rangely	Golf Course	(58)	---	---	---	---	---	---	---
# units with violations (0.08 ppm standard):			---	---	---	---	---	---	---
# sites with violations:									
# units with violations (0.075 ppm standard):			0						
# sites with violations:			0						
Sites operated by cooperating state agencies									
Acadia	Cadillac Mountain	74	78	79	82	80	82	88	94
Acadia	McFarland Hill	69	73	72	74	71	74	80	87
Badlands	Visitor Center	54	56	62	68	67	(66)	(64)	(67)
Cape Cod	Cape Cod	75	76	79	84	84	86	88	95
Chamizal	Chamizal	70	71	75	74	73	72	78	79
Congaree	Congaree Bluff	64	66	71	73	72	73	74	77
Cowpens	State Monitor	69	67	74	73	74	75	80	84
Everglades	Cutler Road	67	69	72	69	68	66	(65)	(64)

Table 3. 2010 Ozone violation summary - primary standard^{a,b} (continued).

National Park Unit	Site Name	2008–2010	2007–2009	2006–2008	2005–2007	2004–2006	2003–2005	2002–2004	2001–2003
Sites operated by cooperating state agencies									
<i>Great Smoky Mountains</i>	Cades Cove	69	69	72	70	67	(67)	73	76
<i>Great Smoky Mountains</i>	Purchase Knob	72	74	77	77	75	78	82	86
<i>Indiana Dunes</i>	Ammunition Bunker	(61)	(68)	73	82	75	76	(70)	(76)
<i>Mount Rainier</i>	Jackson Visitor's Center	(52)	(56)	(59)	61	(60)	(59)	---	---
<i>Saguaro</i>	Pima County	69	71	74	76	76	(76)	(76)	(73)
<i>Theodore Roosevelt</i>	Painted Canyon Visitor Cntr	57	59	63	63	(60)	(59)	60	61
<i>Wind Cave</i>	Visitor Center	(59)	(62)	66	70	(71)	(70)	---	---
# park units with violations (0.08 ppm standard):			0	0	0	0	1	2	4
# sites with violations:			0	0	0	0	1	2	3
# park units with violations (0.075 ppm standard):			0						
# sites with violations:			0						

^a The new primary and secondary National Ambient Air Quality Standard for ozone is 0.075 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 76 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 76 ppb.) For reference, values that would violate the new standard are outlined with a black box. The first 3-year period that the new standard will apply to is 2008-2010.

^b The old 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 old standard are highlighted here in orange and red. The old standard applies to all 3-year periods prior to 2008-2010.

Note: The color coding break points follow the color categories used on the EPA's AIRNow Web Site (<http://www.airnow.gov>).

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: 4th highest 8-hour average
 = 85 - 104 ppb ozone concentration
 ≥ 105 ppb ozone concentration
 ≥ 76 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.

Dashed lines represent no data available at that site.

Table 4. 2010 Summary of indices for resource injury (SUM06 and W126).

National Park Unit	Site Name	O ₃ % Valid	SUM06 ^a (ppm-hr)	W126 ^b (ppm-hr)	Period
Sites operated by the National Park Service (Gaseous Pollutant Monitoring Program)					
Big Bend	K-Bar Ranch Road	98.3	6	8	March-May
Canyonlands	Island in the Sky	96.1	16	13	April-June
Chiricahua	Entrance Station	98.7	17	13	April-June
Craters of the Moon	Visitor Center	83.1	6	7	July-September
Death Valley	Park Village	90.6	10	10	April-June
Denali	Headquarters	99.7	0	2	March-May
Glacier	West Glacier Horse Stables	98.9	0	2	April-June
Grand Canyon	The Abyss	99.3	19	15	April-June
Great Basin	Maintenance Yard	94.8	13	11	April-June
Great Smoky Mountains	Clingmans Dome	96.5	13	12	August-October
Great Smoky Mountains	Cove Mountain	99.6	21	15	March-May
Great Smoky Mountains	Look Rock	99.0	20	14	August-October
Joshua Tree	Black Rock	99.9	61	43	June-August
Joshua Tree	Cottonwood Canyon	87.9	27	18	June-August
Lassen Volcanic	Manzanita Lake Fire Station	99.4	10	9	July-September
Mammoth Cave	Houchin Meadow	99.3	13	10	April-June
Mesa Verde	Resource Management Area	98.1	14	12	April-June
Mount Rainier	Tahoma Woods	97.3	1	1	June-August
Petrified Forest	South Entrance	99.3	14	12	April-June
Pinnacles	SW of East Entrance Station	96.0	13	9	July-September
Rocky Mountain	Long's Peak	98.6	28	19	April-June
Sequoia and Kings Canyon	Ash Mountain	99.1	69	54	July-September
Sequoia and Kings Canyon	Lower Kaweah	99.2	39	27	July-September
Shenandoah	Big Meadows	83.8	13	10	July-September
Voyageurs	Sullivan Bay	96.5	8	7	March-May
Yellowstone	Water Tank	99.1	15	11	April-June
Yosemite	Turtleback Dome	98.1	43	26	July-September
Zion	Dalton's Wash	98.2	32	19	April-June
Sites operated by the Bureau of Land Management					
Meeker	Plant Science Center	98.6	10	10	April-June
Rangely	Golf Course	99.6	2	4	August-October
Sites operated by cooperating state agencies					
<i>Acadia</i>	Cadillac Mountain	99.9	4	5	March-May
<i>Acadia</i>	McFarland Hill	96.5	3	4	March-May
<i>Badlands</i>	Visitor Center	99.9	1	3	June-August
<i>Cape Cod</i>	Cape Cod	86.8	8	7	May-July
<i>Chamizal</i>	Chamizal	98.3	5	6	June-August
<i>Congaree</i>	Congaree Bluff	96.4	8	6	March-May
<i>Cowpens</i>	State Monitor	94.8	12	8	March-May
<i>Everglades</i>	Cutler Road	99.0	5	6	February-April
<i>Great Smoky Mountains</i>	Cades Cove	98.2	13	10	March-May
<i>Great Smoky Mountains</i>	Purchase Knob	95.7	10	7	April-June
<i>Indiana Dunes</i>	Ammunition Bunker	98.9	4	4	June-August
<i>Mount Rainier</i>	Jackson Visitor's Center	94.9	1	1	March-May

Table 4. 2010 Summary of indices for resource injury (SUM06 and W126) (continued).

National Park Unit	Site Name	O ₃ % Valid	SUM06 ^a (ppm-hr)	W126 ^b (ppm-hr)	Period
Sites operated by cooperating state agencies					
<i>Saguaro</i>	Pima County	99.4	21	15	April-June
<i>Theodore Roosevelt</i>	Painted Canyon Visitor Center	96.8	2	4	April-June
<i>Wind Cave</i>	Visitor Center	91.2	2	5	July-September
Portable ozone monitoring systems (POMS)					
<u>Assateague Island</u>	Maintenance Area	99.1	12	10	June-August
<u>Carlsbad Caverns</u>	Maintenance Area	86.4	5	6	April-June
<u>Chickamauga/Chatanooga</u>	Lookout Mountain	74.8	21	15	August-October
<u>City of Rocks</u>	Juniper Campground	100.0	2	5	June-August
<u>Colorado</u>	Maintenance Yard	99.3	7	8	May-July
<u>Cumberland Gap</u>	Hensley Settlement	99.8	7	6	May-July
<u>Devil's Tower</u>	Joyner Ridge Trail	98.1	3	5	June-August
<u>Dinosaur</u>	West Entrance Housing	95.3	17	13	May-July
<u>Glacier</u>	Saint Mary's Ranger District	99.9	1	3	May-July
<u>Joshua Tree</u>	Pinto Wells	84.7	27	19	June-August
<u>Mojave</u>	Kelso Mountains	99.4	27	18	June-August
<u>Olympic</u>	Deer Park	99.8	0	0	July-September
<u>Scotts Bluff</u>	Visitor Center	97.8	2	5	June-August
<u>Stones River</u>	Beasley Field	91.7	3	4	July-September
<u>Yosemite</u>	School Yard	99.5	10	8	July-September

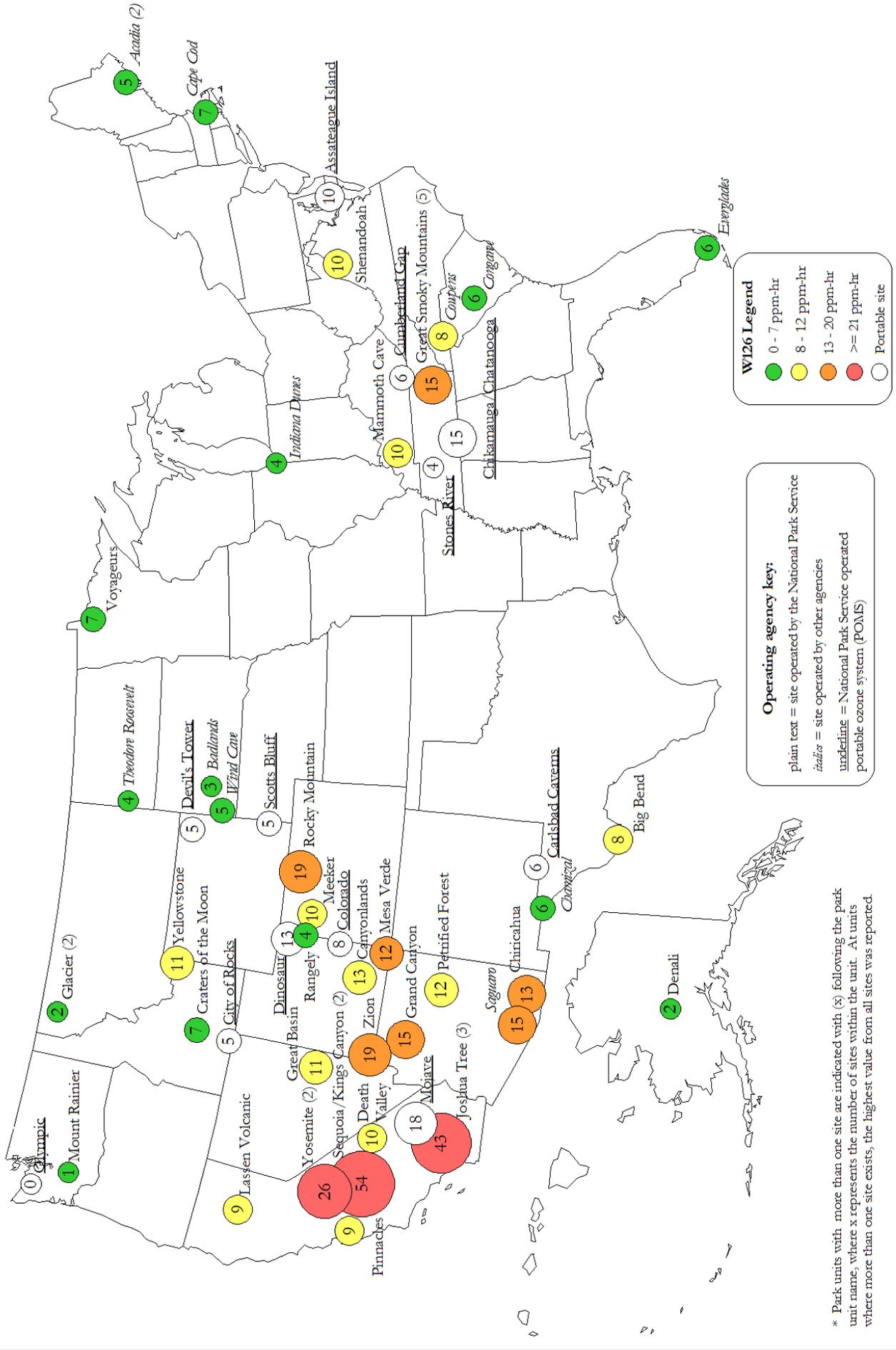
^a SUM06 exposure index represents the 0800-2000 hourly ozone concentrations equaling or exceeding 0.06 ppm. The value reported here represents a three-month maximum value during the ozone season. Units are ppm-hr.

^b W126 exposure index represents 0800-2000 hourly ozone concentrations where each concentration is weighted by a function that gives greater emphasis to the higher hourly concentrations while still including the lower ones. The value reported here represents a three-month maximum value during the ozone season. Units are ppm-hr. For more information on the W126 exposure index go to <http://www.nature.nps.gov/air/aqbasics/glossary.cfm>.

Note: The SUM06 and W126 are described in further detail on pages 3-4 of this report. For more information see the section titled "Resource Injury Indices."

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

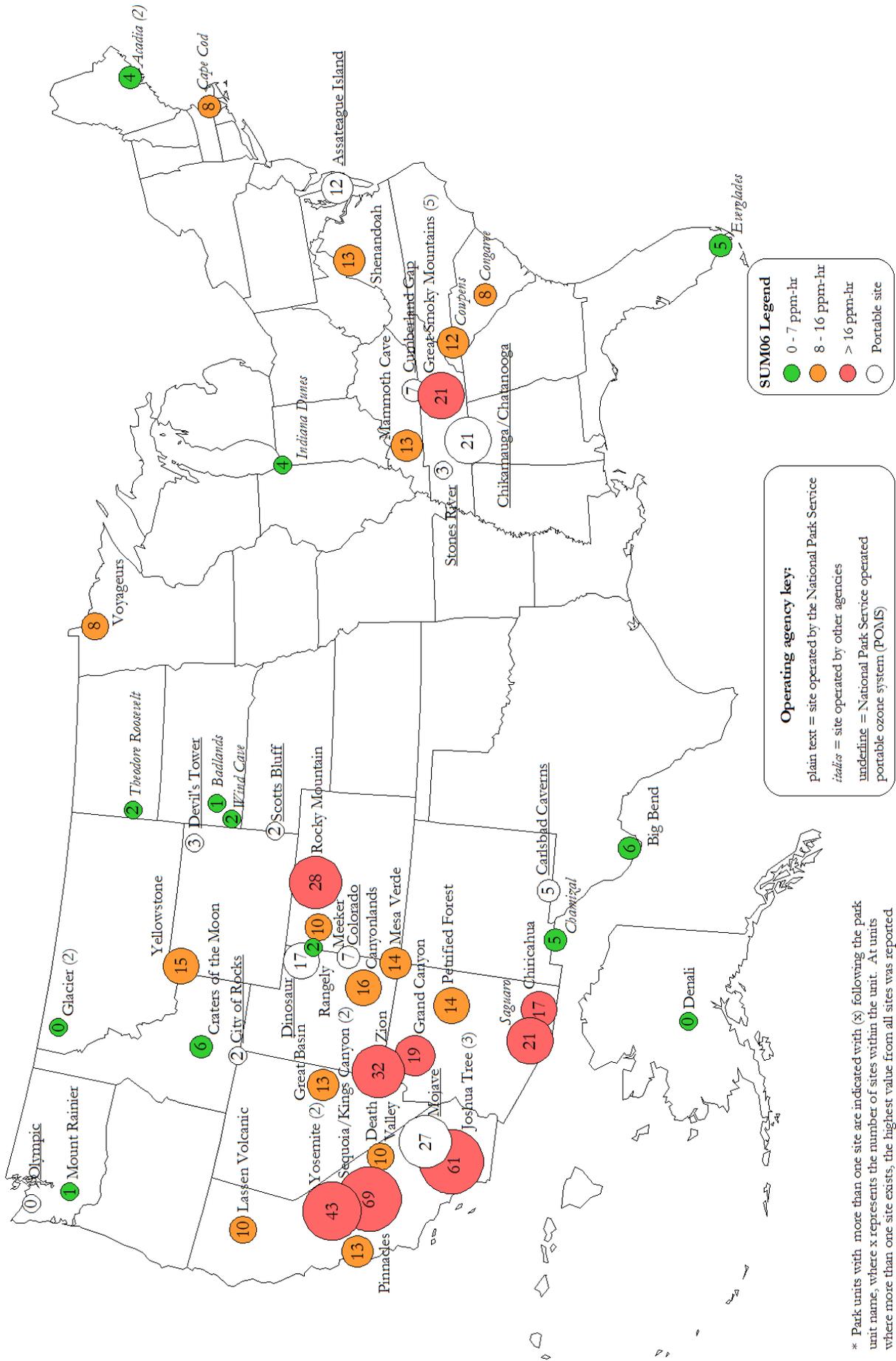
Annual 3 Month Maximum W126 Exposure Index (0800-2000 hourly concentrations)



* 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 5. 2010 3-month maximum W126 exposure index during the ozone season (0800-2000 hourly concentrations).

Annual 3 Month Maximum Sum06 Exposure Index (0800-2000 hourly concentrations)



* 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 6. 2010 3-month maximum SUM06 exposure index during the ozone season (0800-2000 hourly concentrations).

Table 5. 2010 Summary of sulfur dioxide data.

National Park Unit	Site Name	Highest Daily 24-Hour Average Concentration ^a (ppb)				No. of Days with 24-Hr Average \geq 145 ppb	Highest Daily Maximum 1-Hour Average Concentration ^b (ppb)				No. of Days with 1-Hr Average \geq 76 ppb	Highest Daily Maximum 3-Hour Average Concentration ^c (ppb)					
		1 st Highest	2 nd Highest	3 rd Highest	4 th Highest		1 st Highest	2 nd Highest	3 rd Highest	4 th Highest		99 th Percentile Value	1 st Highest	2 nd Highest	3 rd Highest	4 th Highest	No. of Days with 3-Hr Maximum \geq 550 ppb
Sites operated by the National Park Service (Gaseous Pollutant Monitoring Program)																	
Great Smoky Mountains	Cove Mountain	4	4	3	3	0	17	13	11	10	10	0	9	9	8	8	0
Hawaii Volcanoes *	Observatory / Jaggar Museum	1069	990	831	740	28	7131	6755	5679	5392	5392	513	3482	3431	3323	3149	32
Hawaii Volcanoes *	Visitor Center	856	798	624	581	20	5476	4331	4135	3410	3410	442	3239	3123	2768	2428	20
Mammoth Cave	Houchin Meadow	6	6	6	5	0	18	17	16	15	15	0	14	13	12	11	0
Sites operated by cooperating state agencies																	
Badlands	Visitor Center	4	3	3	3	0	17	11	10	7	9	0	12	9	8	8	0
Congaree	Congaree Bluff	7	6	6	4	0	65	44	38	34	34	0	36	24	21	18	0
Indiana Dunes	Ammunition Bunker	30	24	18	18	0	74	65	59	57	57	0	61	60	56	49	0
Theodore Roosevelt	Painted Canyon Visitor Ctr	3	2	1	1	0	15	10	8	6	6	0	10	8	6	5	0
Wind Cave	Visitor Center	3	3	2	1	0	16	10	5	5	5	0	8	7	5	5	0

^a 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 $\mu\text{g}/\text{m}^3$ exceeds that standard.) (40 CFR 50.4.)

^b The primary hourly National Ambient Air Quality Standard for sulfur dioxide is a daily maximum 1-hour average of 75 ppb. (An exceedance of the Standard occurs when a daily maximum 1-hour average exceeds 75 ppb. A violation of the Standard occurs when the 3-year average of the 99th percentile of the daily maximum 1-hour average exceeds 75 ppb.)

^c 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 $\mu\text{g}/\text{m}^3$ exceeds the standard.) (40 CFR 50.5.)

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

Operating agency key: plain text = site operated by the National Park Service

italics = site operated by a state agency

Color shading key: >34 ppb annual arithmetic mean, >144 ppb 24-hour average, > 75 ppb 99th percentile value, or >549 ppb 3-hour average

Table 6. 2010 Summary of PM_{2.5} data from reference and equivalency methods.

National Park Unit	Site Name	Sampler Type*	% Valid ^a	Annual Arithmetic Mean ^b (µg/m ³)	Highest Daily 24-Hour Average Concentrations ^c (µg/m ³)					98 th Percentile Value	No. of Days with 24-Hour Average >35 µg/m ³
					1 st Highest	2 nd Highest	3 rd Highest	4 th Highest	98 th Percentile Value		
Sites operated by the National Park Service (Gaseous Pollutant Monitoring Program)											
Great Smoky Mountains	Look Rock	TEOM	98.6	11.0	32	27	25	24	23	0	
Hawaii Volcanoes	Observatory / Jaggar Museum	SHARP	97.1	8.0	194	78	65	59	43	13	
Sequoia and Kings Canyon	Ash Mountain	BAM	96.0	9.0	36	27	22	22	21	1	
Shenandoah	Big Meadows	TEOM	96.5	5.8	30	26	22	21	18	0	
Yellowstone	Old Faithful	BAM	95.9	3.8	28	10	9	9	8	0	
Zion	Dalton's Wash	FRM or FEM	97.4	3.5	13	13	12	12	9	0	
Sites operated by the Bureau of Land Management											
Meeker	Plant Science Center	TEOM	92.0	3.5	29	17	16	12	12	0	
Rangely	Golf Course	FRM or FEM	88.1	2.0	9	6	6	5	6	0	
Sites operated by cooperating state agencies											
<i>Acadia</i>	McFarland Hill	TEOM	93.0	3.8	21	19	17	17	15	0	
<i>Badlands</i>	Visitor Center	FRM or FEM	97.9	3.3	22	20	18	15	14	0	
<i>Indiana Dunes</i>	Ammunition Bunker	FRM or FEM	92.1	18.0	41	41	41	41	36	10	
<i>Theodore Roosevelt</i>	Painted Canyon Visitor Ctr	TEOM	93.3	5.8	15	15	15	15	13	0	
<i>Wind Cave</i>	Visitor Center	FRM or FEM	96.7	4.0	115	55	27	20	12	2	
<i>Yellowstone</i>	W. Yellowstone State Site	BAM	98.0	0.8	8	8	8	7	5	0	
<i>Yosemite</i>	Village	TEOM	81.5	10.0	61	38	34	27	26	2	
^a At sites operated by an agency other than the National Park Service, the primary responsibility for the operation and data reporting of particulate matter belongs to the operating agency.											
^b The primary annual National Ambient Air Quality Standard for PM _{2.5} is an annual arithmetic mean of 15.0 µg/m ³ . (An exceedance of the standard occurs when an annual arithmetic mean of PM _{2.5} concentrations is greater than 15.0 µg/m ³ . A violation of the standard occurs when the 3-year average of the weighted annual mean PM _{2.5} concentrations is greater than 15.0 µg/m ³ (40 CFR 50.7.)											
^c The primary daily National Ambient Air Quality Standard for PM _{2.5} is a 24-hour average concentration of 35 µg/m ³ . (An exceedance of the standard occurs when a 24-hour average PM _{2.5} concentration is greater than 35 µg/m ³ . A violation of the standard occurs when the 3-year average of the annual 98 th percentile of 24-hour PM _{2.5} concentrations is greater than 35 µg/m ³ .) (40 CFR 50.7.)											
* TEOM = tapered element oscillating microbalance BAM = beta attenuation monitor SHARP = synchronized hybrid ambient real-time particulate monitor FRM = federal reference method monitor FEM = federal equivalent method monitor											
Operating agency key: plain text = site operated by the National Park Service italics = site operated by a state agency											
Color shading key: Annual arithmetic mean > 15 µg/m ³ 98 th percentile value > 35 µg/m ³											

Table 7. 2010 Summary of PM₁₀ data from reference and equivalency methods.

National Park Unit	Site Name	Sampler Type*	% Valid ^a	Annual Arithmetic Mean ^b (µg/m ³)	Highest Daily 24-Hour Average Concentrations ^c (µg/m ³)				No. of Days with 24-Hour Average >150 µg/m ³
					1 st Highest	2 nd Highest	3 rd Highest	4 th Highest	
Sites operated by cooperating state agencies									
<i>Badlands</i>	Visitor Center	BAM	96.1	8	30	30	30	30	0
<i>Wind Cave</i>	Visitor Center	BAM	96.7	9	140	70	40	30	0

^a At sites operated by an agency other than the National Park Service, the primary responsibility for the operation and data reporting of particulate matter belongs to the operating agency.

^b The primary annual National Ambient Air Quality Standard for PM₁₀ is an annual arithmetic mean of 50 µg/m³. (An exceedance of the standard occurs when an annual arithmetic mean of PM₁₀ concentrations is greater than 50 µg/m³. A violation of the standard occurs when the 3-year average of the weighted annual mean PM₁₀ concentrations is greater than 50 µg/m³ (40 CFR 50.6.)

^c The primary daily National Ambient Air Quality Standard for PM₁₀ is a 24-hour average concentration of 150 µg/m³. (An exceedance of the standard occurs when a 24-hour average PM₁₀ concentration is greater than 150 µg/m³. A violation of the standard occurs when a 24-hour average concentration greater than 150 µg/m³ occurs more than once in a calendar year.) (40 CFR 50.6.)

* TEOM = tapered element oscillating microbalance
 BAM = beta attenuation monitor

Color shading key: >50 µg/m³ annual arithmetic mean, >150 µg/m³ 24-hour average

italics = site operated by a state agency

Table 8. 2010 Summary of PM₁₀ data from non-equivalency methods.

National Park Unit	Site Name	Sampler Type	% Valid ^a	Annual Arithmetic Mean ^b (µg/m ³)	Highest Daily 24-Hour Average Concentrations ^c (µg/m ³)				No. of Days with 24-Hour Average >150 µg/m ³
					1 st Highest	2 nd Highest	3 rd Highest	4 th Highest	
Sites operated by the National Park Service (Gaseous Pollutant Monitoring Program)									
Joshua Tree	Cottonwood Canyon	E-sampler	32.7	3	10	10	10	10	0

^a At sites operated by an agency other than the National Park Service, the primary responsibility for the operation and data reporting of particulate matter belongs to the operating agency.

^b The primary annual National Ambient Air Quality Standard for PM₁₀ is an annual arithmetic mean of 50 µg/m³. (An exceedance of the standard occurs when an annual arithmetic mean of PM₁₀ concentrations is greater than 50 µg/m³. A violation of the standard occurs when the 3-year average of the weighted annual mean PM₁₀ concentrations is greater than 50 µg/m³ (40 CFR 50.6.)

^c The primary daily National Ambient Air Quality Standard for PM₁₀ is a 24-hour average concentration of 150 µg/m³. (An exceedance of the standard occurs when a 24-hour average PM₁₀ concentration is greater than 150 µg/m³. A violation of the standard occurs when a 24-hour average concentration greater than 150 µg/m³ occurs more than once in a calendar year.) (40 CFR 50.6.)

Color shading key: >50 µg/m³ annual arithmetic mean, >150 µg/m³ 24-hour average

Table 9. PM₁₀ summary - maximum daily 24-hour average concentration in 2008-2010 (µg/m³)^a.

National Park Unit	Site Name	Sampler Type*	2010	2009	2008
Sites operated by cooperating state agencies					
<i>Badlands</i>	Visitor Center	BAM	30	40	90
<i>Wind Cave</i>	Visitor Center	BAM	140	340	50

^a The primary daily National Ambient Air Quality Standard for PM₁₀ is a 24-hour average concentration of 150 µg/m³. (An exceedance of the standard occurs when a 24-hour average PM₁₀ concentration is greater than 150 µg/m³. A violation of the standard occurs when a 24-hour average concentration greater than 150 µg/m³ occurs more than once in a calendar year.) (40 CFR 50.6.)

* TEOM = tapered element oscillating microbalance
 BAM = beta attenuation monitor

Color shading key: > 1 24-hour average concentration >150 µg/m³

italics = site operated by a state agency

Table 10. 2010 Annual summary of selected meteorological data.

National Park Unit	Site Name	Wind Speed (m/s)	Ambient Temperature (degrees C)		Relative Humidity (%)			Precipitation (mm)	
		Average	Average	Maximum	Minimum	Average	Maximum	Minimum	Annual Accumulation
Sites operated by the National Park Service (Gaseous Pollutant Monitoring Program)									
Big Bend	K-Bar Ranch Road	3.6	20.4	40.0	-5.6	41	99	2	164
Canyonlands	Island in the Sky	2.9	11.5	35.0	-12.9	44	97	5	250
Chiricahua	Entrance Station	2.9	15.2	35.5	-6.6	46	100	6	508
Craters of the Moon	Visitor Center	3.3	5.1	32.5	-22.5	57	98	8	---
Denali	Headquarters	1.2	-1.3	25.4	-33.5	67	95	15	169
Everglades	Beard Center	2.3	22.1	33.5	-0.3	82	100	24	949
Glacier	West Glacier Horse Stables	0.8	5.3	30.1	-25.3	76	96	16	793
Grand Canyon	The Abyss	2.9	10.4	31.9	-15.8	45	95	3	423
Great Basin	Maintenance Yard	2.8	9.1	32.4	-19.0	47	94	5	307
Great Smoky Mountains	Clingmans Dome	3.6	12.4	21.3	-4.7	84	100	2	1068
Great Smoky Mountains	Cove Mountain	3.9	10.4	28.2	-17.3	73	100	6	837
Great Smoky Mountains	Look Rock	2.3	12.7	31.0	-15.8	72	100	22	837
Hawaii Volcanoes	Observatory / Jaggar Museum	5.3	15.2	24.1	7.9	84	99	14	533
Hawaii Volcanoes	Visitor Center	3.9	15.5	23.6	7.7	89	100	18	934
Joshua Tree	Black Rock	3.7	16.0	35.8	-5.4	36	96	2	466
Joshua Tree	Cottonwood Canyon	3.4	19.2	38.2	1.0	31	100	4	169
Lassen Volcanic	Manzanita Lake Fire Station	2.0	6.1	29.1	-15.8	66	98	8	1160
Mammoth Cave	Houchin Meadow	1.7	14.1	36.2	-16.2	69	100	16	1239
Mesa Verde	Resource Management Area	3.0	10.2	32.9	-16.7	45	99	5	425
Mount Rainier	Tahoma Woods	1.0	8.9	33.4	-15.0	84	100	11	1690
Petrified Forest	South Entrance	4.2	12.5	35.9	-16.8	45	95	4	141
Pinnacles	SW of East Entrance Station	2.2	13.8	42.4	-5.6	61	87	6	546
Rocky Mountain	Long's Peak	2.6	4.5	25.0	-22.3	49	100	2	553
Sequoia and Kings Canyon	Ash Mountain	2.4	16.3	40.4	-1.1	57	100	10	1060
Sequoia and Kings Canyon	Lower Kaweah	1.7	8.0	28.4	-11.7	61	98	8	1415
Shenandoah	Big Meadows	2.2	8.5	28.0	-16.9	69	100	0	1467
Voyageurs	Sullivan Bay	2.7	5.9	30.6	-31.3	70	95	13	862
Yellowstone	Old Faithful	1.6	1.8	26.7	-34.5	69	100	9	---
Yellowstone	Water Tank	1.6	1.6	25.4	-29.7	66	95	10	549
Yosemite	Turtleback Dome	3.9	10.3	31.9	-9.3	55	98	7	954
Zion	Dalton's Wash	4.2	15.6	39.2	-8.8	41	100	4	430
Sites operated by the Bureau of Land Management									
Meeker	Plant Science Center	3.4	7.0	32.1	-26.0	59	100	8	370
Rangely	Golf Course	2.8	9.6	32.8	-22.3	53	99	6	98
Sites operated by cooperating state agencies									
Acadia	Cadillac Mountain	5.5	15.5	29.4	-0.3	80	100	21	---
Acadia	McFarland Hill	2.7	8.6	33.0	-21.8	75	100	14	1737
Cape Cod	Cape Cod	2.5	11.2	33.9	-12.2	70	91	16	---
Chamizal	Chamizal	3.3	19.4	40.8	-4.1	34	92	4	---
Great Smoky Mountains	Cades Cove	1.2	12.0	30.6	-16.2	74	100	17	1231
Indiana Dunes	Ammunition Bunker	3.3	11.0	35.1	-18.7	74	100	16	---
Saguaro	Pima County	2.6	21.3	40.9	-0.7	34	97	5	---

Table 10. 2010 Annual summary of selected meteorological data (continued).

National Park Unit	Site Name	Wind Speed (m/s)	Ambient Temperature (degrees C)			Relative Humidity (%)			Precipitation (mm)
		Average	Average	Maximum	Minimum	Average	Maximum	Minimum	Annual Accumulation
Sites operated by cooperating state agencies									
<i>Theodore Roosevelt</i>	Painted Canyon Visitor Cntr	4.9	6.2	34.1	-28.3	69	95	15	444
<i>Wind Cave</i>	Visitor Center	2.7	8.8	34.9	-24.0	58	98	7	568
Portable ozone monitoring systems (POMS) (seasonal)									
<u>Assateague Island</u>	Maintenance Area	1.3	21.4	36.5	3.0	78	100	24	143
<u>Carlsbad Caverns</u>	Maintenance Area	4.3	23.8	40.6	6.8	50	99	4	445
<u>Chickamauga/Chatanooga</u>	Lookout Mountain	1.6	21.9	36.7	2.0	64	100	14	---
<u>City of Rocks</u>	Juniper Campground	2.4	14.3	33.2	-5.6	43	99	7	137
<u>Colorado</u>	Maintenance Yard	1.6	15.8	37.6	-16.0	40	99	6	180
<u>Cumberland Gap</u>	Hensley Settlement	2.0	20.0	28.8	1.6	80	100	32	775
<u>Devil's Tower</u>	Joyner Ridge Trail	1.4	16.5	38.3	-6.0	64	100	9	297
<u>Dinosaur</u>	West Entrance Housing	1.2	13.5	38.0	-21.4	50	97	7	160
<u>Glacier</u>	Saint Mary's Ranger District	2.3	11.2	29.5	-6.3	67	100	15	388
<u>Joshua Tree</u>	Pinto Wells	3.3	26.0	45.0	-2.7	27	97	4	66
<u>Mojave</u>	Kelso Mountains	3.7	24.3	38.1	1.3	24	95	4	9
<u>Olympic</u>	Deer Park	0.7	10.4	27.5	-1.7	72	100	5	76
<u>Scotts Bluff</u>	Visitor Center	2.6	19.4	37.1	-2.1	53	100	9	246
<u>Stones River</u>	Beasley Field	0.5	22.6	38.6	-1.7	77	100	15	89
<u>Yosemite</u>	School Yard	0.8	16.1	36.5	-2.4	61	99	11	83

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

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

Data quality tables associated with the data presented in this report can be found at:
<http://ard-request.air-resource.com>. Click "Get Reports."

Acknowledgements

The National Park Service expresses appreciation and acknowledges the many park employees and individuals who serve as site operators and maintain our air quality stations, and staff at Air Resource Specialists, Inc. who collect and validate the data, provide technical assistance to the site operators, and prepare data summary products.

Wind Cave National Park, South Dakota
- Visitor Center monitoring site

