National Park Service
U.S. Department of the Interior

Natural Resource Program Center

Air Quality in National Parks

2009 Annual Performance & Progress Report

Natural Resource Report NPS/NRPC/ARD/NRR—2010/266

ON THE COVER

View of Grand Teton National Park, Wyoming.
Credit: Debbie Miller.

ON THIS PAGE

View of Old Rag Mountain at Shenandoah National Park, Virginia.
Credit: National Park Service.

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Air Resources Division
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Denver, Colorado 80225

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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. Data presented in this report were collected and analyzed using methods based on established, peer-reviewed protocols, and were analyzed and interpreted within the guidelines of the protocols.

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The IMPROVE (Interagency Monitoring of Protected Visual Environments) program monitors visibility conditions in National Parks and Wilderness Areas. IMPROVE monitoring stations, like the Houchin's Meadow station at Mammoth Cave National Park, Kentucky, use modular aerosol samplers to measure fine and total aerosol mass by pulling air through specialized filters which are routinely collected and analyzed.

Top photo: The Houchin's Meadow IMPROVE monitoring station at Mammoth Cave National Park, Kentucky. Left: Inside the IMPROVE station. Below: Close-up of module B filter packs used to sample atmospheric PM 2.5, sulfate, and nitrate.
Credit: National Park Service.

Executive Summary

The National Park Service works to preserve, protect, enhance, and understand air quality and resources sensitive to air quality in the National Park System. This is crucial to parks because air pollution affects ecological health, scenic views, human health, and visitor enjoyment even at relatively low levels.

The National Park Service (NPS) measures progress toward improving park air quality by examining trends for key air quality indicators, including:

- visibility—which affects how well and how far visitors can see;
- ozone—which affects human health and native vegetation; and
- atmospheric deposition—which affects ecological health through acidification and fertilization of soil and surface waters.

The NPS monitors one or more of these indicators in 57 park units, and there are sufficient data to assess conditions and trends in all of these parks. In addition, many state and local air quality monitoring stations are located near enough to parks that the data they collect are considered reasonably representative of park air quality. As a result, air quality conditions and trends have been calculated for 195 monitoring locations representing 241 park units.

Air quality trends provide one measure of performance and progress. In general, air quality that is improving, or showing no deteriorating trend, may be considered a sign of success. In accordance with the Government Performance and Results Act (GPRA), the NPS has established performance goals based on trends, and reports annually on progress. For fiscal year 2009, these goals are improving or not degrading:

- visibility in 95% of NPS reporting parks,
- ozone in 86% of NPS reporting parks, and
- atmospheric deposition in 76% of NPS reporting parks.

For this annual performance report, ozone, visibility, and deposition data collected between 1999 and 2008 were examined.[1] The NPS exceeds air quality performance goals for 2009, with 97 percent of the reporting parks showing no trends or improving trends in visibility, 100 percent showing no trends or improving trends in ozone concentrations, and 93 percent showing no trends or improving trends in atmospheric deposition.

While improving trends certainly show progress, the lack of a worsening trend in air quality may not be sufficient to protect an area already experiencing poor air quality. Current air quality conditions are characterized for those park units with available trend information to identify areas where the lack of an improving trend may be of some concern. Using an index for each type of air quality data collected (visibility, wet deposition concentrations, and ozone concentrations), park air quality is characterized as good, moderate (or cautionary), or of significant concern.

Acadia National Park, Maine, is one of 49 parks showing significant improvement in visibility on clearest days.
Credit: National Park Service.

- With respect to visibility, 57 percent of the parks are in good or moderate condition. None of the parks with significant visibility concerns have improving trends.
- With respect to ozone, 35 percent of the parks are in good or moderate condition. Among the parks where current ozone conditions are of significant concern, 12 have improving trends, 89 have no trends, and none have degrading trends.
- For nitrogen deposition, only 29 percent of the parks are in good or moderate condition. Of the parks where nitrogen deposition is a significant concern, three parks have degrading trends, 35 have no trends, and two have improving trends.
- For sulfur deposition, 46 percent of the parks are in good or moderate condition. Of the parks where sulfur deposition is a significant concern, seven have improving trends and 23 have no trends. No park has a degrading trend with respect to sulfur deposition.

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[1] The lag time in data reporting results from quality assurance and data analysis procedures.

Air quality in parks is expected to improve as regulations aimed at reducing tailpipe emissions from motor vehicles and pollution from electric-generating facilities take full effect over the next few years. In addition, states and tribes, with assistance from regional planning organizations, are in the process of implementing programs to improve visibility in national parks and wilderness areas in response to Environmental Protection Agency regulations. Information available through the NPS air quality monitoring program has provided a foundation and impetus for pollution control programs that will benefit parks. The Park Service's ability to offer expert and constructive assistance and advice to regulatory and permitting agencies has stimulated collaborative efforts to find creative and cost-effective air quality management approaches.

The images above show clear, moderate, and hazy visibility conditions (top to bottom) at Great Smoky Mountains National Park, North Carolina and Tennessee.
Credit: National Park Service.

1. Measuring Progress–Air Quality Goals and Trends

The NPS Strategic Plan established the following interim air quality goals for 2009:

- visibility in 95% of NPS reporting parks has improved or shows no deteriorating trend;
- ozone in 86% of NPS reporting parks has improved or shows no deteriorating trend;
- and atmospheric deposition in 76% of NPS reporting parks has improved or shows no deteriorating trend.

The NPS exceeded these goals with 97 percent of the reporting parks showing improving or no trends in visibility, 100 percent showing improving or no trends in ozone concentrations, and 93 percent showing improving or no trends in atmospheric deposition. Performance exceeded the goals in part because many of the park units included in this year's report are in or near urban areas, where pollution control programs have been in effect for many years. More detail on how trends are calculated appears in Appendix A.

Progress toward these goals is measured annually through target goals. Data from visibility, ozone, and precipitation monitoring are used to assess air quality trends. Six total measures are used in calculating the goal percentages: two are used to measure progress toward the visibility goal, one measure is used for the ozone goal, and three measures are used for the atmospheric deposition goal. Not all parks monitor all six of the indicators. A park is considered to have air quality that is improving or not deteriorating if none of the measures used for that goal show a statistically significant degrading trend (denoted in red on attached figures and tables). In this report, significant trends are defined as those having at least a 95% probability of being correct (i.e., those with p-values ≤ 0.05). However, due to the variable nature of the statistics being used to track progress, it is possible that some locations experiencing a change in conditions may have trend slopes with less than a 95% probability of being correct. For this reason, we have also noted sites where the probability that the trend slope is correct lies between 85% and 95% (i.e., those with p-values > 0.05 and ≤ 0.15). These locations are denoted by light blue (where trend slopes suggest possible improvement) and pink (where trend slopes suggest possible degradation) in tables and figures throughout the report. However, only the significant trends are counted for purposes of assessing progress toward the air quality goals; sites noted as having only possible improvement or degradation are counted as having no trend. A summary of the trend results is presented in Table 1 showing the numbers of parks in each category that had no trends, significant improving trends, and significant degrading trends. Results of the trend analyses for individual parks are shown in Appendix B.

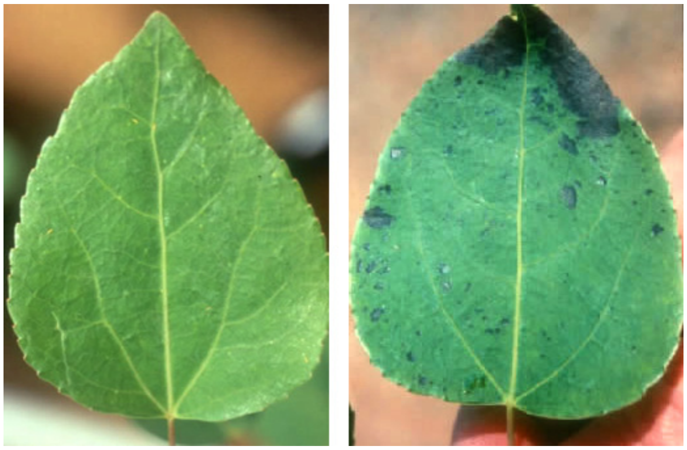

Photo of healthy (left) and ozone-injured (right) aspen foliage.
Credit: National Park Service.

Table 1. Summary of trend results for national park units with available monitoring data.

Trend Category	Total Number of Parks Trended	Number of Parks with No Significant Trend	Number of Parks with Significant Improving Trends	Number of Parks with Significant Degrading Trends
Visibility—Clearest Days	163	114	49	0
Visibility—Haziest Days	163	146	12	5
Wet Deposition—Ammonium	56	50	2	4
Wet Deposition—Nitrate	56	31	25	0
Wet Deposition—Sulfate	56	43	13	0
Ozone	159	137	22	0

1.1. Visibility Measures

The NPS examines the clearest days and haziest days to measure visibility conditions.[2] The Environmental Protection Agency (EPA) uses these measures to assess progress toward the national goal of remedying any existing and preventing any future human-caused visibility impairment in protected Class I areas.[3] This year we are able to report on 157 parks, both Class I and non-Class I, that have representative visibility monitoring and have at least 6 years of visibility data available during the period 1999–2008. Only five of the parks trended for visibility recorded a significant degrading trend on either clear or hazy days. This means that 97 percent are meeting the visibility goal. On the clearest days, 49 parks are showing significant improvement; these parks include Acadia National Park and Saint Croix Island International Historic Site in the eastern U.S., Isle Royale National Park in the Midwest, and sites in the northwestern U.S., California, Colorado Plateau, southern Arizona, southern New Mexico, western Texas, and the Rocky Mountain region. No parks show significant degrading trends on the clearest days. These trends are shown in Figure 1. On hazy days, parks showing improving trends include Catoctin Mountain, Cumberland Island, Mojave, Mount Rainier, Fort Frederica, Olympic, Gettysburg, and Joshua Tree. Most areas do not show significant trends on the haziest days, while only parks in the Virgin Islands (Virgin Islands, Buck Island Reef, Christiansted, Salt River Bay) and Hawaii (Hawaii Volcanoes) show significant increasing trends. Trends on the haziest days are shown in Figure 2. Improvements in visibility in the eastern US are influenced by reductions in sulfur dioxide and nitrogen oxide emissions from electric utilities and industrial boilers, required by the Acid

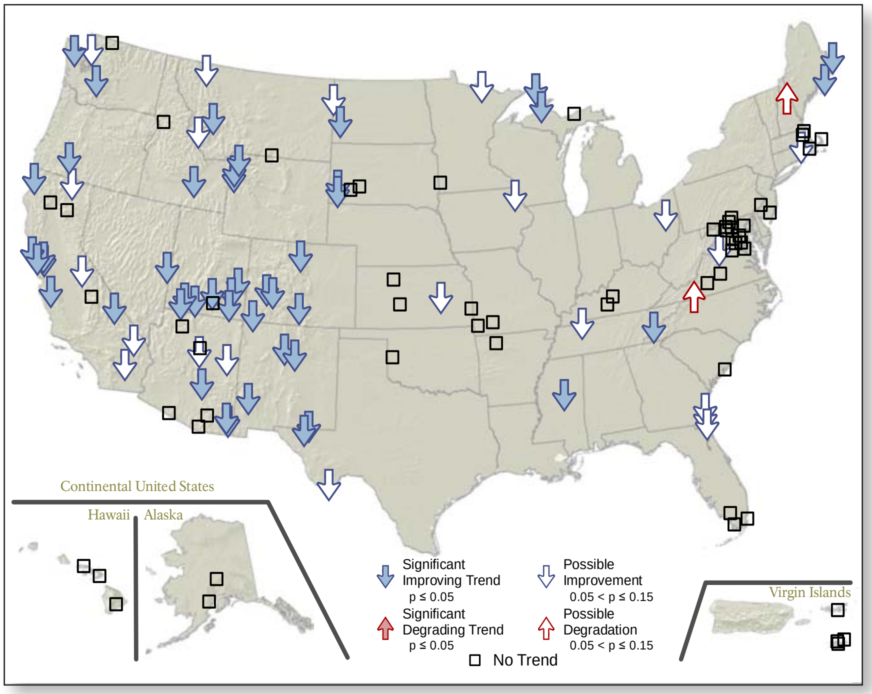

Figure 1. Trends in haze index (deciview) on clearest days, 1999–2008.

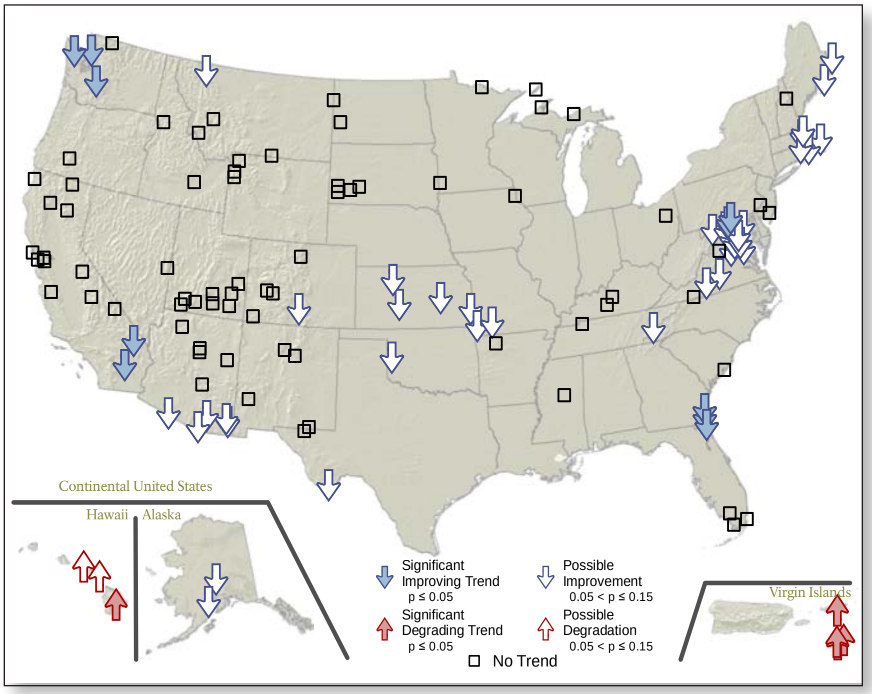

Figure 2. Trends in haze index (deciview) on haziest days, 1999–2008.

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[2] The clearest days are defined as the clearest 20% of those days each year for which visibility measurements are available, and the haziest days are the haziest 20%.

[3] Class I areas include national parks greater than 6,000 acres and wilderness areas greater than 5,000 acres that were in existence or authorized as of August 7, 1977. They receive the highest degree of air quality protection under the Clean Air Act.

Rain Program and the NO$_x$ SIP Call.[4] Implementation of the Regional Haze Rule[5] will further reduce emissions responsible for visibility impairment (EPA 2010).

1.2. Ozone Measures

The Environmental Protection Agency has established a primary National Ambient Air Quality Standard for ozone concentrations that is designed to protect the public health. In previous trend reporting, NPS has used the EPA's ozone metric to evaluate trends. The metric used by EPA is the 3-year average of the annual 4th-highest 8-hour ozone concentration. This year, however, we chose to evaluate 10-year trends in ozone concentrations using the annual 4th-highest daily maximum 8-hour ozone concentration, instead of the 3-year average, as the annual statistic is available over a longer period. Of the 159 park units that have representative ozone monitoring, 22 units are showing significant improvement and the remaining 137 show no trends. These trends are shown in Figure 3. In the East, where ozone concentrations in parks like Great Smoky Mountains, Mammoth Cave, and Shenandoah sometimes exceed health-based ozone standards, the ozone trends are largely improving over the past ten years. Ozone improvements in the East are influenced by the implementation of the NO$_x$ SIP Call rule (EPA 2010).

In January 2010, EPA proposed to lower the ozone standard from 0.075 ppm (75 ppb) to a level within the range of 0.060–0.070 ppm (60–70 ppb).[6] EPA will continue to use the same indicator and averaging time for the new standard, although its proposal does contain some minor changes to the procedures for calculating the indicator. Table 2 shows those NPS units with on-site monitoring that recorded 3-year average annual 4th-highest daily maximum 8-hour ozone concentrations equal to or greater than 60 ppb. These values were calculated in accordance with the procedures EPA specified for the current primary standard; it is possible that there could be some minor differences in these values once the new standard and calculation procedures are finalized. The table lists 28 parks; these include a number of eastern parks such as Acadia, Great Smoky Mountains, Shenandoah, and Mammoth Cave as well as western parks such as Chiricahua, Grand Canyon, Petrified Forest, Great Basin, and Zion.

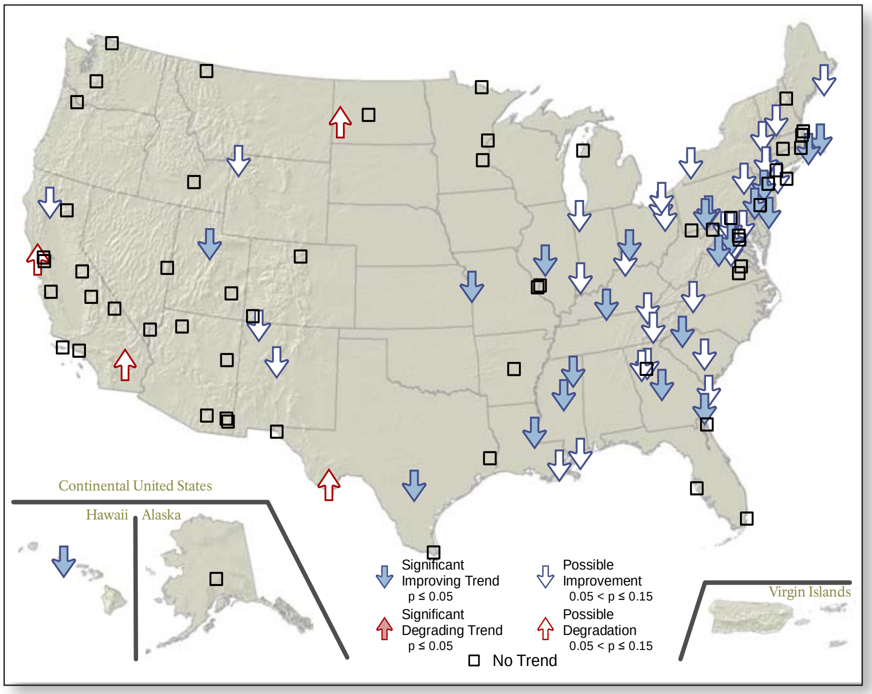

Figure 3. Trends in annual 4th-highest 8-hour ozone concentration, 1999–2008.

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[4] In October 1998, EPA finalized the NO$_x$ State Implementation Plan, also known as the "NO$_x$ SIP Call", that was designed to mitigate transport of NO$_x$. NO$_x$ (the total concentration of NO and NO$_2$) is an important precursor for ozone. Under this program, the EPA in 2003 began to administer a cap and trade program to reduce emissions of NO$_x$.

[5] The EPA's Regional Haze Rule aims to improve visibility in 156 federally mandated parks and wilderness areas.

[6] See Federal Register Vol. 75 No. 11, 40 CFR Parts 50 and 58, National Ambient Air Quality Standards for Ozone, Proposed Rules, January 19, 2010, p. 2938.

Table 2. Monitoring locations with 3-Year average 4th-highest 8-hour ozone concentration greater than or equal to 60 ppb (2008).

Park	3-Year Average 4th-Highest 8-Hour Ozone Concentration (ppb)
Acadia National Park - Cadillac Mountain	79
Acadia National Park - McFarland Hill	72
Big Bend National Park	66
Canyonlands National Park	71
Cape Cod National Seashore	79
Chamizal National Memorial	75
Chiricahua National Monument	69
Congaree National Park	71
Cowpens National Battlefield	74
Death Valley National Park	81
Grand Canyon National Park	70
Great Basin National Park	72
Great Smoky Mountains National Park - Cades Cove	72
Great Smoky Mountains National Park - Clingmans Dome	84
Great Smoky Mountains National Park - Cove Mountain	82
Great Smoky Mountains National Park - Look Rock	85
Great Smoky Mountains National Park - Purchase Knob	77
Joshua Tree National Park	104
Lassen Volcanic National Park	77
Mammoth Cave National Park	74
Mesa Verde National Park	71
Petrified Forest National Park	70
Pinnacles National Monument	79
Rocky Mountain National Park	76
Saguaro National Park	74
Sequoia and Kings Canyon National Parks - Ash Mountain	105
Sequoia and Kings Canyon National Parks - Lower Kaweah	96
Shenandoah National Park	76
Theodore Roosevelt National Park	63
Voyageurs National Park	61
Wind Cave National Park	66
Yellowstone National Park	66
Yosemite National Park	89
Zion National Park	71

1.3. Atmospheric Deposition Measures

Ammonium, nitrate, and sulfate ions in precipitation (rain and snow) are used as indicators of atmospheric deposition because they can be directly linked to ecological effects (e.g., acidification of surface waters or nutrient enrichment that disrupts natural systems). This year we determined trends for 56 parks that had representative monitoring. Table 1 gives the results of the trend analyses for wet deposition.

Ammonium, a form of nitrogen, shows no significant trends in 50 areas (89 percent), with just two areas showing a significant improvement in concentrations. Ammonium concentrations are increasing in four areas, Chiricahua, Fort Bowie, Mount Rainier, and George Rogers Clark. Trends in ammonium are shown in Figure 4. Ammonium forms from emissions of ammonia released by agricultural activities, feedlots, fires, and catalytic converters. Ammonia is not currently regulated.

Nitrate concentrations show significant improving trends in 25 parks with no significant trends in the remaining 31 parks. Trends in nitrate concentrations are shown in Figure 5. In 43 areas (77 percent), sulfate concentrations showed no trend, and 13 showed significantly improving trends. No area showed significant deteriorating trends (Figure 6). Reductions in sulfate and nitrate are primarily due to reductions in sulfur dioxide and nitrogen oxide emissions from electric utilities and industrial boilers required by the Acid Rain Program and the NO_x SIP Call in the East (EPA 2010).

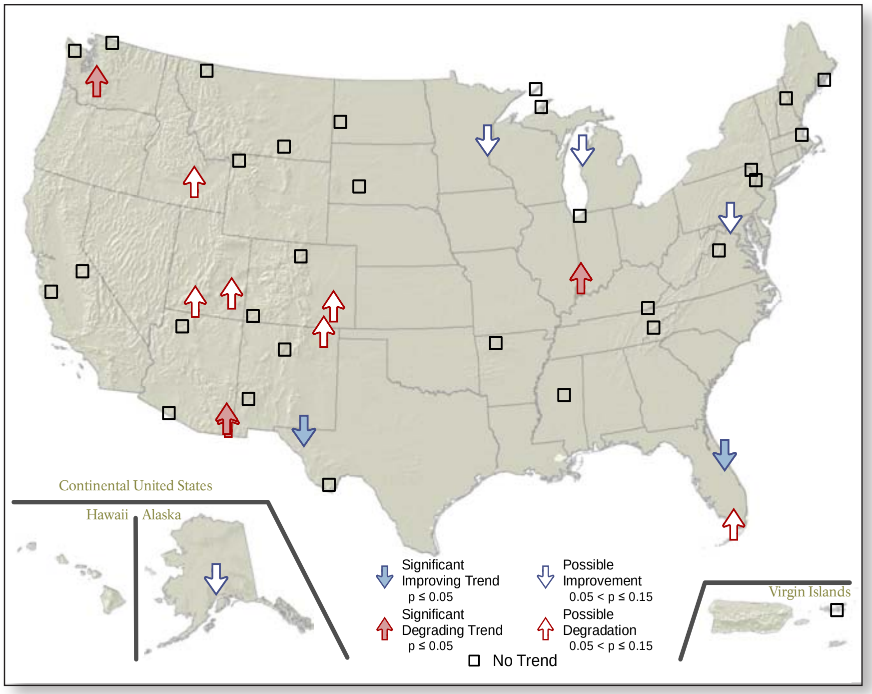

Figure 4. Trends in ammonium concentrations in precipitation, 1999–2008.

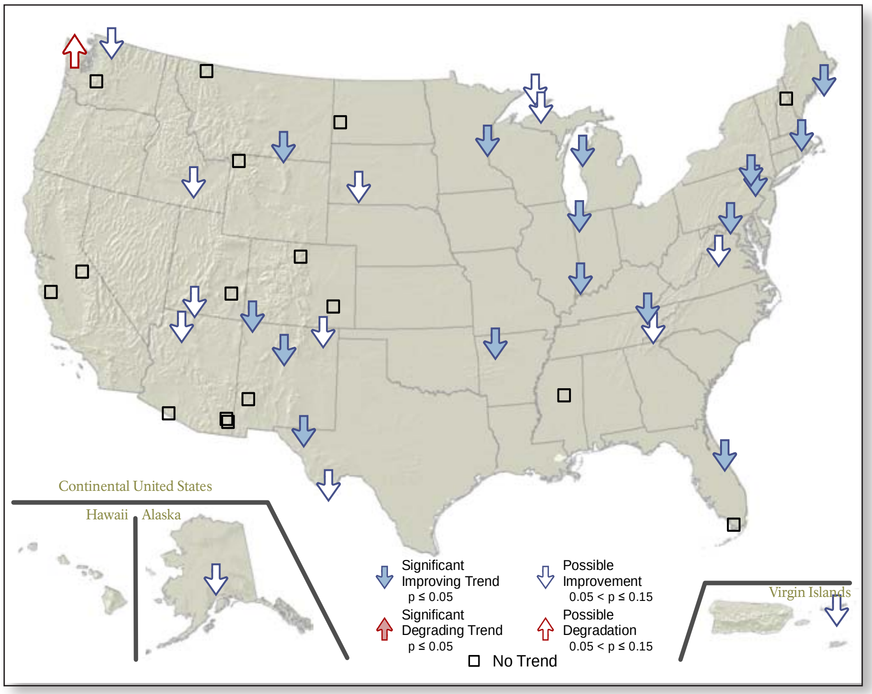

Figure 5. Trends in nitrate concentrations in precipitation, 1999–2008.

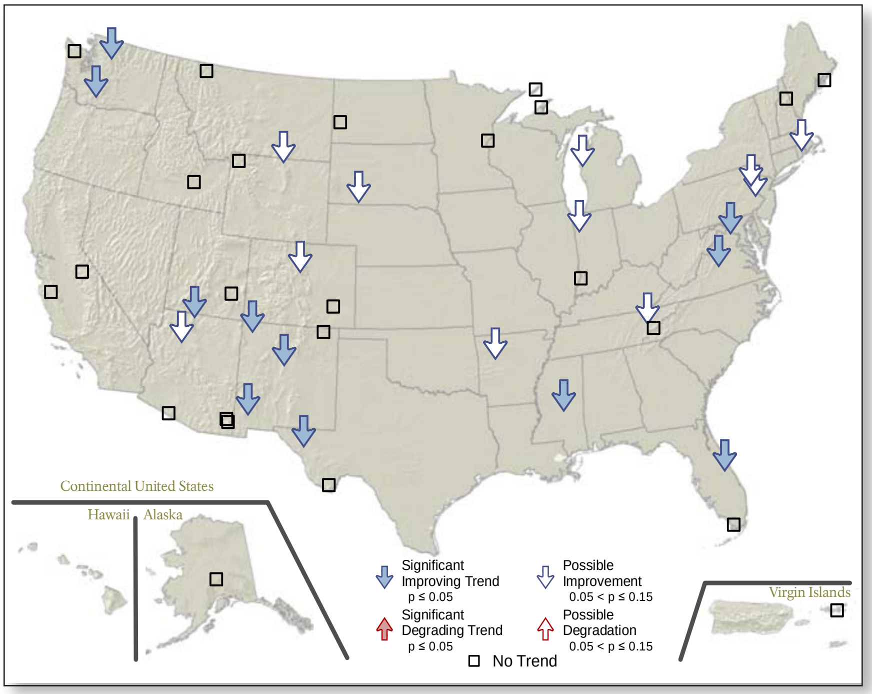

Figure 6. Trends in sulfate concentrations in precipitation, 1999–2008.

2. Measuring Success–Assessment of Air Quality Conditions and Trends

In addition to determining the trends in air quality, the NPS is interested in assessing the current condition of the air resources within NPS units. The absence of a deteriorating trend in air quality may not be sufficient to protect an area that is already experiencing poor air quality.

To assess condition, we first used all available monitoring data from NPS, EPA, state, tribal, and local monitors over the period 2004–2008 to estimate air quality parameters for the reported park units. These parameters were estimated by using the monitoring data to create an interpolation for each air quality parameter covering the lower 48 states. Estimated values for the air quality parameters were selected from the interpolation for individual parks (except for sites outside the continental US, where on-site monitor data were used instead). We then used these estimated values to determine an index for each type of air quality data collected (visibility, wet deposition, and ozone) that assigns the park to one of three condition categories where air quality is:

- in Good Condition,
- in Moderate Condition, or
- of Significant Concern.

For ozone and deposition, "good" air quality generally supports ecosystem health and is not expected to be harmful to natural resources, "moderate" air quality may affect very sensitive resources, and conditions that are of "significant concern" are at levels known to be harmful to sensitive resources or human health. For ozone or deposition, a rating of "significant concern" is not based on park-specific documented harm to resources, but rather potential impacts based on information from a broad body of scientific research. For visibility, condition is based on direct measurements of haze, interpolated for all parks. "Good" visibility is within 20 percent of natural background visibility, where "natural" is presumed to be free of human-caused haze, "moderate" visibility is from 20 to 80 percent hazier than natural conditions, and visibility of "significant concern" is greater than 80 percent hazier than natural conditions. The procedures for estimating the air quality parameters and assigning the condition categories are described in more detail in Appendix C.

2.1. Air Quality Condition Results

Appendix C gives the results of the air quality condition determinations for parks where we were also able to derive trend estimates. For each park, a blue circle indicates a park assigned to the good category for the indicated air quality parameter, a yellow circle indicates the park is assigned to the moderate (or caution) category, and a red circle indicates the park is assigned to the significant concern category. The category symbols in the Appendix C table are also overlaid with an up or down arrow to indicate the direction of the trend if one is present, or a double-headed arrow to indicate that there is no significant trend. Unlike the condition estimates, which were derived from an interpolation, the trends represented by the arrows were derived from data collected at individual monitors (as presented in Appendix B). A blue down arrow indicates a significant improving trend, a yellow double-headed horizontal arrow indicates no trend, and a red up arrow indicates a significant worsening trend. In the case of the nitrogen deposition and visibility trends, two trend indicators were combined to create one trend arrow, and the less favorable trend was chosen to represent the site. For nitrogen deposition, if the trend in the concentration of either nitrate or ammonium is degrading while the other is showing no trend or improving, an up arrow indicating a degrading trend is overlaid on

Scientists collecting data at the National Atmospheric Deposition Program (NADP) site in Rocky Mountain National Park, where precipitation samples have been collected for over 25 years.
Credit: National Park Service.

the condition symbol. If there is no trend in one form of nitrogen while the other is improving, a double-headed arrow indicating no trend is shown. Similarly, trends in visibility on clear days and hazy days were combined and overlaid on the visibility condition symbol. If a trend in one visibility metric is degrading while the other metric shows no trend or improvement, an arrow indicating a degrading trend is shown for that park, and if there is no trend in one indicator along with an improving trend in the other indicator, a double-headed arrow indicating no trend is shown. All up and down arrows represent significant trends (those with p-values ≤ 0.05).

The air quality condition results are shown graphically on maps in Figures 7–10 for parks where we were also able to derive trend estimates. Figure 7 shows the visibility conditions at park units. Only Denali and Lake Clark in Alaska fall into the good category. Most of the 89 parks in the moderate category are located in the western US, with a few in the upper Midwest and the Northeast. The 67 parks in the significant concern category are found mostly in the eastern and central US, with three located in California.

Air quality conditions for nitrogen wet deposition are shown in Figure 8. Only five sites—Denali, Virgin Islands, Canyonlands, Grand Canyon, and Pinnacles—fall into the good category. There are 11 parks that fall into the moderate category; these are located in the southwestern US, Washington, Montana, North and South Dakota, and Maine. The other 40 parks, comprising the majority of the monitored parks and located throughout the US, fall into the significant concern category. Sulfur wet deposition conditions are shown in Figure 9. The 26 parks in the good and moderate categories are located largely in the western US, along with a few in the upper Midwest. There are 30 parks in the significant concern category; they are found in the eastern US, Midwest, Colorado, Montana, and Washington State.

Results for the ozone condition assessment are shown in Figure 10. The 101 parks in the significant concern category are concentrated largely on the east and west coasts, with a few located near the Great Lakes region and eastern Texas. There are 45 that fall in the moderate category; these parks are located throughout the US. Only 10 parks fall in the good category, located in Alaska, North Dakota, Washington, Oregon, Montana, and the northern coast of California.

2.2. Longer Term Trends

The sliding 10-year trend period was originally chosen for trend reporting because different monitors began at different times, making it difficult to select a single common starting point, and because the 10-year time period reflects the most recent progress toward improving air quality. In addition to the 10-year trends already presented, we examined trends over longer time periods. Longer-term trends are useful for assessing overall progress made during the course of

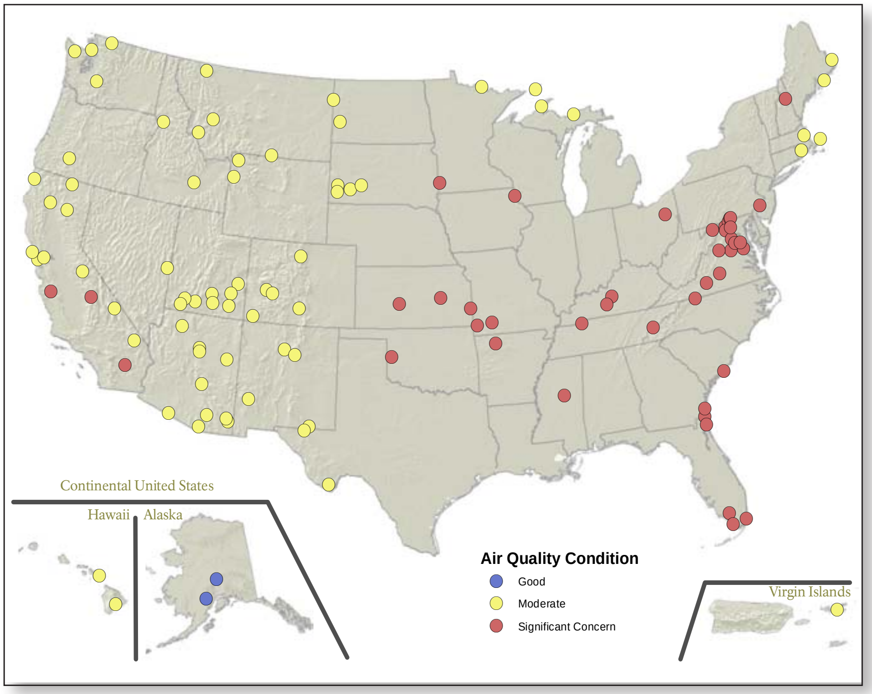

Figure 7. Air quality condition assessments for visibility.
Condition assessments derived from interpolations of average visibility conditions, 2004–2008.

each monitoring program, and for identifying parks that may be of special concern. For this evaluation we selected monitors located within park borders that had at least 10 years of monitoring beginning in 1998 or earlier and used all available data (since 1999 is the beginning of the current 10-year trend period used to evaluate strategic goals, trends beginning in 1999 and later have already been presented). We computed a trend for each of the six indicators used for measuring progress toward strategic goals. The results of these trends are presented below.

We evaluated long term progress in ozone concentrations using the annual 4th-highest 8-hour daily maximum ozone concentration. Each monitoring location was analyzed over the entire record of available data. We required that each year have at least 75% of possible valid daily 8-hour maximum ozone concentrations during the local ozone season in order for it to be used in the trend analysis. We generated long-term trends for 27 parks. The trend results and number of available years of data are presented in Table 3. Significant degrading trends were observed at Craters of the Moon, Denali, Mesa Verde, and Rocky Mountain. Despite the slight increase over the long term at Denali, ozone values there remain low, and are generally well below the current and proposed standards. Significant improving trends were found at Cape Cod, Mammoth Cave, one of the two monitoring locations in Acadia, and one of the four monitoring locations in Great Smoky Mountains. No significant trends were found for the other 19 parks listed in the table.

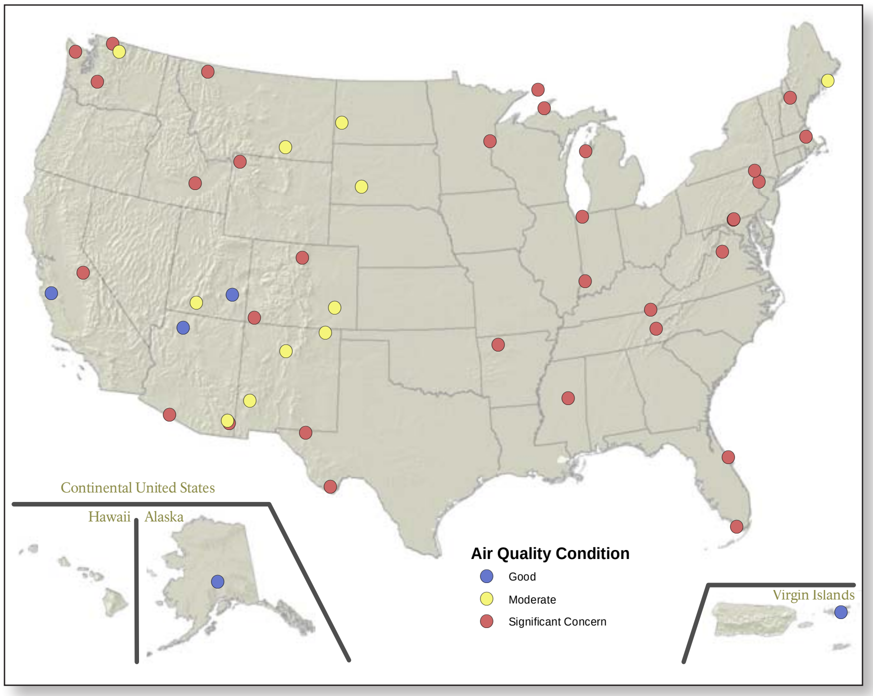

Figure 8. Air quality condition assessments for nitrogen deposition.
Condition assessments derived from interpolations of wet nitrogen deposition, 2004–2008.

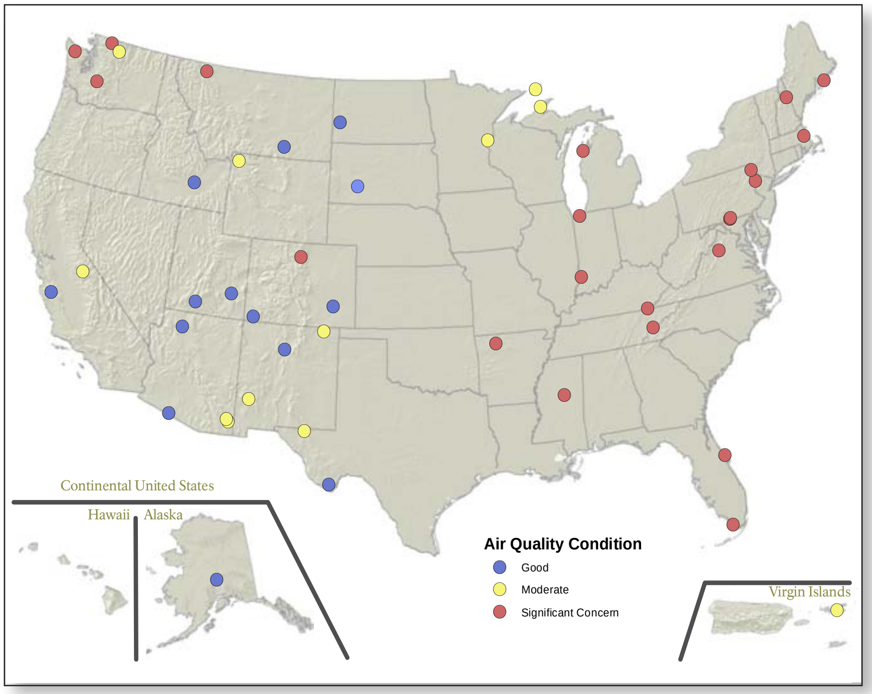

Figure 9. Air quality assessments for sulfur deposition.
Condition assessments derived from interpolations of wet sulfur deposition, 2004–2008.

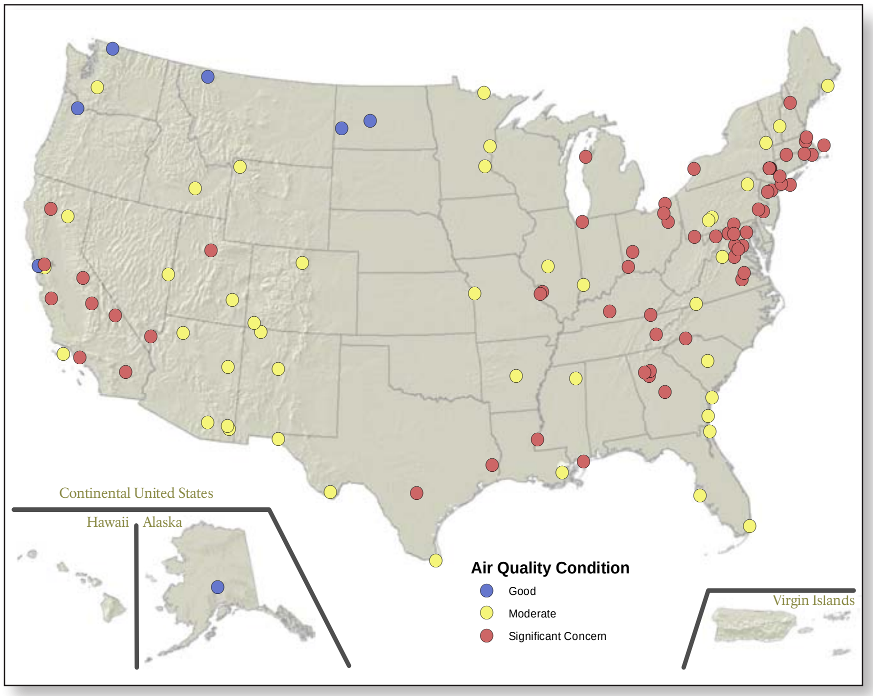

Figure 10. Air quality condition assessments for ozone.
Condition assessments derived from interpolated values of the mean annual 4th-highest 8-hour ozone concentrations, 2004–2008.

Table 3. Long-term trends in annual 4th-highest 8-hour daily maximum ozone concentration.

Park	Slope (ppb/year)	P-value	Number of Valid Years	First Year of Data	Last Year of Data
Acadia—Cadillac Mountain	-0.89	0.13	13	1996	2008
Acadia—McFarland Hill	-2.40	0.02	11	1998	2008
Big Bend	0.05	0.38	16	1992	2008
Canyonlands	0.32	0.18	16	1993	2008
Cape Cod	-1.00	<0.01	19	1989	2008
Chamizal	0.00	0.45	17	1992	2008
Chiricahua	0.09	0.25	18	1990	2008
Cowpens	-0.30	0.16	20	1989	2008
Craters Of The Moon	0.68	<0.01	13	1993	2008
Death Valley	0.25	0.23	14	1994	2008
Denali	0.33	<0.01	19	1990	2008
Glacier	0.15	0.21	20	1989	2008
Grand Canyon	0.00	0.48	16	1993	2008
Great Basin	0.17	0.22	15	1994	2008
Great Smoky Mountains—Purchase Knob	-0.89	0.08	13	1996	2008
Great Smoky Mountains—Look Rock	-0.15	0.31	19	1989	2008
Great Smoky Mountains—Cades Cove	-0.69	0.03	13	1995	2008
Great Smoky Mountains—Cove Mountain	-0.65	0.14	17	1991	2008
Joshua Tree	-0.50	0.22	15	1994	2008
Lassen Volcanic	0.16	0.19	20	1989	2008
Mammoth Cave	-2.70	<0.01	11	1998	2008
Mesa Verde	0.50	0.04	14	1994	2008
Mount Rainier	-0.25	0.23	14	1994	2008
Pinnacles	-0.32	0.06	20	1989	2008
Rocky Mountain	0.40	0.02	19	1989	2008
Saguaro	-0.03	0.36	20	1989	2008
Sequoia and Kings Canyon	0.00	0.46	20	1989	2008
Shenandoah	-0.25	0.25	20	1989	2008
Voyageurs	-0.50	0.08	11	1997	2007
Yellowstone	-0.05	0.27	12	1997	2008
Yosemite	-0.13	0.28	15	1994	2008

🟦	Improving air quality trend, statistically significant (p ≤ 0.05)	□	Possible improvement, not significant (0.05 < p ≤ 0.15)
🟥	Degrading air quality trend, statistically significant (p ≤ 0.05)	□	Possible degradation, not significant (0.05 < p ≤ 0.15)

An examination of the time series plots is helpful in identifying parks that may be of concern despite flat or improving trends. Several parks have annual 4th-highest 8-hour ozone concentrations that are consistently at or above the standard of 75 ppb. These parks include Great Smoky Mountains, Death Valley, Joshua Tree, Sequoia and Kings Canyon, Shenandoah, and Yosemite (see Figure 11). A number of other parks have ozone levels generally below the current standard, but within the EPA's proposed range for a new ozone standard. These parks include Canyonlands, Chiricahua, Great Basin, Grand Canyon, Big Bend, and Yellowstone (see Figure 12).

Long-term visibility trends were also calculated for park visibility monitors with at least 10 years of data beginning in 1998 or earlier. We calculated trends in deciview on the clearest and haziest days for the period of record at 29 locations. The results are shown in Table 4. On the clearest days, most sites indicated a significant improving trend. These locations include: Acadia, Badlands, Bandelier, Big Bend, Bryce Canyon, Canyonlands, Chiricahua, Crater Lake, Denali, Glacier, Great Basin, Great Sand Dunes, Great Smoky Mountains, Guadalupe Mountains, Lassen Volcanic, Mesa Verde, Mount Rainier, Petrified Forest, Pinnacles, Point Reyes, Redwood, Rocky Mountain, Shenandoah, Tonto, Washington D.C., Yellowstone, and Yosemite. No trend was observed on the best days at Mammoth Cave or Sequoia. On the haziest days, significant improving trends occurred at Acadia, Canyonlands, Denali, Great Smoky Mountains, Mount Rainier, Pinnacles, Point Reyes, Redwood, Shenandoah, and Washington D.C. A significant degrading trend was found at Guadalupe Mountains.

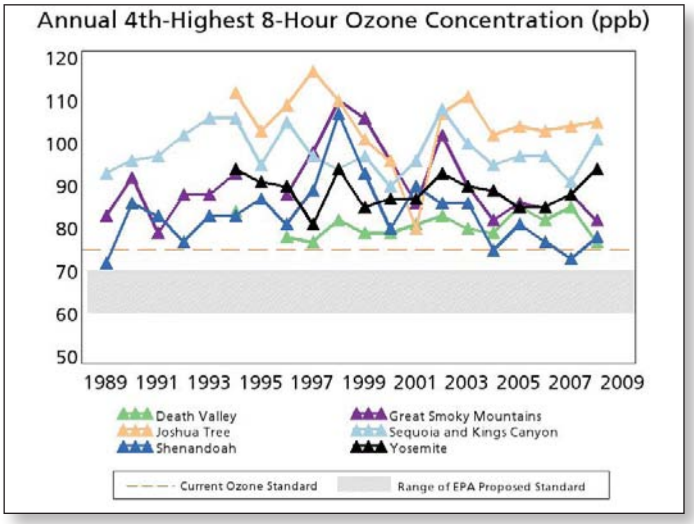

Figure 11. Long-term ozone trends in parks at or above the ozone standard.
The annual 4th-highest daily maximum 8-hour ozone concentration at these parks has been consistently at or above the ozone standard of 75 ppb.

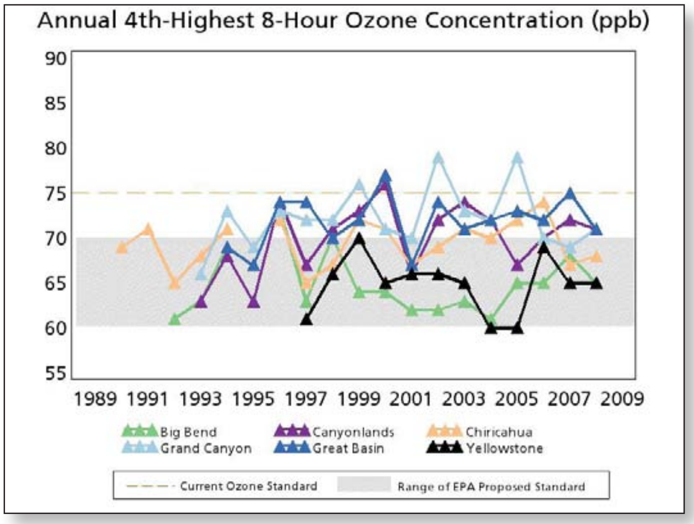

Figure 12. Long-term ozone trends in parks likely to exceed the new ozone standard.
Ozone levels at these parks have been generally below the current standard of 75 ppb, but are within the EPA's proposed range (60–70 ppb) for a new ozone standard.

Table 4. Long-term trends in annual deciview (dv) on clearest and haziest days.

Park	Clearest Days		Haziest Days		Number of Valid Years	First Year of Data	Last Year of Data
	Slope (dv/year)	P-value	Slope (dv/year)	P-value			
Acadia	-0.18	<0.01	-0.26	<0.01	19	1990	2008
Badlands	-0.04	0.04	-0.04	0.10	20	1989	2008
Bandelier	-0.10	<0.01	-0.07	0.08	18	1989	2008
Big Bend	-0.10	<0.01	0.04	0.14	17	1990	2008
Bryce Canyon	-0.10	<0.01	0.03	0.11	18	1990	2008
Canyonlands	-0.16	<0.01	-0.10	<0.01	19	1990	2008
Chiricahua	-0.11	<0.01	-0.05	0.13	19	1990	2008
Crater Lake	-0.17	<0.01	0.00	0.46	14	1992	2008
Denali	-0.10	<0.01	-0.10	<0.01	20	1989	2008
Glacier	-0.11	<0.01	-0.07	0.11	18	1989	2008
Great Basin	-0.15	<0.01	0.04	0.23	16	1993	2008
Great Sand Dunes	-0.09	<0.01	-0.01	0.41	20	1989	2008
Great Smoky Mountains	-0.09	0.02	-0.15	<0.01	19	1990	2008
Guadalupe Mountains	-0.08	<0.01	0.12	0.02	18	1989	2008
Lassen Volcanic	-0.10	<0.01	0.07	0.07	20	1989	2008
Mammoth Cave	-0.03	0.25	-0.12	0.06	15	1992	2008
Mesa Verde	-0.08	<0.01	0.02	0.44	18	1989	2008
Mount Rainier	-0.15	<0.01	-0.38	<0.01	18	1989	2008
Petrified Forest	-0.07	<0.01	0.05	0.17	17	1990	2008
Pinnacles	-0.11	<0.01	-0.17	<0.01	18	1989	2008
Point Reyes	-0.07	<0.01	-0.13	0.02	17	1989	2008
Redwood	-0.14	<0.01	-0.17	<0.01	20	1989	2008
Rocky Mountain	-0.11	<0.01	0.00	0.50	18	1991	2008
Sequoia and Kings Canyon	-0.02	0.38	-0.14	0.18	11	1994	2008
Shenandoah	-0.19	<0.01	-0.27	<0.01	18	1990	2008
Tonto	-0.12	<0.01	-0.01	0.39	15	1991	2008
Washington	-0.20	<0.01	-0.25	<0.01	18	1990	2008
Yellowstone	-0.10	<0.01	0.16	0.22	11	1997	2008
Yosemite	-0.10	<0.01	0.04	0.27	20	1989	2008

🟦	Improving air quality trend, statistically significant (p ≤ 0.05)	▨	Possible improvement, not significant (0.05 < p ≤ 0.15)
🟥	Degrading air quality trend, statistically significant (p ≤ 0.05)	▧	Possible degradation, not significant (0.05 < p ≤ 0.15)

Although a majority of the observed trends over the long-term are favorable (either improving or not degrading), visibility at all parks suffers from at least some impairment, particularly on the haziest days. Annual mean deciview values on the haziest days at 47 NPS locations with visibility monitoring data during the period 2006–2008 ranged from 1.5 dv to 21 dv higher than estimated natural conditions and averaged approximately 8.3 dv higher than estimated natural conditions. Eastern sites such as Acadia, Great Smoky Mountains, Mammoth Cave, and Shenandoah have consistently experienced annual mean deciview values on the haziest days well in excess of estimated natural conditions (Figures 13–16). Some western parks, such as Mount Rainier, Pinnacles, Glacier, and Yosemite, also experience haze levels well above estimated natural conditions, although long-term trends at Mount Rainier and Pinnacles suggest that conditions on the haziest days are improving (Figures 17–20).

Visibility conditions on the clearest days are also impaired, although to a lesser degree. At all NPS sites with data during 2006–2008, mean deciview values on the clearest days ranged from 0.7 to 11 dv above estimated natural conditions, and averaged roughly 3.3 dv above estimated natural conditions. All but two of the 29 monitoring locations evaluated for long-term trends show significant improving trends on the clearest days, while the remaining two show no trends. Monitoring locations with the greatest differences between measured visibility on the clearest days and estimated natural conditions include Washington D.C., Shenandoah, Mammoth Cave, and Great Smoky Mountains (Figures 21–24).

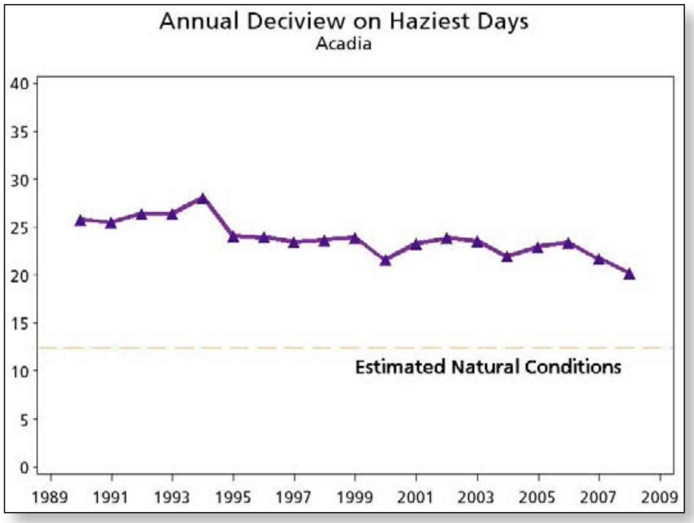

Figure 13. Annual deciview at Acadia.

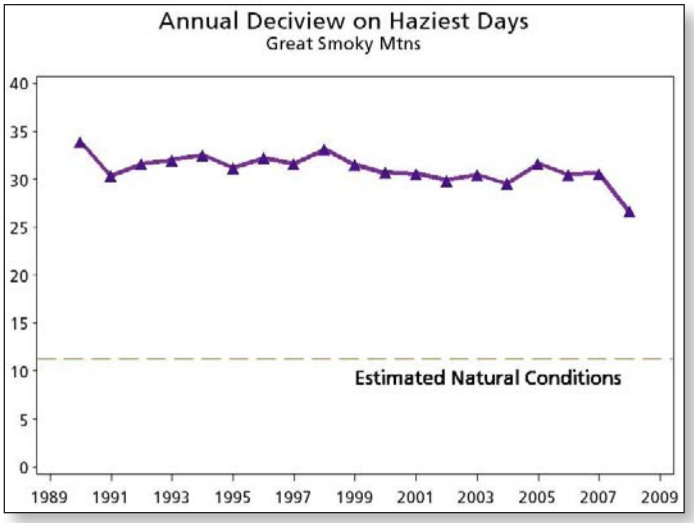

Figure 14. Annual deciview at Great Smoky Mountains.

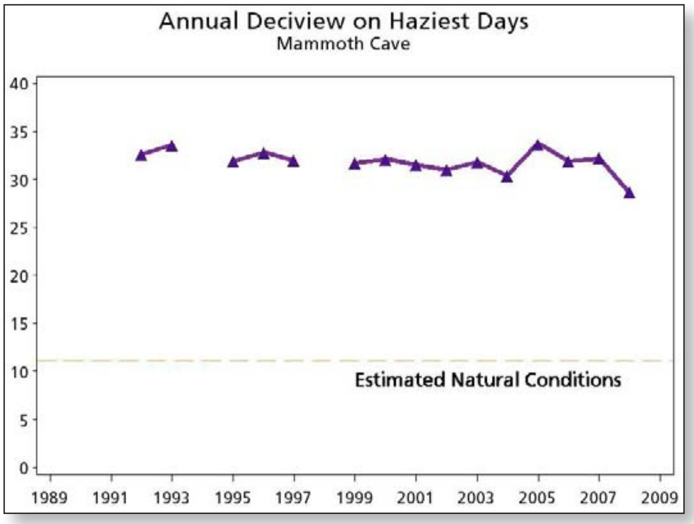

Figure 15. Annual deciview at Mammoth Cave.

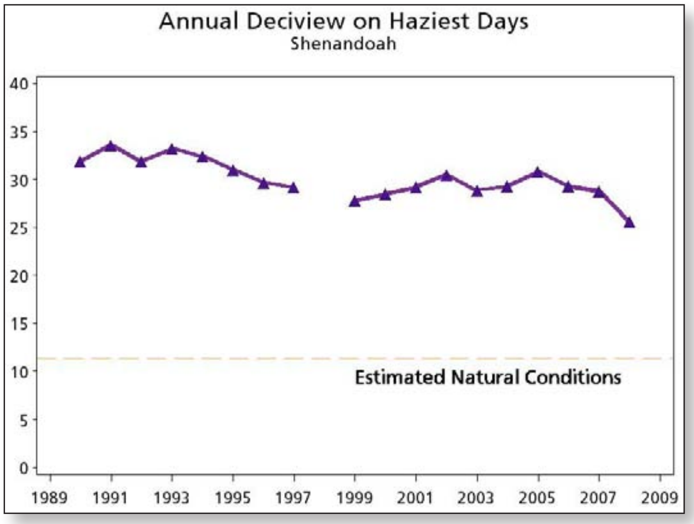

Figure 16. Annual deciview at Shenandoah.

Figures 13–16: Visibility monitoring data from Acadia, Great Smoky Mountains, Mammoth Cave, and Shenandoah National Parks shows annual mean deciview values on the haziest days that are well in excess of estimated natural conditions.

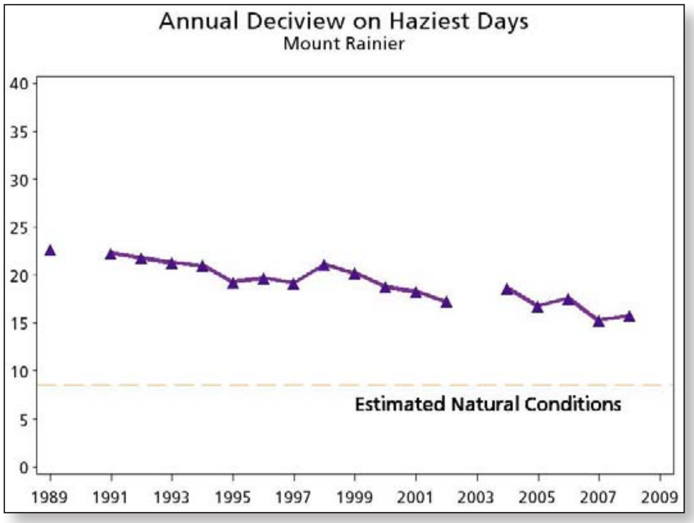

Figure 17. Mean deciview values on the haziest days at Mount Rainier.
Haze levels on the haziest days remain above estimated natural conditions, although long-term trends suggest conditions are improving.

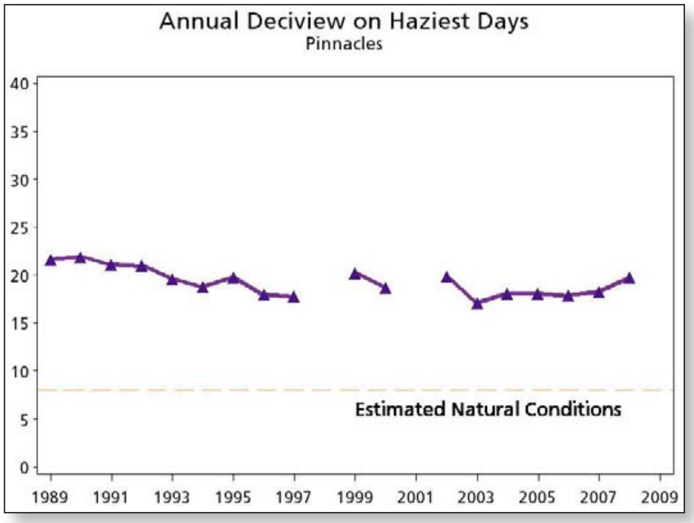

Figure 18. Mean deciview values on the haziest days at Pinnacles.
Haze levels on the haziest days remain above estimated natural conditions, although long-term trends suggest conditions are improving.

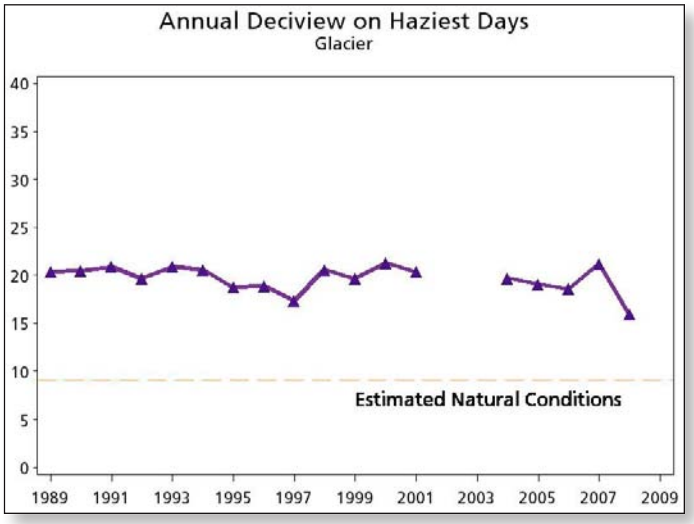

Figure 19. Mean deciview values on the haziest days at Glacier.
Haze levels on the haziest days remain above estimated natural conditions.

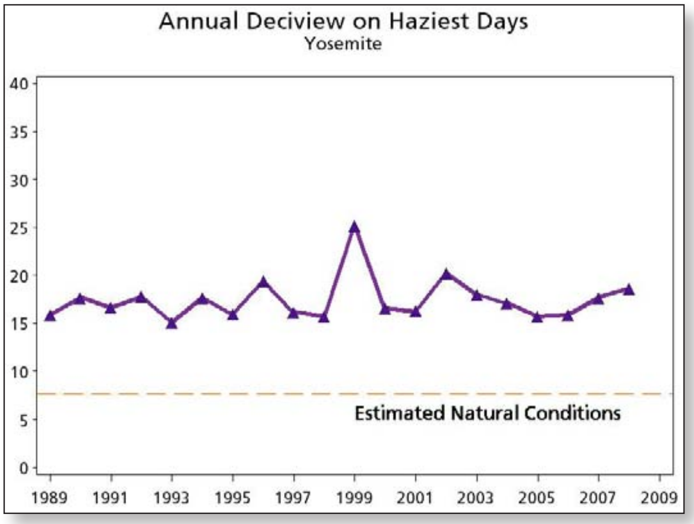

Figure 20. Mean deciview values on the haziest days at Yosemite.
Haze levels on the haziest days remain above estimated natural conditions.

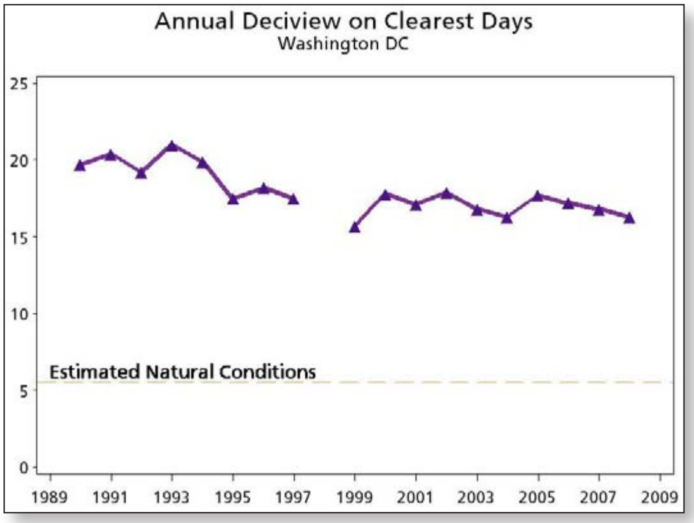

Figure 21. Mean deciview values on the clearest days at Washington D.C..
Haze levels on the clearest days remain well above estimated natural conditions at these locations.

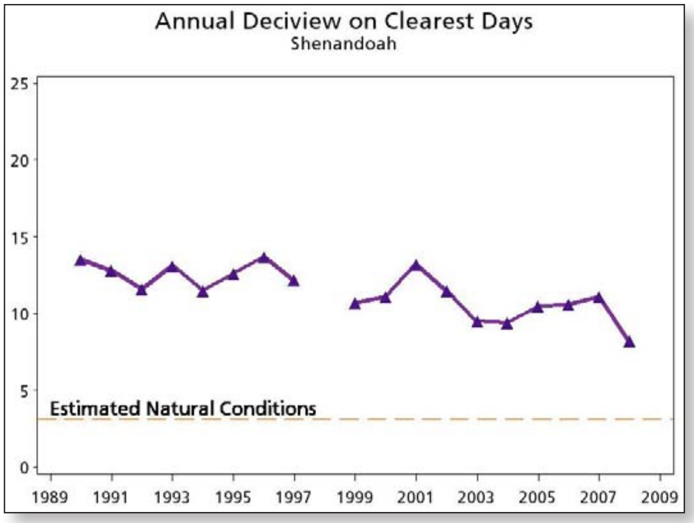

Figure 22. Mean deciview values on the clearest days at Shenandoah.
Haze levels on the clearest days remain well above estimated natural conditions at these locations.

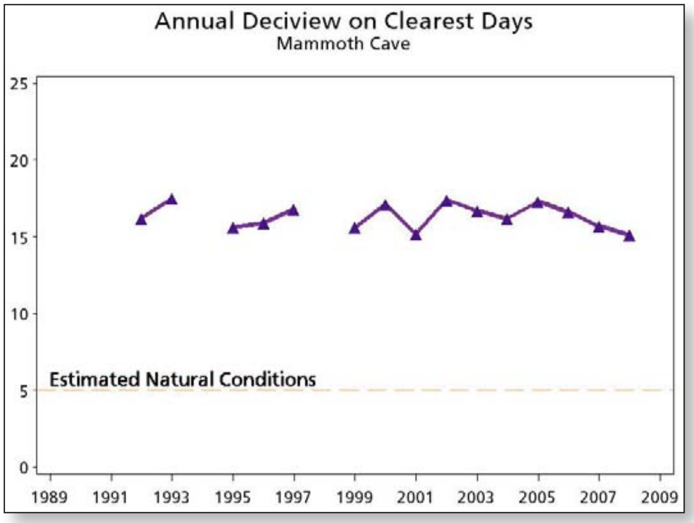

Figure 23. Mean deciview values on the clearest days at Mammoth Cave.
Haze levels on the clearest days remain well above estimated natural conditions at this location.

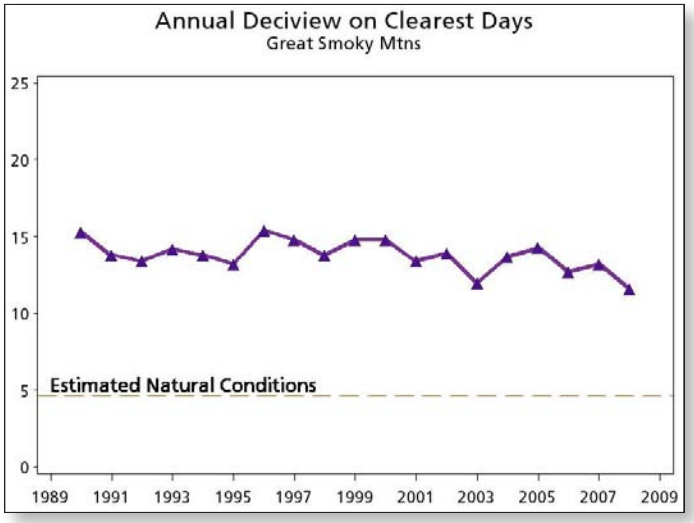

Figure 24. Mean deciview values on the clearest days at Great Smoky Mountains.
Haze levels on the clearest days remain well above estimated natural conditions at this location.

Long-term trends in concentrations of ammonium, nitrate, and sulfate in wet deposition were calculated for park monitors with 10 years or more of data beginning in 1998 or earlier (two monitors, those used to evaluate Mount Rainier and Isle Royale, are outside the parks' boundaries). In last year's report, only data collected from 1994 and later were considered due to changes in measured concentrations that occurred as a result of a change in sample handling procedures.[7] A subsequent review concluded that the change did not significantly affect sulfate, nitrate, or ammonium data, and trend analyses have been published elsewhere that used data collected prior to 1994 (e.g., Lehmann et al. 2004). For this report, we calculated long-term trends in ammonium, nitrate, and sulfate concentrations using the entire data record for each site. The results are shown in Table 5. There were 29 monitoring locations with sufficient data for long-term trends. Eleven of the 29 locations exhibited significant degrading trends in ammonium concentrations (Bandelier, Bryce Canyon, Canyonlands, Capulin Volcano, Craters of the Moon, Gila Cliff Dwellings, Glacier, Mesa Verde, Rocky Mountain, Yellowstone, and Yosemite). Only two parks (Olympic and North Cascades) observed a significant improving trend in ammonium concentrations. Parks with the lowest ammonium concentrations include Denali, North Cascades, Olympic, Pinnacles, and Virgin Islands (Figure 25). Parks with the highest ammonium concentrations include Capulin Volcano, Chiricahua, Indiana Dunes, Rocky Mountain, and Theodore Roosevelt (Figure 26).

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[7] See NADP data advisory, http://nadp.sws.uiuc.edu/documentation/advisory.html.

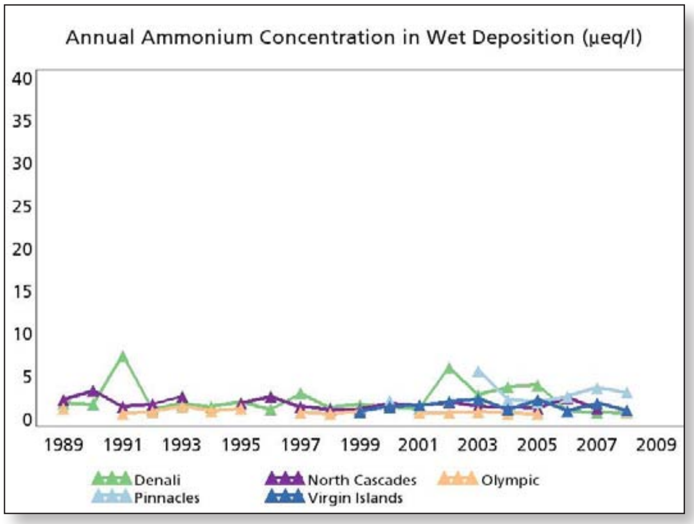

Figure 25. Parks with comparatively low concentrations of ammonium.

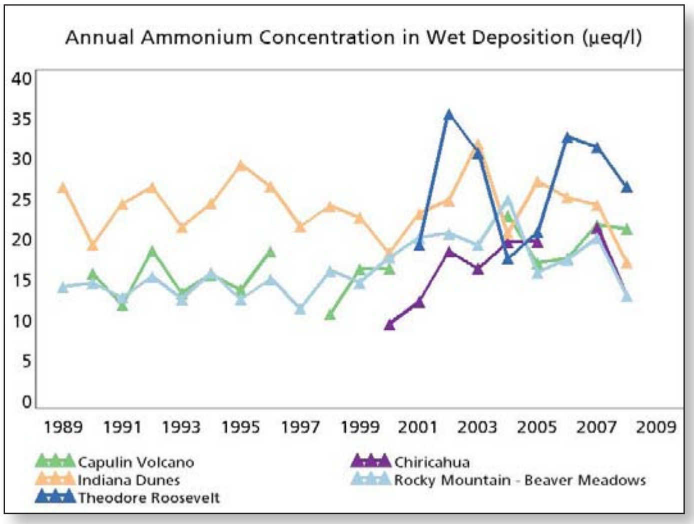

Figure 26. Parks with comparatively high concentrations of ammonium.

Table 5. Long-term trends in wet deposition concentrations.

Park	Ammonium		Nitrate		Sulfate		Number of Valid Years	First Year of Data	Last Year of Data
	Slope (meq/ liter/yr)	P-value	Slope (meq/ liter/yr)	P-value	Slope (meq/ liter/yr)	P-value			
Acadia	-0.03	0.42	-0.28	<0.01	-0.57	<0.01	19	1989	2008
Bandelier	0.23	<0.01	0.10	0.22	-0.28	<0.01	19	1989	2008
Big Bend	-0.18	0.25	-0.25	0.02	-0.51	0.07	18	1989	2008
Bryce Canyon	0.33	0.04	-0.13	0.14	-0.42	<0.01	14	1989	2008
Buffalo	0.00	0.52	-0.17	0.03	-0.54	<0.01	17	1989	2008
Canyonlands	0.64	0.02	0.05	0.43	-0.05	0.36	10	1998	2008
Cape Cod	-0.06	0.19	-0.34	0.04	-0.69	<0.01	10	1989	2008
Capulin Volcano	0.36	0.01	0.04	0.35	-0.14	0.06	15	1990	2008
Craters Of The Moon	0.30	0.04	-0.07	0.24	-0.29	<0.01	19	1989	2007
Denali	-0.04	0.14	-0.02	0.14	-0.03	0.19	20	1989	2008
Everglades	-0.01	0.48	-0.04	0.10	-0.00	0.52	16	1989	2008
Gila Cliff Dwellings	0.35	<0.01	0.47	0.04	-0.31	0.05	16	1989	2007
Glacier	0.11	0.02	0.03	0.25	-0.16	<0.01	20	1989	2008
Grand Canyon	0.15	0.10	-0.03	0.45	-0.18	0.05	16	1989	2008
Great Basin	0.13	0.30	-0.24	0.08	-0.26	<0.01	13	1990	2006
Great Smoky Mountains	0.02	0.42	-0.18	<0.01	-0.62	<0.01	19	1990	2008
Guadalupe Mountains	0.06	0.35	-0.16	0.15	-0.56	0.04	18	1989	2008
Indiana Dunes	-0.07	0.39	-0.49	<0.01	-1.40	<0.01	20	1989	2008
Isle Royale	0.27	<0.01	-0.08	0.08	-0.49	<0.01	18	1989	2008
Little Bighorn Battlefield	0.18	<0.01	-0.06	0.14	-0.26	<0.01	20	1989	2008
Mesa Verde	0.16	0.05	0.06	0.31	-0.58	<0.01	19	1990	2008
Mount Rainier	-0.02	0.25	-0.04	0.16	-0.31	<0.01	15	1989	2006
North Cascades	-0.05	0.04	-0.05	0.08	-0.15	<0.01	18	1989	2007
Olympic	-0.02	0.05	-0.00	0.42	0.05	0.07	15	1989	2008
Organ Pipe Cactus	0.42	0.07	0.35	0.10	-0.03	0.41	18	1989	2008
Rocky Mountain	0.33	<0.01	0.08	0.27	-0.24	<0.01	20	1989	2008
Shenandoah	-0.05	0.20	-0.28	0.01	-0.77	<0.01	17	1989	2008
Yellowstone	0.20	<0.01	-0.00	0.45	-0.12	0.07	19	1989	2008
Yosemite	0.23	0.10	-0.11	0.16	-0.04	0.31	15	1989	2007

🟦 Improving air quality trend, statistically significant ($p \le 0.05$)

⬜ Possible improvement, not significant ($0.05 < p \le 0.15$)

🟥 Degrading air quality trend, statistically significant ($p \le 0.05$)

▫ Possible degradation, not significant ($0.05 < p \le 0.15$)

Significant improving trends in nitrate concentrations were found at seven monitoring locations (Acadia, Big Bend, Buffalo, Cape Cod, Great Smoky Mountains, Indiana Dunes, and Shenandoah) and a significant degrading trend was found at one location (Gila Cliff Dwellings); no significant trends in nitrate concentrations were found at the remaining monitors. Parks with the lowest nitrate concentrations include Denali, North Cascades, Olympic, Pinnacles, and Virgin Islands (Figure 27). Parks with the highest nitrate concentrations include Canyonlands, Chiricahua, Indiana Dunes, Mesa Verde, and Rocky Mountain (Figure 28).

Sulfate concentrations in precipitation showed significant improvement at 20 NPS monitoring locations (Acadia, Bandelier, Bryce Canyon, Buffalo, Cape Cod, Craters of the Moon, Gila Cliff Dwellings, Glacier, Grand Canyon, Great Basin, Great Smoky Mountains, Guadalupe Mountains, Indiana Dunes, Isle Royale, Little Bighorn, Mesa Verde, Mount Rainier, North Cascades, Rocky Mountain, and Shenandoah). No long-term trends in sulfate concentrations were found at the remaining nine NPS monitoring locations. Parks with the lowest sulfate concentrations include Denali, North Cascades, Olympic, Pinnacles, and Yosemite (Figure 29). Parks with the highest sulfate concentrations include Acadia, Cape Cod, Great Smoky Mountains, Indiana Dunes, and Shenandoah (Figure 30).

A number of parks also have mercury wet deposition monitors. Mercury is of particular concern because it is toxic to animals and people. Mercury is primarily emitted

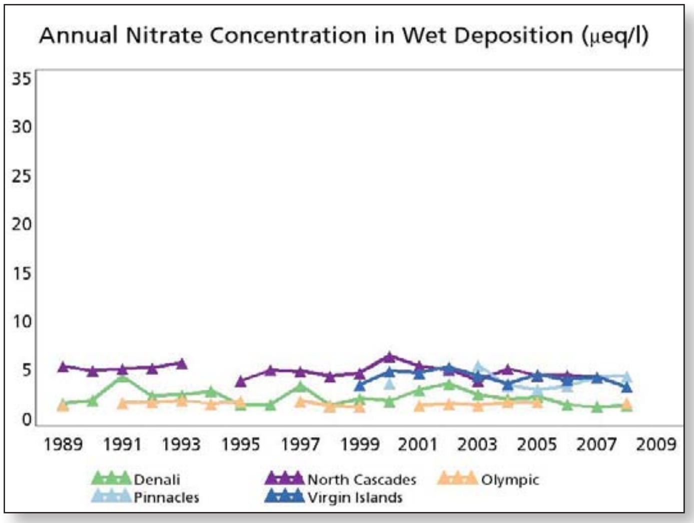

Figure 27. Parks with comparatively low nitrate concentrations.

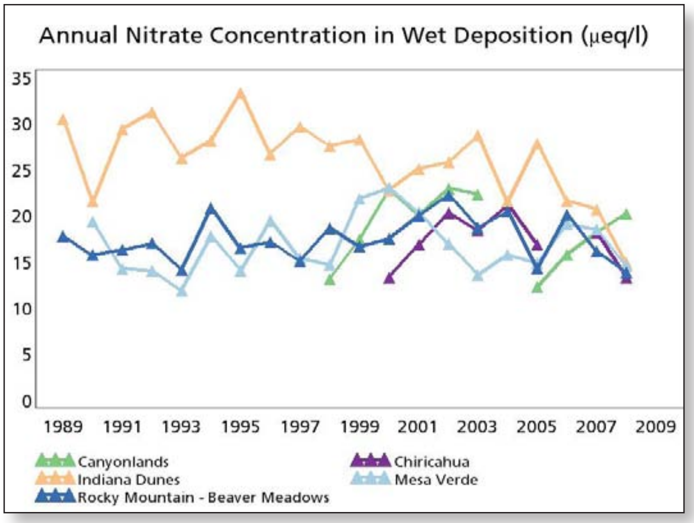

Figure 28. Parks with comparatively high nitrate concentrations.

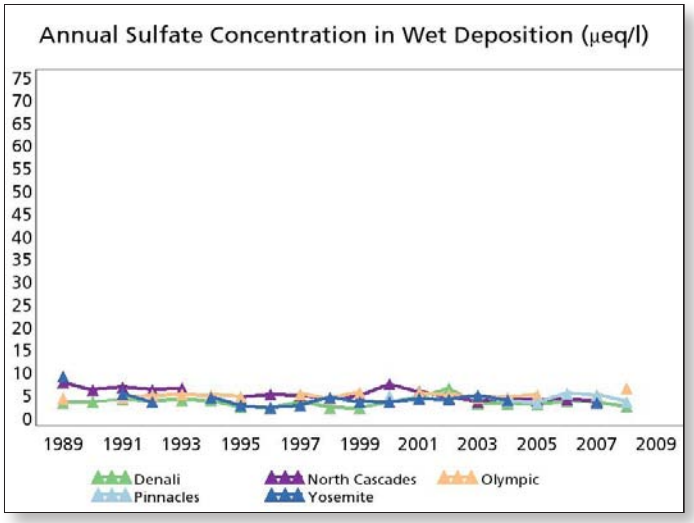

Figure 29. Parks with comparatively low sulfate concentrations.

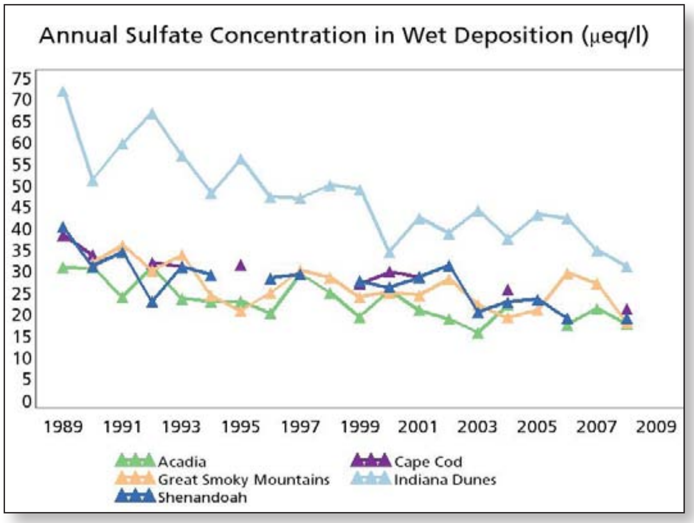

Figure 30. Parks with comparatively high sulfate concentrations.

by the burning of coal in power plants. Atmospheric mercury that is deposited to surface waters can change into toxic methylmercury, which can then enter the food chain. Methylmercury that enters the food chain tends to accumulate in organisms as it moves higher in the chain. Animals and people who eat fish contaminated with mercury are at greatest risk for mercury exposure.

Mercury monitors in parks have not been in operation as long as other deposition monitors, but there are now nine parks with sufficiently long data records for trend analysis. Results of the trend analyses are given in Table 6. All available years of data were used. Two parks, Allegheny Portage and Indiana Dunes, show significant improving trends in mercury concentrations. None of the other seven parks (Acadia, Congaree, Everglades, Great Smoky Mountains, Mammoth Cave, Mesa Verde, and Shenandoah) show any significant trends.

High concentrations of mercury in precipitation may be indicative of a large nearby source of mercury, like a coal-burning power plant. However, ecosystem impacts are the result of mercury deposition and ecosystem processes that transform deposited mercury into methylmercury. Three-year means of annual mercury wet deposition were computed for 13 parks with at least two years of valid data during the time period 2006–2008. The results are shown in Figure 31. In addition, the 3-year mean for the remaining non-NPS mercury deposition monitors is indicated on the figure by the red horizontal line. Parks with deposition above the mean include Everglades, Great Smoky Mountains, Indiana Dunes, Mammoth Cave, and Shenandoah. The parks with the lowest wet deposition were Mesa Verde, Sequoia, Yellowstone, and Craters of the Moon.

Table 6. Trends in mercury wet deposition concentrations.

Park	Slope (ng/liter/yr)	P-value	Number of Valid Years	First Year of Data	Last Year of Data
Acadia	-0.08	0.16	12	1997	2008
Allegheny Portage Railroad	-0.17	0.02	12	1997	2008
Congaree	-0.18	0.06	11	1997	2008
Everglades	-0.11	0.22	13	1996	2008
Great Smoky Mountains	-0.22	0.19	7	2002	2008
Indiana Dunes	-0.56	0.03	8	2001	2008
Mammoth Cave	0.05	0.36	6	2003	2008
Mesa Verde	-0.28	0.50	7	2002	2008
Shenandoah	0.45	0.14	6	2003	2008

🟦	Improving air quality trend, statistically significant ($p \le 0.05$)	⬜	Possible improvement, not significant ($0.05 < p \le 0.15$)
🟥	Degrading air quality trend, statistically significant ($p \le 0.05$)	⬜	Possible degradation, not significant ($0.05 < p \le 0.15$)

2.3. Ozone Exposure

In January 2010 the EPA proposed a new secondary ozone standard.[8] Secondary standards set limits to protect public welfare, including protection against damage to vegetation. Ozone causes visible injury to sensitive plants and may also reduce growth. The proposed standard is based upon a cumulative sum of hourly ozone concentrations, where the hourly values are weighted according to their magnitude. This sum provides an index of the total amount of ozone that plants are exposed to during the daytime. The three-month period with the highest cumulative exposure index is used as the reporting statistic, which is referred to as the W126 statistic (more details on how this value is calculated are provided in Appendix D). The units of the W126 statistic are ppm-hours. In last year's report, we reported W126 values based upon a previously proposed (July 2007) W126-based secondary standard that was not ultimately adopted by EPA.[9] The January 2010 proposal prescribes a slightly different method for calculating the W126 annual metric, and bases the standard on a 3-year average of the annual metric rather than the annual value itself. We have calculated new W126 values based upon the new proposal; however, some portions of the calculation that specify methods for handling missing data have not yet been fully implemented by EPA. As a result, our values are preliminary and could change slightly once the secondary standard is finalized.

The EPA has proposed to set the level of the new secondary standard in the range of 7–15 ppm-hours. Table 7 shows parks with on-site monitoring that had W126 index values at or above 7 ppm-hours in 2008. There were 26 parks that equaled or exceeded this exposure value, which is at the lower end of the range of the proposed EPA standard. There were 17 parks (Canyonlands, Chiricahua, Death Valley, Grand Canyon, Great Basin, Great Smoky Mountains, Joshua Tree, Lassen Volcanic, Mammoth Cave, Mesa Verde, Petrified Forest, Pinnacles, Rocky Mountain, Saguaro, Sequoia and Kings Canyon, Yosemite, and Zion) that exceeded the upper end of the proposed range of 15 ppm-hours. Parks with 3-month maximum ozone exposures between 7 and 15 ppm-hours include Acadia, Big Bend, Cape Cod, Chamizal, Congaree, Cowpens, Shenandoah, Wind Cave, and Yellowstone.

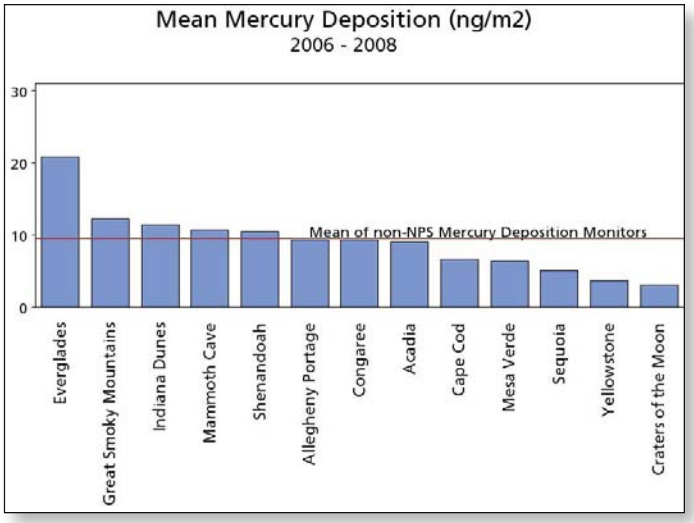

Figure 31. Mean mercury wet deposition.
Three-year means of annual mercury wet deposition for parks with at least two years of valid data during the time period 2006–2008.

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[8] See Federal Register Vol. 75 No. 11, 40 CFR Parts 50 and 58, National Ambient Air Quality Standards for Ozone, Proposed Rules, January 19, 2010, p. 2938.

[9] See Federal Register Vol. 72 No. 132, 40 CFR Part 50, National Ambient Air Quality Standards for Ozone, A Proposed Rule, July 11, 2007.

Table 7. Monitoring locations with 3-year average of the annual maximum 3-month W126 greater than or equal to 7 ppm-hrs (2008).

Park	3-year Average Maximum 3-month W126 (ppm-hrs)
Acadia	9
Big Bend	11
Canyonlands	17
Cape Cod	13
Chamizal	13
Chiricahua	17
Congaree	10
Cowpens	13
Death Valley	29
Grand Canyon	19
Great Basin	16
Great Smoky Mountains	22
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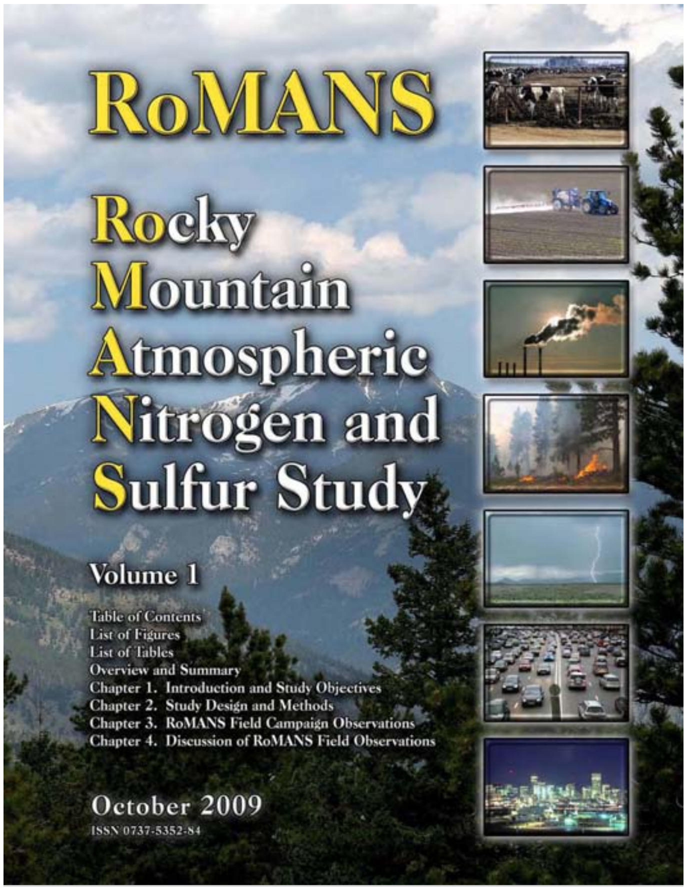
3. Producing Results–Information and Collaboration

Making progress toward meeting park air quality goals is challenging because while we are given a consultation role under the Clean Air Act, the NPS has no direct authority to control sources of pollution located outside park boundaries. In order to achieve park air quality goals, the NPS works collaboratively with federal and state air regulatory agencies, as well as neighboring land management agencies, to enhance and protect air quality in the parks to the greatest extent possible. These goals are also achieved by understanding and sharing information about air quality conditions and trends in parks with regulatory agencies and the public, which supports or helps shape federal and state air pollution control programs. Information on air quality conditions and trends in parks has provided the impetus for a number of collaborative efforts with states, tribes, EPA, the private sector, and the public to protect and improve air quality in parks. Some of these efforts are described below.



RoMANS

Rocky
Mountain
Atmospheric
Nitrogen and
Sulfur Study

Volume 1

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The Rocky Mountain Atmospheric Nitrogen and Sulfur Study (RoMANS) assessed the source regions of nitrogen and sulfur that affect deposition and visibility at Rocky Mountain National Park.
Credit: National Park Service.

3.1. Visibility and Regional Haze

NPS is continuing to consult with states on their Regional Haze State Implementation Plans that are designed to reduce visibility impairment caused by haze-producing pollutants. States must inform the public of federal land manager concerns and respond to those concerns before submitting the plans for approval to the EPA. The visibility protection plans were due to EPA from all 50 states in December, 2007 and must include strategies for making reasonable progress toward natural visibility conditions. As of November, 2010, 32 of 53 states, territories, and municipalities that are required to submit regional haze implementation plans to EPA had done so. EPA is requiring those states that have not completed the State Implementation Plans to deliver those plans by January 2011. The NPS has focused its comments on state actions to retrofit certain larger industrial facilities with pollution control devices and the long-term programs that states will implement to achieve progress towards natural visibility conditions at the Class I parks. We expect major reductions in visibility-impairing pollutants as a result of these efforts.

NPS is working closely with the U.S. Fish and Wildlife Service and the U.S. Forest Service to review regional haze plans since they also manage Class I units.

3.2. Ecosystem Protection Initiatives

The NPS has been encouraging the use of critical loads for atmospheric deposition to assess ecological health and the effectiveness of air pollution control programs. A critical load is the amount of a pollutant, usually nitrogen or sulfur in deposition, below which harmful environmental effects are not known to occur. NPS is cooperating with EPA, other federal land management agencies, states and scientists to develop research, monitoring, and modeling approaches for critical loads.

Studies on the ecological effects of air pollution in national parks are currently ongoing through agreements with researchers at universities and other federal agencies. Research projects are underway to assess the effects of nitrogen, sulfur or mercury deposition on plants, soils or waters in many national parks. For example, the effects of excess nitrogen on plant communities and soil nutrient cycling are being examined at Acadia, Voyageurs, Rocky Mountain, Grand Teton, Grand Canyon, Sequoia, Yosemite, Joshua Tree, Isle Royale, and parks in the National Capital Region and the Northern Great Plains Network. Acidification of soils and streams from sulfur and nitrogen deposition is being evaluated at Great Smoky Mountains, Shenandoah, and the Appalachian Trail. Mercury bioaccumulation is being examined at Acadia and at Mammoth Cave and other parks in the Cumberland Piedmont Network.

3.3. Assessing Air Pollution Risk to NPS Resources

The NPS Inventory and Monitoring Program has enabled broad regional and national-scale assessments of air pollution effects and resource sensitivities to air quality changes in parks. Scientists from universities, government agencies, and the private sector have assessed air pollution risks for 270 national parks. Natural resource risk assessments have been completed for ozone (Kohut 2007), and are underway for mercury, acid deposition, and excess nitrogen impacts.

3.4. Natural Resource Condition Assessments

The NPS is conducting assessments to determine the current conditions for important natural resources in all parks that are part of the NPS Inventory and Monitoring Program. Each assessment relies on existing data and knowledge, is focused on a park-specific subset of important resource indicators, and summarizes overall conditions by individual park area. The Air Resources Division is providing guidance, data, and information to assess air quality conditions for ozone, deposition, and visibility as part of the park assessments.[10]

3.5. Rocky Mountain National Park Initiative

The Rocky Mountain National Park Initiative was formed several years ago to study and recommend action on air quality issues facing the park. The initiative is a joint effort of Rocky Mountain National Park, the Air Resources Division of the National Park Service, the Environmental Protection Agency, and the state of Colorado. In Fiscal Year 2009, the NPS helped draft the Rocky Mountain National Park Initiative Nitrogen Deposition Reduction Contingency Plan to identify steps to be taken if interim goals for decreasing nitrogen deposition in the park are not met. More information can be found on the initiative at the web page for the initiative, http://www.cdphe.state.co.us/ap/rmnp.html.

The first step in mitigating the potential effects of enhanced nitrogen deposition to the park's ecosystem is to identify the source regions that are upwind of the park, and to quantify their relative contributions to the overall nitrogen deposition budget. The NPS, in collaboration with the other agencies, conducted the Rocky Mountain Atmospheric Nitrogen and Sulfur Study (RoMANS) to assess the source regions of nitrogen and sulfur that affect deposition and visibility at Rocky Mountain National Park. The RoMANS study was conducted during two intensive data collection periods over several weeks during the spring and summer of 2006. This peer-reviewed study provides invaluable information regarding the characteristics and sources of nitrogen deposition in the park to effectively identify air pollution control strategies. Increases in nitrogen wet deposition have been observed in the park for two decades. These increases have been linked to several documented ecosystem changes, including harmful changes in soil, water and tree chemistry, surface water nitrogen saturation, and changes in microscopic aquatic species and in alpine plant species composition. The complete RoMANS Study Report can be found at http://www.nature.nps.gov/air/studies/romans.cfm.

As part of the RoMANS Study, monitoring was conducted at sites within the park as well as other locations in Colorado, Utah, and Nebraska. Historical and current meteorological data were extensively examined and incorporated into the analyses. A weight of evidence approach was used to compare results from multiple analysis techniques to derive information on the source regions and types of pollutants found in the park. The study estimated that 55% of total nitrogen deposition came from Colorado. During the spring data collection period, most of the nitrogen deposition occurred during one particular upslope precipitation event that brought air masses from the northeastern part of the state. The majority of nitrogen deposition that occurred during the spring resulted from sources to the east of the park, with ammonia and ammonium arriving largely from northeastern Colorado, and nitrogen oxides arriving largely from Denver and other Front Range communities. During the summer data collection period, deposition episodes were smaller and more frequent. Relatively more of the nitrogen deposition that occurred during the summer resulted from sources to the west of the park; ammonia and ammonium came largely from sources within the park and in western Colorado. Oxidized nitrogen deposition had large contributions from the four corners region where power plants and oil and gas wells are located, as well as from California, Denver, and other Front Range communities that have large numbers of mobile sources. The study concluded that at least 30% of the nitrogen deposition is not routinely measured, and that more ammonia monitoring is needed.

3.6. Climate Change

The Climate Friendly Parks Program was funded through July 2009 via an interagency agreement between the National Park Service and the EPA. NPS assumed full funding for the program in August 2009. The program encourages and enables national parks to develop strategies to reduce their greenhouse gas emissions. The program also entails a commitment on the part of participating parks to educate the public about the actions the park is taking to mitigate emissions. Over 89 parks are participating in the program.

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[10] Air Quality Guidance for Natural Resource Condition Assessments is available at http://www.nature.nps.gov/air/planning/index.cfm.

The Pacific West Region is on track to have all of their parks be Climate Friendly Parks by FY 2011. NPS interpreters have been working in partnership with National Aeronautics and Space Administration and other scientists to develop climate change training materials and interpretive products such as brochures and exhibits. NPS, in cooperation with EPA, Bureau of Land Management, Fish and Wildlife Service, U.S. Forest Service, the National Aeronautics and Space Administration, and the National Oceanic and Atmospheric Administration, developed a product entitled "Climate Change: Wildlife & Wildlands, a Toolkit for Formal and Informal Educators." The kit will aid educators in teaching how climate change is affecting our nation's wildlife and public lands, and how everyone can become "climate stewards." The toolkit is available online at http://www.globalchange.gov/resources/educators/toolkit. The information, expertise and management concerns that the NPS brings to many external decision making arenas have made a difference in the past and will continue to do so in the future.

Air quality monitoring at Acadia National Park in Maine includes monitoring of mercury wet deposition (equipment pictured above) as well as visibility, ozone, and dry deposition of nitrogen and sulfur (equipment pictured to the left).
Credit: National Park Service.

Appendix A: GPRA Goal Assessment Methodology

The National Park Service (NPS) recently completed the FY 2009 performance assessment for the service-wide air quality program as required by GPRA. The NPS evaluates performance based on a few air quality goals established by the NPS.

Long Term NPS Air Quality Goal

The NPS Strategic Plan establishes the following air quality goals for reporting parks to meet by September 30, 2012:

- Ia3A—visibility in 95% of NPS reporting parks has improved or shows no deteriorating trend;
- Ia3B—ozone in 89% of NPS reporting parks has improved or shows no deteriorating trend;
- Ia3C—atmospheric deposition in 79% of NPS reporting parks has improved or shows no deteriorating trend.

Intermediate goals have been established for each of the years from FY 2008 through FY 2011. The FY 2009 target percentages are 95 percent for goal Ia3A, 86 percent for goal Ia3B, and 76 percent for goal Ia3C. All three goals were met or exceeded for FY 2009.

NPS Goal Ia3 Performance Indicators

Determining progress toward meeting NPS Goal Ia3 requires an assessment whether park air quality is improving or not degrading. Assessing performance for this goal is based on a 10-year trend of three performance indicators: visibility, atmospheric deposition, and ozone. Six measures are used to assess performance under the three indicators.

Visibility: Two measures are used to assess this indicator. Particle measurements made at or near 163 NPS units were used to calculate the annual reconstructed atmospheric extinction in deciviews for both clear and hazy days. (Extinction depends on the mass and chemical composition of the particles and is a quantitative measure of how the passage of light through the atmosphere is affected by air pollutants). The visibility goal Ia3A was met at 97 percent of reporting parks in FY 2009.

Ozone: This goal is evaluated by determining the 10-year trend in the annual 4th-highest 8-hour ozone concentration. Ozone measurements made in or near 159 parks were used to evaluate this measure. The ozone goal Ia3B was met at 100 percent of reporting parks in FY 2009.

Atmospheric Deposition: Three measures were used to assess this goal. Annual precipitation-weighted means of sulfate, nitrate, and ammonium ion concentrations at or near 56 NPS areas were trended to gauge air quality for this indicator. Changes in ammonium ion concentration in precipitation were included in the wet deposition indicator beginning in 2004 because ammonium contributes to total nitrogen deposition and data indicate that ammonium concentrations are increasing at a faster rate than nitrate ion concentrations alone. The atmospheric deposition goal Ia3C was met at 93 percent of reporting parks in FY 2009.

Significance Levels Refined: The method used to determine statistical significance of trends was modified to use a value more commonly used in the literature. In past trend reporting, we had used a significance level of 0.15, meaning there was a 15 percent chance that we could wrongly conclude that there was a trend when in fact the change was due to chance. We decided to change the significance level to 0.05, which is commonly used by many researchers. This reduces the chance that we would incorrectly conclude that there is a trend from 15 percent to 5 percent.

Calculating Progress: To calculate the service-wide percentages to compare with the air quality goals, we first performed a trend analysis for each of the above six air quality measures (2 visibility, 1 ozone, and 3 atmospheric deposition) over a ten-year period. The FY 2009 analysis used 1999–2008 data and required each monitoring site to have a minimum of six years of data in this 10-year period. Calendar year 2009 data were not used in this FY 2009 analysis because all of that year's data were not available. There is typically at least a three to six month lag between the time the data are collected in the field and when they are validated and available for analysis. Our trend time period is a sliding 10-year window and will change to 2000–2009 for next year's analysis. A sliding 10-year trend window was chosen rather than a variable length trend from a single fixed baseline year because individual parks began monitoring in different years and thus there is no individual fixed baseline year that can be applied to all parks. Trends were computed using a non-parametric technique that does not require any assumptions about the distribution of the data. This method was described by Theil (1950). In this method all possible ordered pairs of points are compared and the differences are computed. Each positive difference is recorded as a +1, each negative difference is recorded as a -1, and the sum of the +1 and +1 values is computed. This sum is then used to determine the probability that the observed differences could have occurred by chance as a result of random fluctuations in the time series. The EPA has also used this method to determine trends in air quality data (see http://www.epa.gov/visibility/report/APPd.pdf).

A few parks operate more than one ozone, visibility, or deposition monitor. We considered data from all monitoring sites at a park and if, for example, any one of the ozone monitors at a park showed a statistically significant degrading trend, the park was considered as not meeting the goal for that measure. In past years' analyses, the same park monitoring site was used for the trend analysis, even if other park site monitoring data were available. Initially when the GPRA air quality goal reporting started, we chose to use the park monitoring site with the longest period of data collection. Monitoring at parks with multiple sites has occurred long enough for there to be more than one park monitor that can be used for trend analysis. In addition, some park units that do not have monitors within their borders have more than one nearby monitor with sufficient data for trend analysis. Here also if one of the nearby monitors indicated a degrading trend we chose that monitor to represent the park unit in this report. In all cases if a monitor exists within a park for a particular measure and that monitor has sufficient data for trending we chose the in-park monitor over any nearby monitors.

In this report, we include information from deposition or ozone monitors within 10 miles of the boundary of that park. For a particulate (visibility) monitor, we required that it lie within 100 km (approximately 60 miles) of a park unit and within 130 meters in elevation of the park's minimum or maximum elevation in order to be considered representative of that park. This is consistent with the Interagency Monitoring for Visual Environments (IMPROVE) program, which considers IMPROVE monitors within 100 km of a Class I area to be representative of that area for monitoring progress under the Regional Haze Rule program. In some cases where parks do not have monitors within their borders and are located relatively closely together, particularly in urban areas, these parks have been grouped together and represented by a single nearby monitor. These areas include the San Francisco, Washington D.C., Boston, New York City, Philadelphia, and Baltimore metropolitan areas. They also include the following non-urban parks: Charles Pinckney National Historic Site and Fort Sumter National Monument; Eisenhower National Historic Site and Gettysburg National Military Park; two parks included in the North Cascades Complex (North Cascades National Park and Ross Lake National Recreation Area); Fort Washington and Piscataway Parks; and Fort Caroline National Memorial and Timucuan Ecological and Historic Preserve.

A park is considered to have air quality that is improving or not degrading for each of the three measures if none of the trends used to assess that measure show a statistically significant degrading trend. This means that for a park to be meeting the goal with respect to visibility its trends must not be degrading on both the clearest and haziest days. In addition, for a park to be considered to have met the air quality goal for atmospheric deposition it must not have degrading trends for deposition of nitrate, ammonium, and sulfate. The tabulated values (Appendix B) include the slope or change in the measure per year and a level of statistical significance (p-value). Slopes with p-values at 0.05 or less are considered statistically significant. The number of NPS areas not showing statistically significant deterioration in each of the performance indicators at the 0.05 level of significance is divided by the total number of NPS units with monitoring in that indicator to calculate a system-wide percentage. The three resulting percentages are then compared to the target percentages for the three GPRA goals.

Appendix B: Table of Trend Results, 1999–2008

Trends in individual park air quality for 1999–2008 are shown below. Data used to calculate these trends came from air quality monitors that are inside park boundaries, within 10 miles of parks (for ozone and deposition), and within 100 kilometers of parks (for visibility). Red indicates a degrading trend and blue indicates an improving trend. Statistically significant trends, shown with solid red and blue backgrounds, have at least a 95% probability that they did not occur by chance (p-values ≤ 0.05). Also identified are parks showing possible improvement or degradation where there is an 85% to 95% probability that the estimated trend slope did not occur by chance (p-values from 0.05 to 0.15); these parks are indicated by light blue (improving) and pink (degrading) backgrounds.

🟦	Improving air quality trend, statistically significant (p ≤ 0.05)	⬜	Possible improvement, not significant (0.05 < p ≤ 0.15)
🟥	Degrading air quality trend, statistically significant (p ≤ 0.05)	⬜	Possible degradation, not significant (0.05 < p ≤ 0.15)

Individual park 1999–2008 trend results.

Park	Visibility				Atmospheric Deposition						Ozone	
	Clear Days		Hazy Days		Ammonium		Nitrate		Sulfate		Annual 4th-Highest 8-Hour	
	dv/yr	p-value	dv/yr	p-value	µeq/liter/yr	p-value	µeq/liter/yr	p-value	µeq/liter/yr	p-value	ppb/yr	p-value
Abraham Lincoln Birthplace	-0.08	0.24	-0.03	0.50								
Acadia	-0.12	<0.01	-0.27	0.08	0.06	0.46	-0.46	<0.01	-0.30	0.24	-1.80	0.08
Allegheny Portage Railroad											-1.80	<0.01
Antietam	-0.07	0.30	-0.18	0.08							-1.00	0.11
Appalachian	0.25	0.07	0.03	0.43	0.12	0.36	-0.53	0.24	-0.20	0.43	-0.13	0.46
Appomattox Court House	-0.20	0.27	-0.41	0.14								
Arches	-0.20	<0.01	-0.07	0.36								
Aztec Ruins											-1.80	0.05
Badlands	0.01	0.50	-0.03	0.43								
Baltimore Metropolitan Area Parks	-0.07	0.30	-0.18	0.08							-1.70	0.11
Fort McHenry												
Hampton												
Bandelier	-0.13	<0.01	-0.08	0.43	-0.15	0.43	-0.85	0.02	-0.68	0.02		
Bent’s Old Fort					1.00	0.11	-0.17	0.24	0.23	0.50		
Big Bend	-0.23	0.06	-0.21	0.06	-0.19	0.38	-0.44	0.09	-0.50	0.18	0.20	0.11
Big Cypress	0.09	0.27	-0.53	0.20								
Big Hole	-0.07	0.14	2.00	0.23								
Big Thicket											0.00	0.50
Bighorn Canyon	0.00	0.64	0.47	0.50								

Individual park 1999–2008 trend results.

Park	Visibility				Atmospheric Deposition						Ozone	
	Clear Days		Hazy Days		Ammonium		Nitrate		Sulfate		Annual 4th-Highest 8-Hour	
	dv/yr	p-value	dv/yr	p-value	µeq/ liter/ yr	p-value	µeq/ liter /yr	p-value	µeq/ liter/ yr	p-value	ppb/ yr	p-value
Biscayne	0.09	0.27	-0.53	0.20							0.33	0.50
Black Canyon Of The Gunnison	-0.14	<0.01	-0.06	0.38								
Blue Ridge	0.25	0.07	0.03	0.43							-1.40	0.05
Booker T Washington	-0.20	0.27	-0.41	0.14								
Boston Metropolitan Area Parks	-0.10	0.19	-0.30	0.07	-0.03	0.54	-0.79	0.04	-1.30	0.06	0.13	0.50
Adams												
Boston African American												
Boston Harbor Islands												
Boston												
Frederick Law Olmsted												
John F Kennedy												
Longfellow												
Minute Man												
Saugus Iron Works												
Bryce Canyon	-0.16	<0.01	0.00	0.50	0.51	0.14	-0.64	0.05	-0.51	0.03		
Buck Island Reef	0.15	0.19	0.30	<0.01								
Buffalo	-0.05	0.36	-0.13	0.19	0.21	0.31	-0.53	0.02	-0.44	0.06		
Canaveral					-0.23	0.01	-0.50	0.01	-1.30	0.01		
Canyonlands	-0.20	<0.01	-0.07	0.36	0.58	0.09	-0.28	0.38	-0.07	0.38	-0.25	0.19
Cape Cod	-0.10	0.19	-0.30	0.07							-2.70	<0.01
Capitol Reef	-0.16	<0.01	0.00	0.50								
Capulin Volcano					0.56	0.07	-0.40	0.07	-0.23	0.19		
Carlsbad Caverns	-0.14	<0.01	-0.16	0.24								
Catoctin Mountain	-0.28	0.19	-0.60	0.04								
Cedar Breaks	-0.16	<0.01	0.00	0.50								
Central High School											-1.00	0.19
Chamizal											-0.33	0.36
Channel Islands											-0.17	0.36
Charles Pinckney/Fort Sumter	0.00	0.57	-0.17	0.19								
Charles Pinckney												
Fort Sumter												
Chattahoochee River											-2.70	0.11
Chesapeake & Ohio Canal	-0.07	0.30	-0.18	0.08							-0.50	0.24

Individual park 1999–2008 trend results.

Park	Visibility				Atmospheric Deposition						Ozone	
	Clear Days		Hazy Days		Ammonium		Nitrate		Sulfate		Annual 4th-Highest 8-Hour	
	dv/yr	p-value	dv/yr	p-value	µeq/ liter/ yr	p-value	µeq/ liter /yr	p-value	µeq/ liter/ yr	p-value	ppb/ yr	p-value
Chiricahua	-0.19	0.01	-0.10	0.15	1.10	0.03	-0.01	0.55	-0.39	0.27	-0.17	0.43
Christiansted	0.15	0.19	0.30	<0.01								
Congaree											-0.62	0.09
Cowpens											-2.20	<0.01
Crater Lake	-0.08	0.03	-0.29	0.45								
Craters Of The Moon	-0.24	0.02	-0.08	0.45	0.58	0.13	-0.20	0.13	0.07	0.46	-0.11	0.39
Cumberland Gap					0.00	0.57	-0.90	<0.01	-1.50	0.05	-2.10	0.06
Cumberland Island	-0.12	0.11	-0.32	0.04								
Curecanti	-0.14	<0.01	-0.06	0.38								
Cuyahoga Valley											-1.50	0.15
Dayton Aviation Heritage											-1.70	<0.01
De Soto											-0.90	0.18
Death Valley	-0.10	0.02	0.10	0.28							0.33	0.24
Delaware Water Gap					-0.13	0.36	-0.90	<0.01	-0.97	0.11		
Denali	-0.03	0.19	-0.10	0.15	-0.10	0.15	-0.18	0.05	-0.08	0.36	0.00	0.43
Ebey's Landing	-0.27	0.07	-0.68	<0.01								
Effigy Mounds	-0.30	0.07	-0.33	0.36								
Eleanor Roosevelt											-1.80	0.11
Eugene O'Neill	-0.21	<0.01	-0.16	0.20							-1.00	0.24
Everglades	0.09	0.27	-0.53	0.20	0.30	0.09	0.02	0.54	0.08	0.38		
Fire Island											-1.20	0.18
First Ladies	-0.25	0.07	-0.33	0.19							-1.40	0.05
Fort Bowie	-0.19	0.01	-0.10	0.15	1.10	0.03	-0.01	0.55	-0.39	0.27	-0.17	0.43
Fort Donelson	-0.32	0.12	-0.03	0.50								
Fort Frederica	-0.12	0.11	-0.32	0.04							-1.30	<0.01
Fort Larned	-0.10	0.50	-0.66	0.07								
Fort Pulaski											-1.30	0.05
Fort Scott	-0.05	0.50	-0.60	0.07								
Fort Union Trading Post	-0.08	0.14	0.15	0.36								
Fort Vancouver											0.33	0.30
Fredericksburg & Spotsylvania	-0.07	0.30	-0.18	0.08							-0.86	0.11
Friendship Hill											-1.50	0.24
George Rogers Clark					0.48	0.02	-0.41	<0.01	-0.39	0.24	-2.00	0.08
George Washington Birthplace	-0.07	0.30	-0.18	0.08								
George Washington Carver	-0.05	0.50	-0.60	0.07								

Individual park 1999–2008 trend results.

Park	Visibility				Atmospheric Deposition						Ozone	
	Clear Days		Hazy Days		Ammonium		Nitrate		Sulfate		Annual 4th-Highest 8-Hour	
	dv/yr	p-value	dv/yr	p-value	μeq/liter/yr	p-value	μeq/liter/yr	p-value	μeq/liter/yr	p-value	ppb/yr	p-value
Gettysburg/Eisenhower	-0.28	0.19	-0.60	0.04	-0.33	0.15	-1.50	<0.01	-1.60	0.02	-0.67	0.50
Eisenhower												
Gettysburg												
Gila Cliff Dwellings	-0.20	<0.01	-0.08	0.38	0.08	0.36	-1.10	0.36	-1.30	<0.01		
Glacier	-0.07	0.09	-0.38	0.09	0.13	0.19	-0.13	0.19	-0.03	0.50	0.50	0.19
Glen Canyon	-0.09	0.24	-0.06	0.24								
Grand Canyon	-0.09	0.24	-0.06	0.24	-0.15	0.36	-0.96	0.05	-0.47	0.05	-0.40	0.19
Grand Teton	-0.10	0.01	0.10	0.24								
Grant-Kohrs Ranch	-0.28	0.02	-0.13	0.45								
Great Basin	-0.22	<0.01	0.03	0.36							0.00	0.50
Great Egg Harbor River	0.11	0.18	-0.02	0.54							-1.90	<0.01
Great Sand Dunes	-0.14	0.02	-0.15	0.08								
Great Smoky Mountains	-0.26	0.02	-0.14	0.08	0.07	0.24	-0.30	0.08	-0.48	0.30	-1.10	0.13
Guadalupe Mountains	-0.14	<0.01	-0.16	0.24	-0.91	0.01	-1.00	<0.01	-1.70	<0.01		
Gulf Islands											-1.00	0.11
Haleakala	0.00	0.55	0.18	0.09								
Harpers Ferry	-0.07	0.30	-0.18	0.08								
Harry S Truman											-1.30	0.04
Hawaii Volcanoes	-0.02	0.36	1.30	<0.01								
Home Of Franklin D Roosevelt											-1.80	0.11
Indiana Dunes					0.18	0.43	-0.95	0.04	-0.97	0.11	-1.80	0.11
Isle Royale	-0.12	0.04	-0.01	0.54	0.42	0.20	-0.24	0.09	-0.29	0.36		
James A Garfield											-2.50	0.05
Jean Lafitte											-1.00	0.09
Jefferson											-0.69	0.38
John D Rockefeller Jr	-0.10	0.01	0.03	0.50								
John Muir	-0.21	<0.01	-0.16	0.20							-0.60	0.30
Johnstown Flood											-3.00	<0.01
Joshua Tree	-0.13	0.05	-0.49	0.02							0.67	0.11
Kalaupapa	0.00	0.55	0.18	0.09								
Kennesaw Mountain											-2.10	0.09
Keweenaw	-0.12	0.04	-0.01	0.54	0.42	0.20	-0.24	0.09	-0.29	0.36		
Knife River Indian Villages											0.45	0.24
Lake Chelan	-0.02	0.36	-0.15	0.36								
Lake Clark	-0.02	0.50	-0.40	0.12								

Individual park 1999–2008 trend results.

Park	Visibility				Atmospheric Deposition						Ozone	
	Clear Days		Hazy Days		Ammonium		Nitrate		Sulfate		Annual 4th-Highest 8-Hour	
	dv/yr	p-value	dv/yr	p-value	µeq/ liter/ yr	p-value	µeq/ liter /yr	p-value	µeq/ liter/ yr	p-value	ppb/ yr	p-value
Lake Mead											0.50	0.18
Lassen Volcanic	-0.08	0.24	0.05	0.36							-0.11	0.50
Lava Beds	-0.10	0.09	-0.13	0.45								
Lincoln Home											-1.40	0.04
Little Bighorn Battlefield					-0.19	0.19	-0.35	<0.01	-0.19	0.11		
Maggie L Walker											-0.71	0.43
Mammoth Cave	-0.08	0.24	-0.03	0.50							-2.30	<0.01
Manassas	-0.07	0.30	-0.18	0.08							-1.50	<0.01
Martin Luther King Jr											-1.30	0.30
Mesa Verde	-0.20	<0.01	-0.14	0.36	0.05	0.43	-0.67	0.04	-0.93	<0.01	0.17	0.30
Minuteman Missile	0.01	0.50	-0.03	0.43	-0.04	0.43	-0.50	0.05	-0.26	0.08		
Mississippi											-0.94	0.24
Mojave	-0.13	0.05	-0.49	0.02								
Monocacy	-0.07	0.30	-0.18	0.08							-1.40	0.08
Morristown											-2.00	0.04
Mount Rainier	-0.11	0.04	-0.44	<0.01	0.10	0.03	0.00	0.64	-0.66	<0.01	-0.35	0.38
Mount Rushmore	-0.15	0.01	-0.01	0.46								
Natchez											-1.50	0.01
Natchez Trace	-0.30	0.02	-0.21	0.38	-0.06	0.50	-0.20	0.30	-0.47	0.02	-1.40	0.01
Natural Bridges	-0.20	<0.01	-0.07	0.36								
New Bedford Whaling	-0.10	0.19	-0.30	0.07							-1.90	0.04
New York Metropolitan Area Parks											0.13	0.55
African Burial Ground												
Castle Clinton												
Edison												
Federal Hall												
Gateway												
General Grant												
Governors Island												
Hamilton Grange												
Saint Paul’s Church												
Statue Of Liberty												
Theodore Roosevelt Birthplace												
Nez Perce	-0.22	0.20	2.00	0.23								
Nicodemus	-0.10	0.50	-0.66	0.07								

Individual park 1999–2008 trend results.

Park	Visibility				Atmospheric Deposition						Ozone	
	Clear Days		Hazy Days		Ammonium		Nitrate		Sulfate		Annual 4th-Highest 8-Hour	
	dv/yr	p-value	dv/yr	p-value	µeq/liter/yr	p-value	µeq/liter/yr	p-value	µeq/liter/yr	p-value	ppb/yr	p-value
North Cascades Complex	-0.02	0.36	-0.15	0.36	-0.04	0.46	-0.19	0.06	-0.20	0.01		
North Cascades												
Ross Lake												
Ocmulgee											-2.50	<0.01
Olympic	-0.10	0.04	-0.35	0.04	-0.03	0.28	0.04	0.07	-0.10	0.50		
Organ Pipe Cactus	0.00	0.36	-0.23	0.07	0.05	0.54	-0.63	0.18	-0.51	0.18		
Palo Alto Battlefield											0.20	0.36
Pecos	-0.13	<0.01	-0.08	0.43								
Petersburg											0.00	0.57
Petrified Forest	-0.10	0.05	0.00	0.50							-0.50	0.36
Petroglyph											-0.54	0.06
Philadelphia Metropolitan Area Parks	0.11	0.18	-0.02	0.54							-1.70	0.18
Edgar Allan Poe												
Independence												
Thaddeus Kosciuszko												
Pictured Rocks	-0.07	0.38	0.08	0.38								
Pinnacles	-0.17	0.02	-0.08	0.31	0.13	0.28	0.09	0.50	-0.05	0.50	-0.43	0.24
Pipestone	-0.10	0.50	-0.48	0.23								
Piscataway/Fort Washington											-1.50	0.19
Fort Washington												
Piscataway												
Point Reyes	-0.21	<0.01	-0.16	0.20								
Prince William Forest	-0.07	0.30	-0.18	0.08							-1.30	0.11
Redwood	-0.10	0.04	-0.10	0.19								
Richmond											0.00	0.57
Rocky Mountain	-0.10	0.02	-0.10	0.30	-0.03	0.43	-0.31	0.24	-0.20	0.11	0.00	0.50
Roger Williams	-0.33	0.14	-0.62	0.07							-0.38	0.36
Sagamore Hill											-2.00	0.11
Saguaro	-0.16	0.19	-0.27	0.12							0.50	0.30
Saint Croix					-0.58	0.13	-0.80	0.04	-0.45	0.18	-0.88	0.19
Saint Croix Island	-0.16	<0.01	-0.34	0.08								
Saint-Gaudens											-0.86	0.15
Salem Maritime	-0.10	0.19	-0.30	0.07							-0.33	0.30
Salt River Bay	0.15	0.19	0.30	<0.01								

Individual park 1999–2008 trend results.

Park	Visibility				Atmospheric Deposition						Ozone	
	Clear Days		Hazy Days		Ammonium		Nitrate		Sulfate		Annual 4th-Highest 8-Hour	
	dv/yr	p-value	dv/yr	p-value	µeq/liter/yr	p-value	µeq/liter/yr	p-value	µeq/liter/yr	p-value	ppb/yr	p-value
San Antonio Missions											-0.89	0.02
San Francisco Bay Area Parks	-0.21	<0.01	-0.16	0.20							0.25	0.43
Fort Point												
Golden Gate												
Muir Woods												
Rosie the Riveter WWII Home Front												
San Francisco Maritime												
Santa Monica Mountains											1.70	0.24
Saratoga											-1.30	0.05
Sequoia and Kings Canyon	-0.04	0.36	-0.02	0.55							0.14	0.43
Shenandoah	-0.23	0.15	0.03	0.43	-0.10	0.38	-0.48	0.06	-1.10	0.04	-1.80	0.01
Sleeping Bear Dunes					-0.60	0.14	-1.40	0.03	-0.90	0.07	-2.00	0.36
Springfield Armory											0.00	0.50
Steamtown											-1.70	0.15
Sunset Crater Volcano	-0.09	0.24	0.00	0.55								
Tallgrass Prairie	-0.27	0.07	-0.50	0.14								
Theodore Roosevelt	-0.23	<0.01	0.00	0.61	0.30	0.45	-0.09	0.45	-0.00	0.55	0.46	0.13
Theodore Roosevelt Inaugural											-2.00	0.08
Thomas Stone	-0.07	0.30	-0.18	0.08								
Timpanogos Cave											-1.00	0.04
Timucuan/Fort Caroline	-0.12	0.11	-0.32	0.04							0.13	0.50
Fort Caroline												
Timucuan												
Tonto	-0.19	<0.01	-0.12	0.20								
Tumacácori	-0.16	0.19	-0.27	0.12								
Tupelo											-2.00	<0.01
U S S Arizona											-0.78	0.02
Ulysses S Grant											-1.30	0.24
Upper Delaware					-0.13	0.36	-0.90	<0.01	-0.97	0.11		
Valley Forge											-2.00	0.03
Vanderbilt Mansion											-1.80	0.11
Virgin Islands	0.15	0.19	0.30	<0.01	0.02	0.43	-0.10	0.11	-0.24	0.30		
Voyageurs	-0.09	0.13	0.05	0.38							-0.37	0.24
Walnut Canyon	-0.16	0.05	0.00	0.55								

Individual park 1999–2008 trend results.

Park	Visibility				Atmospheric Deposition						Ozone	
	Clear Days		Hazy Days		Ammonium		Nitrate		Sulfate		Annual 4th-Highest 8-Hour	
	dv/yr	p-value	dv/yr	p-value	µeq/ liter/ yr	p-value	µeq/ liter /yr	p-value	µeq/ liter/ yr	p-value	ppb/ yr	p-value
Washington Metropolitan Area Parks	-0.07	0.30	-0.18	0.08							-0.50	0.24
Arlington House												
Carter G. Woodson Home												
Clara Barton												
Ford's Theatre												
Frederick Douglass												
Greenbelt												
George Washington												
Lyndon Baines Johnson Memorial Grove												
Mary McLeod Bethune Council House												
National Mall & Memorial Parks												
National Mall												
Pennsylvania Avenue												
Rock Creek												
Theodore Roosevelt Island												
Washington												
President's Park (White House)												
Wolf Trap												
Washita Battlefield	-0.13	0.23	-0.52	0.14								
Weir Farm											-1.00	0.19
Whiskeytown	0.10	0.23	0.50	0.36							-1.40	0.09
William Howard Taft											-0.67	0.15
Wilson's Creek	-0.05	0.50	-0.60	0.07								
Wind Cave	-0.15	0.01	-0.01	0.46								
Yellowstone	-0.10	0.01	0.03	0.50	0.24	0.31	-0.17	0.18	0.04	0.38	-0.17	0.15
Yosemite	-0.16	0.15	-0.15	0.30	0.27	0.19	-0.25	0.19	-0.03	0.50	0.17	0.24
Zion	-0.16	<0.01	0.00	0.50								

Appendix C: Determination of Air Quality Conditions

To assess condition, we first used all available monitoring data over the period 2004–2008 to generate interpolations for the continental United States. Monitors used included NPS, EPA, state, tribal, and local monitors. These interpolations allowed us to derive estimates of the air quality parameters at NPS units located within the continental United States, including those without on-site monitoring. (Since there were not sufficient monitors to generate interpolations outside the continental US, on-site monitoring data were used to derive the condition category estimates for Denali, Lake Clark, Virgin Islands, Hawaii Volcanoes, and Haleakala). We then used these interpolated values to determine an index for each type of air quality data collected (ozone concentrations, wet deposition concentrations, and visibility) that assigns the park to one of three condition categories:

- Significant Concern
- Moderate
- Good

The interpolated values were then used to assign parks to condition categories using the following procedures.

Visibility Condition

Individual park scores for visibility were based on the deviation of the current Group 50 visibility conditions from estimated Group 50 natural visibility conditions,[1] where Group 50 is defined as the mean of the visibility observations falling within the range from the 40th through the 60th percentiles. For parks within the continental US, current visibility was estimated from the interpolation of the five-year averages of the Group 50 visibility. For sites outside the continental US, five-year averages were computed from on-site data. Visibility in this calculation is expressed in terms of a haze index[2] in deciviews (dv). As the haze index increases, the visibility worsens. The visibility condition is expressed as:

Visibility Condition = (current Group 50 visibility) - (estimated Group 50 visibility under natural conditions)

Parks with a visibility condition estimate of less than two dv above estimated natural conditions were considered to be in good condition. Parks with visibility condition estimates ranging from two to eight dv above natural conditions were considered to be in moderate condition, and parks with visibility condition estimates greater than eight dv above natural conditions were considered to have a significant concern. The dv ranges of these categories, while somewhat subjective, were chosen to reflect as nearly as possible the variation in visibility conditions across the monitoring network.

Visibility Condition	Difference from Estimated Natural Condition (dv)
Significant Concern 🔴	> 8
Moderate 🟡	2–8
Good 🔵	< 2

Atmospheric Deposition Condition

Park scores for current condition of atmospheric deposition were based on wet deposition because dry deposition data was not available for most areas. Wet deposition for sites within the continental US was calculated by multiplying nitrogen (N) or sulfur (S) concentrations in precipitation by a normalized precipitation amount.[3] (For sites outside the continental US, where interpolations could not be calculated and normalized precipitation amounts were not available, five-year averages of on-site deposition were used. Deposition data were obtained from the National Atmospheric Deposition Program). Several factors were considered in rating deposition condition, including natural background deposition estimates and deposition effects on ecosystems. Estimates of natural background deposition for total deposition are approximately 0.25 kilograms per hectare per year (kg/ha/yr) in the West and 0.50 kg/ha/yr in the East for either N or S. For wet deposition only, this is roughly equivalent to 0.13 kg/ha/yr in the West and 0.25 kg/ha/yr in the East.[4] Certain sensitive ecosystems respond to levels of deposition on the order of 3 kg/ha/yr total deposition, or about 1.5 kg/ha/yr wet deposition.[5]

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[1] The natural visibility conditions used in this treatment are those visibility conditions that have been estimated to exist in a given area in the absence of human-caused visibility impairment. These estimates were determined in accordance with the EPA's Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule, EPA-454/B-03-005.

[2] The haze index is a measure of visibility derived from calculated light extinction (EPA-454/B-03-005).

[3] Normalized 30-year precipitation values from the PRISM database were used to calculate deposition in order to minimize interannual variation in deposition caused by interannual fluctuations in precipitation (http://www.ocs.orst.edu/prism/).

[4] The proportion of wet to dry deposition varies by location but, in general, wet deposition is approximately one-half of total deposition.

[5] Fenn et al. 2003. BioScience 53: 404–420; Krupa 2002. Environmental Pollution 124: 179–221.

Evidence indicating that wet deposition amounts less than 1 kg/ha/yr cause ecosystem harm is not currently available. Therefore, parks with wet deposition less than 1 kg/ha/yr were considered to be in good condition for deposition, parks with 1–3 kg/ha/yr were considered to be in moderate condition, and parks with greater than 3 kg/ha/yr were considered to have a significant concern for deposition. Scores for parks with ecosystems potentially sensitive to N or S were adjusted up one category[6] (e.g., a park with N deposition from 1–3 kg/ha/yr that contains N-sensitive ecosystems would be assigned to the significant concern category).

Nitrogen/Sulfur Deposition Condition	Wet Deposition (kg/ha/yr)
Significant Concern 🔴	> 3
Moderate 🟡	1–3
Good 🔵	< 1

Ozone Condition

The ozone standard was used as a benchmark for rating current ozone air quality. This standard was revised in 2008 in order to be more protective of human health. To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 75 parts per billion (ppb). To derive an estimate of the current ozone condition at parks, the five-year average of the annual 4th-highest 8-hour ozone concentration was determined for each park from the interpolated values described above. If the resulting five-year average was greater than or equal to 76 ppb the park was assigned to the significant concern category. Parks with average five-year 4th-highest 8-hour ozone concentrations from 61 to 75 ppb (concentrations greater than 80 percent of the standard) were assigned to the moderate condition for ozone. The good condition for ozone was assigned to parks with average five-year ozone concentrations less than 61 ppb (concentrations less than 80 percent of the standard).

Ozone Condition	Ozone concentration
Significant Concern 🔴	≥ 76 ppb
Moderate 🟡	61–75 ppb
Good 🔵	≤ 60 ppb

In addition to the standard, vegetation sensitivity was considered for park condition. Data show that some plant species[7] are more sensitive to ozone than humans and the ozone standard is not protective of some vegetation. Ozone injury to vegetation has been documented at a number of parks, including Great Smoky Mountains NP, Shenandoah NP, and Sequoia and Kings Canyon NPs. A risk assessment completed in 2004 rated parks at low, moderate, or high risk for ozone injury to vegetation, based on presence of sensitive plant species, ozone exposures,[8] and environmental conditions, i.e., soil moisture. For this report, parks that were evaluated at high risk were moved into the next condition category (e.g., a park with an average ozone concentration of 72 ppb, but judged to be at high risk for vegetation injury, would move from the moderate condition for ozone to the significant concern condition).

Air Quality Condition Table

The table below gives the results of the air quality condition determinations for parks where we were also able to derive trend estimates. For each park, a blue circle indicates a park is assigned to the good category for the indicated air quality parameter, a yellow circle indicates the park is assigned to the moderate category, and a red circle indicates the park is assigned to the significant concern category. The category symbols in the table are also overlaid with an up or down arrow to indicate the direction of the trend if one is present, or a double-headed arrow to indicate that there is no significant trend. Unlike the condition estimates, which were derived from an interpolation, the trends represented by the arrows were computed from data collected at individual monitors (as presented in Appendix B). A blue down arrow indicates a significant improving trend, a yellow double-headed horizontal arrow indicates no trend, and a red up arrow indicates a significant worsening trend. In the case of the nitrogen deposition and visibility trends, two trend indicators were combined to create one trend arrow, and the less favorable trend was chosen to represent the site. For nitrogen deposition, if the trend in the concentration of either nitrate or ammonium is degrading while the other

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[6] Ecosystems that are considered potentially sensitive to N or S deposition include high-elevation ecosystems in the West, upland areas in the East, areas on granitic bedrock, coastal and estuarine waters, arid ecosystems, and some grasslands.

[7] Lists of ozone sensitive species, by park, are available from NPSpecies (http://science.nature.nps.gov/im/apps/npspp/).

[8] The ozone risk assessment for injury to vegetation was based on ozone exposures over the growing seasons from 1995–1999. The ozone exposure metrics are described in the ozone risk assessments at http://www.nature.nps.gov/air/Pubs/ozone.cfm?CFID=11153828&CFTOKEN=39004787.

is showing no trend or improving, an arrow indicating a degrading trend is overlaid on the condition symbol. If there is no trend in one form of nitrogen while the other is improving, an arrow indicating no trend is shown. Similarly, trends in visibility on clear days and hazy days were combined and overlaid on the visibility condition symbol. If a trend in one visibility indicator is degrading while the other indicator shows no trend or improvement, an arrow indicating a degrading trend is shown for that park, and if there no trend in one indicator along with an improving trend in the other indicator, a symbol indicator no trend is shown. All up and down arrows represent trends that have at least a 95% probability of being correct (those with p-values ≤ 0.05).

Air Quality Condition		Air Quality Trend	
Significant Concern	🔴	Degrading	↑
Moderate	🟡	None	↔
Good	🔵	Improving	↓

Park	Condition and Trend Symbol			
	Visibility	Nitrogen Deposition	Sulfur Deposition	Ozone
Abraham Lincoln Birthplace	🔴↔			
Acadia	🟡↔	🟡↔	🔴↔	🟡↔
Adams	🟡↔	🔴↔	🔴↔	🔴↔
African Burial Ground				🔴↔
Allegheny Portage Railroad				🟡↓
Antietam	🔴↔			🔴↔
Appalachian	🔴↔	🔴↔	🔴↔	🔴↔
Appomattox Court House	🔴↔			
Arches	🟡↔			
Arlington House, The Robert E. Lee Memorial	🔴↔			🔴↔
Aztec Ruins				🟡↔
Badlands	🟡↔			
Bandelier	🟡↔	🟡↔	🔵↓	
Bent's Old Fort		🟡↔	🔵↔	
Big Bend	🟡↔	🔴↔	🔵↔	🟡↔
Big Cypress	🔴↔			
Big Hole	🟡↔			
Big Thicket				🔴↔
Bighorn Canyon	🟡↔			
Biscayne	🔴↔			🟡↔
Black Canyon Of The Gunnison	🟡↔			
Blue Ridge	🔴↔			🟡↔

Park	**Condition and Trend Symbol**			
	Visibility	**Nitrogen Deposition**	**Sulfur Deposition**	**Ozone**
Booker T Washington	🔴⇔			
Boston	🟡⇔	🔴⇔	🔴⇔	🔴⇔
Boston African American	🟡⇔	🔴⇔	🔴⇔	🔴⇔
Boston Harbor Islands	🟡⇔	🔴⇔	🔴⇔	🔴⇔
Bryce Canyon	🟡⇔	🟡⇔	🔵⇩	
Buffalo	🔴⇔	🔴⇔	🔴⇔	
Canaveral		🔴⇩	🔴⇩	
Canyonlands	🟡⇔	🔵⇔	🔵⇔	🟡⇔
Cape Cod	🟡⇔			🔴⇩
Capitol Reef	🟡⇔			
Capulin Volcano		🟡⇔	🟡⇔	
Carlsbad Caverns	🟡⇔			
Carter G. Woodson Home	🔴⇔			🔴⇔
Castle Clinton				🔴⇔
Catoctin Mountain	🔴⇔			
Cedar Breaks	🟡⇔			
Central High School				🟡⇔
Chamizal				🟡⇔
Channel Islands				🟡⇔
Charles Pinckney	🔴⇔			
Chattahoochee River				🔴⇔
Chesapeake & Ohio Canal	🔴⇔			🔴⇔
Chiricahua	🟡⇔	🔴⇧	🟡⇔	🟡⇔
Clara Barton	🔴⇔			🔴⇔
Congaree				🟡⇔
Cowpens				🔴⇩
Crater Lake	🟡⇔			
Craters Of The Moon	🟡⇔	🔴⇔	🔵⇔	🟡⇔
Cumberland Gap		🔴⇔	🔴⇔	🔴⇔
Cumberland Island	🔴⇔			
Curecanti	🟡⇔			
Cuyahoga Valley				🔴⇔
Dayton Aviation Heritage				🔴⇩

Park	Condition and Trend Symbol			
	Visibility	Nitrogen Deposition	Sulfur Deposition	Ozone
De Soto				🟡⇔
Death Valley	🟡⇔			🔴⇔
Delaware Water Gap		🔴⇔	🔴⇔	
Denali	🔵⇔	🔵⇔	🔵⇔	🔵⇔
Ebey's Landing	🟡⇔			
Edgar Allan Poe	🔴⇔			🔴⇔
Edison				🔴⇔
Effigy Mounds	🔴⇔			
Eisenhower	🔴⇔	🔴⇔	🔴⇩	🔴⇔
Eleanor Roosevelt				🔴⇔
Eugene O'Neill	🟡⇔			🟡⇔
Everglades	🔴⇔	🔴⇔	🔴⇔	
Federal Hall				🔴⇔
Fire Island				🔴⇔
First Ladies	🔴⇔			🔴⇔
Ford's Theatre	🔴⇔			🔴⇔
Fort Bowie	🟡⇔	🟡⇧	🟡⇔	🟡⇔
Fort Caroline	🔴⇔			🟡⇔
Fort Donelson	🔴⇔			
Fort Frederica	🔴⇔			🟡⇩
Fort Larned	🔴⇔			
Fort McHenry	🔴⇔			🔴⇔
Fort Point	🟡⇔			🔵⇔
Fort Pulaski				🟡⇔
Fort Scott	🔴⇔			
Fort Sumter	🔴⇔			
Fort Union Trading Post	🟡⇔			
Fort Vancouver				🔵⇔
Fort Washington				🔴⇔
Frederick Douglass	🔴⇔			🔴⇔
Frederick Law Olmsted	🟡⇔	🔴⇔	🔴⇔	🔴⇔
Fredericksburg & Spotsylvania	🔴⇔			🔴⇔
Friendship Hill				🔴⇔

Park	**Condition and Trend Symbol**			
	Visibility	**Nitrogen Deposition**	**Sulfur Deposition**	**Ozone**
Gateway				🔴↔
General Grant				🔴↔
George Rogers Clark		🔴⬆	🔴↔	🟡↔
George Washington	🔴↔			🔴↔
George Washington Birthplace	🔴↔			
George Washington Carver	🔴↔			
Gettysburg	🔴↔	🔴↔	🔴⬇	🔴↔
Gila Cliff Dwellings	🟡↔	🟡↔	🟡⬇	
Glacier	🟡↔	🔴↔	🔴↔	🔵↔
Glen Canyon	🟡↔			
Golden Gate	🟡↔			🔵↔
Governors Island				🔴↔
Grand Canyon	🟡↔	🔵↔	🔵↔	🟡↔
Grand Teton	🟡↔			
Grant-Kohrs Ranch	🟡↔			
Great Basin	🟡↔			🟡↔
Great Sand Dunes	🟡↔			
Great Smoky Mountains	🔴↔	🔴↔	🔴↔	🔴↔
Greenbelt	🔴↔			🔴↔
Guadalupe Mountains	🟡↔	🔴⬇	🟡⬇	
Gulf Islands				🔴↔
Haleakala	🟡↔			
Hamilton Grange				🔴↔
Hampton	🔴↔			🔴↔
Harpers Ferry	🔴↔			
Harry S Truman				🟡⬇
Hawaii Volcanoes	🟡⬆			
Home Of Franklin D Roosevelt				🔴↔
Independence	🔴↔			🔴↔
Indiana Dunes		🔴↔	🔴↔	🔴↔
Isle Royale	🟡↔	🔴↔	🟡↔	
James A Garfield				🔴↔
Jean Lafitte				🟡↔

Park	**Condition and Trend Symbol**			
	Visibility	**Nitrogen Deposition**	**Sulfur Deposition**	**Ozone**
Jefferson				🔴⇔
John D Rockefeller Jr	🟡⇔			
John F Kennedy	🟡⇔	🔴⇔	🔴⇔	🔴⇔
John Muir	🟡⇔			🔴⇔
Johnstown Flood				🟡⇩
Joshua Tree	🔴⇔			🔴⇔
Kennesaw Mountain				🔴⇔
Keweenaw	🟡⇔	🔴⇔	🟡⇔	
Knife River Indian Villages				🔵⇔
Lake Chelan	🟡⇔			
Lake Clark	🔵⇔			
Lake Mead				🔴⇔
Lassen Volcanic	🟡⇔			🟡⇔
Lava Beds	🟡⇔			
Lincoln Home				🟡⇩
Little Bighorn Battlefield		🟡⇔	🔵⇔	
Longfellow	🟡⇔	🔴⇔	🔴⇔	🔴⇔
Lyndon Baines Johnson Memorial Grove	🔴⇔			🔴⇔
Mammoth Cave	🔴⇔			🔴⇩
Manassas	🔴⇔			🔴⇩
Martin Luther King Jr				🔴⇔
Mary McLeod Bethune Council House	🔴⇔			🔴⇔
Mesa Verde	🟡⇔	🔴⇔	🔵⇩	🟡⇔
Minute Man	🟡⇔	🔴⇔	🔴⇔	🔴⇔
Minuteman Missile	🟡⇔	🟡⇔	🔵⇔	
Mississippi				🟡⇔
Mojave	🟡⇔			
Monocacy	🔴⇔			🔴⇔
Morristown				🔴⇩
Mount Rainier	🟡⇩	🔴⇧	🔴⇩	🟡⇔
Mount Rushmore	🟡⇔			
Muir Woods	🟡⇔			🔵⇔
Natchez				🔴⇩

Park	Condition and Trend Symbol			
	Visibility	Nitrogen Deposition	Sulfur Deposition	Ozone
Natchez Trace	🔴↔	🔴↔	🔴↓	🟡↓
National Mall	🔴↔			🔴↔
National Mall & Memorial Parks	🔴↔			🔴↔
Natural Bridges	🟡↔			
New Bedford Whaling	🟡↔			🔴↓
Nez Perce	🟡↔			
Nicodemus	🔴↔			
North Cascades	🟡↔	🔴↔	🔴↓	
Ocmulgee				🔴↓
Olympic	🟡↓	🔴↔	🔴↔	
Organ Pipe Cactus	🟡↔	🔴↔	🔵↔	
Palo Alto Battlefield				🟡↔
Pecos	🟡↔			
Pennsylvania Avenue	🔴↔			🔴↔
Petersburg				🔴↔
Petrified Forest	🟡↔			🟡↔
Petroglyph				🟡↔
Pictured Rocks	🟡↔			
Pinnacles	🔴↔	🔵↔	🔵↔	🔴↔
Pipestone	🔴↔			
Piscataway				🔴↔
Point Reyes	🟡↔			
President's Park (White House)	🔴↔			🔴↔
Prince William Forest	🔴↔			🔴↔
Redwood	🟡↔			
Richmond				🔴↔
Rock Creek	🔴↔			🔴↔
Rocky Mountain	🟡↔	🔴↔	🔴↔	🟡↔
Roger Williams	🟡↔			🔴↔
Rosie the Riveter WWII Home Front	🟡↔			🔵↔
Ross Lake	🟡↔	🟡↔	🟡↓	
Sagamore Hill				🔴↔
Saguaro	🟡↔			🟡↔

Park	**Condition and Trend Symbol**			
	Visibility	**Nitrogen Deposition**	**Sulfur Deposition**	**Ozone**
Saint Croix		🔴↔	🟡↔	🟡↔
Saint Croix Island	🟡↔			
Saint Paul's Church				🔴↔
Saint-Gaudens				🟡↔
Salem Maritime	🟡↔			🔴↔
San Antonio Missions				🔴↓
San Francisco Maritime	🟡↔			🔵↔
Santa Monica Mountains				🔴↔
Saratoga				🟡↔
Saugus Iron Works	🟡↔	🔴↔	🔴↔	🔴↔
Sequoia & Kings Canyon	🔴↔			🔴↔
Shenandoah	🔴↔	🔴↔	🔴↓	🟡↓
Sleeping Bear Dunes		🔴↔	🔴↔	🔴↔
Springfield Armory				🔴↔
Statue Of Liberty				🔴↔
Steamtown				🟡↔
Sunset Crater Volcano	🟡↔			
Tallgrass Prairie	🔴↔			
Thaddeus Kosciuszko	🔴↔			🔴↔
Theodore Roosevelt	🟡↔	🟡↔	🔵↔	🔵↔
Theodore Roosevelt Birthplace				🔴↔
Theodore Roosevelt Inaugural				🔴↔
Theodore Roosevelt Island	🔴↔			🔴↔
Thomas Stone	🔴↔			
Timpanogos Cave				🔴↓
Timucuan	🔴↔			🟡↔
Tonto	🟡↔			
Tumacácori	🟡↔			
Tupelo				🟡↓
Ulysses S Grant				🔴↔
Upper Delaware		🔴↔	🔴↔	
Valley Forge				🔴↓
Vanderbilt Mansion				🔴↔

Park	**Condition and Trend Symbol**			
	Visibility	**Nitrogen Deposition**	**Sulfur Deposition**	**Ozone**
Virgin Islands	🟡⬆	🔵↔	🟡↔	
Voyageurs	🟡↔			🟡↔
Walnut Canyon	🟡↔			
Washington	🔴↔			🔴↔
Washita Battlefield	🔴↔			
Weir Farm				🔴↔
Whiskeytown	🟡↔			🔴↔
William Howard Taft				🔴↔
Wilson's Creek	🔴↔			
Wind Cave	🟡↔			
Wolf Trap National Park for the Performing Arts	🔴↔			🔴↔
Yellowstone	🟡↔	🔴↔	🟡↔	🟡↔
Yosemite	🟡↔	🔴↔	🟡↔	🔴↔
Zion	🟡↔			

Appendix D: Calculation of the Ozone W126 Statistic

In January 2010 the EPA proposed a new secondary ozone standard. The proposed standard will be based upon a cumulative sum of hourly ozone values, where the hourly values are weighted according to their concentrations. The weighted value is usually referred to as the W126 statistic. Each hourly index value is computed by multiplying the hourly concentration (O_3) by the weighting function as given by the following equation:

$$W126 = O_3 * \left(\frac{1}{1 + \left(4403 * e^{-126 * O_3}\right)} \right)$$

The hourly index values are then summed over the daylight hours from 8 a.m. to 8 p.m. for each 3-month period during the local ozone season. For a month to be valid, it must have hourly ozone values available for at least 75% of possible hours. The W126 index is then adjusted for missing hourly data by multiplying it by the ratio of the number of possible hours to the available hours. Months with fewer than 75% of possible hourly ozone measurements are not considered. For each year, the three-month period with the highest cumulative W126 value is selected, and the annual values are then averaged over three years. The resulting number is the standard-related summary statistic, and it is expressed in ppm-hours.

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