



Air Quality in National Parks

Trends (2000–2009) and Conditions (2005–2009)

Natural Resource Report NPS/NRSS/ARD/NRR—2013/683





ON THE COVER

Fall colors at the Hensley Settlement in Cumberland Gap National Historical Park, Kentucky.

Credit: National Park Service.

ON THIS PAGE

A hiker enjoys the tranquility of McAlester Lake at North Cascades National Park, Washington.

Credit: National Park Service.

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Executive Summary

The National Park Service (NPS) Air Resources Division (ARD) measures progress toward clearer skies, cleaner air, and healthier ecosystems by examining key air quality indicators, including:

- visibility – how well and how far visitors can see;
- ozone – which affects human health and vegetation;
- sulfur and nitrogen deposition – which affects ecosystem health through acidification and nutrient enrichment of soils, surface waters, and vegetation; and
- mercury deposition – which affects human and wildlife health through bioaccumulation to toxic levels in food webs.

The NPS monitors one or more of these indicators in 58 parks. In addition, many state and local air quality monitoring stations are located in or near parks and collect data that provide valuable information about air quality in parks. Air quality trends and conditions for one or more indicators have been calculated for 347 parks using these data.

Air quality trends are one way of demonstrating progress in reducing air pollution. In general, air quality that is improving, or showing no deteriorating trend, may be considered a sign of progress toward clearer skies, cleaner air, and healthier ecosystems. To identify trends for this report, visibility, ozone, and deposition data collected from 2000 to 2009 were examined.¹ For this time period, over 95 percent of parks with air quality data show no trends or improving trends in visibility, ozone, and deposition.

A park with improving air quality is showing progress, but its air quality condition may still be significantly degraded. For this report, conditions are based on 2005 to 2009 data. Using an index for each air quality indicator (visibility, ozone, and deposition), park air quality is characterized as *Indicator is in Good Condition, Warrants Moderate Concern, or Warrants Significant Concern*.

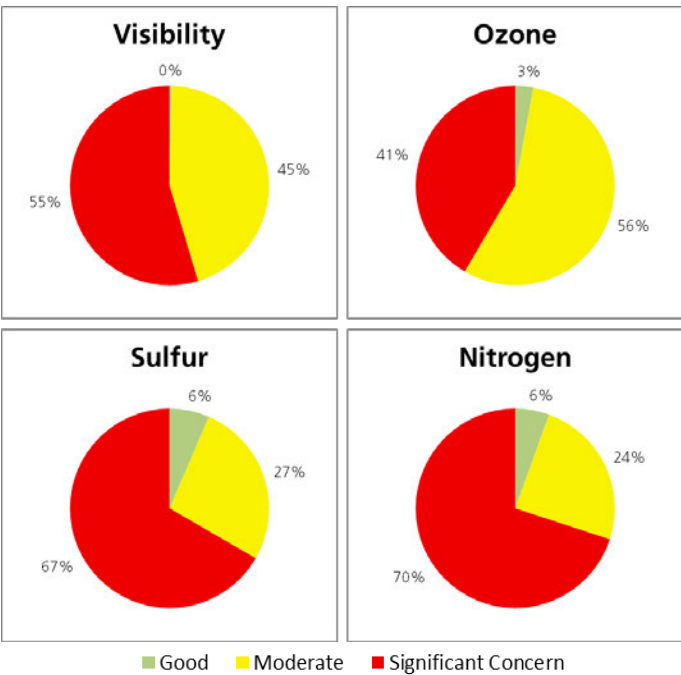


Figure I. Park Condition Summary

Unfortunately, a large proportion of parks warrant significant concern for each of the air quality indicators and very few parks have air quality that is considered to be in good condition (Figure I). Understanding air quality trends is especially important for protecting park resources in areas where the air quality conditions warrant significant concern.

In parks where visibility warrants significant concern, the vast majority show statistically significant improvement. The same cannot be said for parks where ozone, sulfur deposition, and/or nitrogen deposition is of significant concern. Most of these parks show no significant trend, likely indicating that unless pollution levels are reduced they will remain in the significant concern category.

Table I. Trend Overview for Parks with Significant Concern Condition						
Air Quality Indicator	Significantly Improving Parks		Significantly Degrading Parks		No Significant Trend Parks	
	Number	Percent	Number	Percent	Number	Percent
Visibility	49	73	0	0	18	27
Ozone	20	22	2	3	67	75
Sulfur	10	37	0	0	17	63
Nitrogen	6	18	1	3	26	79

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

Condition was not identified for mercury deposition, as condition thresholds for mercury deposition have not been established. Of 16 parks with available trend data, 3 (19 percent) have statistically significant improving trends, none have statistically significant deteriorating trends, and 13 (81 percent) have no statistically significant trends. Air quality in parks is expected to improve as states and tribes implement programs to improve visibility in national parks and wilderness areas.

Air quality in parks will also improve as a result of other air pollution control programs, such as those aimed at reducing

tailpipe emissions from cars. Information available through the NPS air quality monitoring program supports pollution control programs that will benefit parks. The ARD's ability to offer expert advice to regulatory agencies has stimulated collaborative efforts to find creative and cost-effective air quality management approaches. However, some parks are increasingly affected by oil and gas development, and non-regulated sources, like agriculture. The ARD continues to evaluate impacts on air quality and related resources from these and other sources.

1. Measuring Progress: Air Quality Trends

1.1. Introduction

Data used to calculate trends come from air quality monitors that are in-park or representative monitors nearby (within 10 kilometers of the park for ozone, 16 kilometers of the park for wet deposition, and 100 kilometers of the park for visibility). A non-parametric regression technique called the Theil method is used to determine visibility, ozone, and deposition trends. Ten-year trends are calculated for sites that have at least 6 years of annual data and an annual value for the final year of the 10-year period.

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). In tables and figures throughout the report, statistically significant trends are shown with dark blue (improving trend) and red (deteriorating trend) backgrounds. Due to the variable nature of the statistics being used to track progress, it is possible that some locations are experiencing a change in conditions but 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). In tables and figures throughout the report, these locations are denoted by light blue (possible improvement) and pink (possible degradation). However, only the significant trends are counted for the purpose of assessing progress toward air quality goals; sites noted as having only possible improvement or degradation are counted as having no trend. Table 1 shows a summary of trend results. Sections 1.2–1.5 describe the trend analyses in more detail, and the results of the trend analyses for individual parks are shown in Appendix A.



Rapid ongoing oil and gas development could impact air resources in Theodore Roosevelt NP. The NPS Air Resources Division is working with other federal land management agencies to develop models that assess the air quality impacts of oil and gas development in the region.

Credit: National Park Service.

For the 2000–2009 reporting period, 100 percent of the parks show no trends or improving trends in visibility on clearest days, 94 percent show no trends or improving trends in visibility on haziest days, 97 percent show no trends or improving trends in ozone, and 96 percent show no trends or improving trends in deposition. Note that although trends may be statistically significant, they may be relatively small. Table A in Appendix A shows trend slopes.

Table 1. Summary of trend results (2000–2009).				
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	165	56	109	0
Visibility–Haziest Days	165	80	76	9
Ozone–Human Health	129	90	36	3
Ozone–Vegetation Effects	132	94	33	5
Wet Deposition–Sulfate	56	39	17	0
Wet Deposition–Nitrate	56	20	36	0
Wet Deposition–Ammonium	56	52	2	2
Wet Deposition–Nitrogen	56	45	9	1
Wet Deposition–Mercury	16	13	3	0

1.2. Visibility Measures

The Air Resources Division (ARD) examines the haze levels on the clearest days and haziest days to characterize visibility conditions. The Environmental Protection Agency (EPA) uses these measures to assess progress toward the Clean Air Act visibility goal of remedying any existing and preventing any future human-caused visibility impairment in Class I² areas. The Regional Haze Rule visibility goals require visibility improvement on the 20% haziest days, with no degradation on the 20% clearest days. States are responsible for meeting these goals.

Visibility 10-year trends are computed from the Haze Index values in deciviews (dv) on the 20% haziest days and the 20% clearest days, consistent with Regional Haze Rule visibility goals. For an overall visibility trend, trends for clearest and haziest days are combined (Table B). If the Haze Index trend on the 20% clearest days is deteriorating, the overall visibility trend is reported as deteriorating. Otherwise, the Haze Index trend on the 20% haziest days is reported as the overall visibility trend.

The ARD calculated 10-year visibility trends for 165 parks, both Class I and Class II, that had representative visibility data. No parks show significant degrading trends on the clearest days. Trends on the clearest days are shown in Figure 1. On the haziest days, 76 parks (46 percent) are showing significant improvement with 9 (6 percent) showing significant degrading trends. There are 80 parks (48 percent) with no statistically significant trends on the haziest days. Trends on the haziest days are shown in Figure 2.

Improvements in visibility in the eastern U.S. are largely influenced by reductions in sulfur dioxide and nitrogen oxide emissions from electric utilities and industrial boilers, required by a variety of Clean Air Act programs. Continued implementation of visibility protection programs will further reduce emissions responsible for visibility impairment throughout the U.S. (EPA 2010).

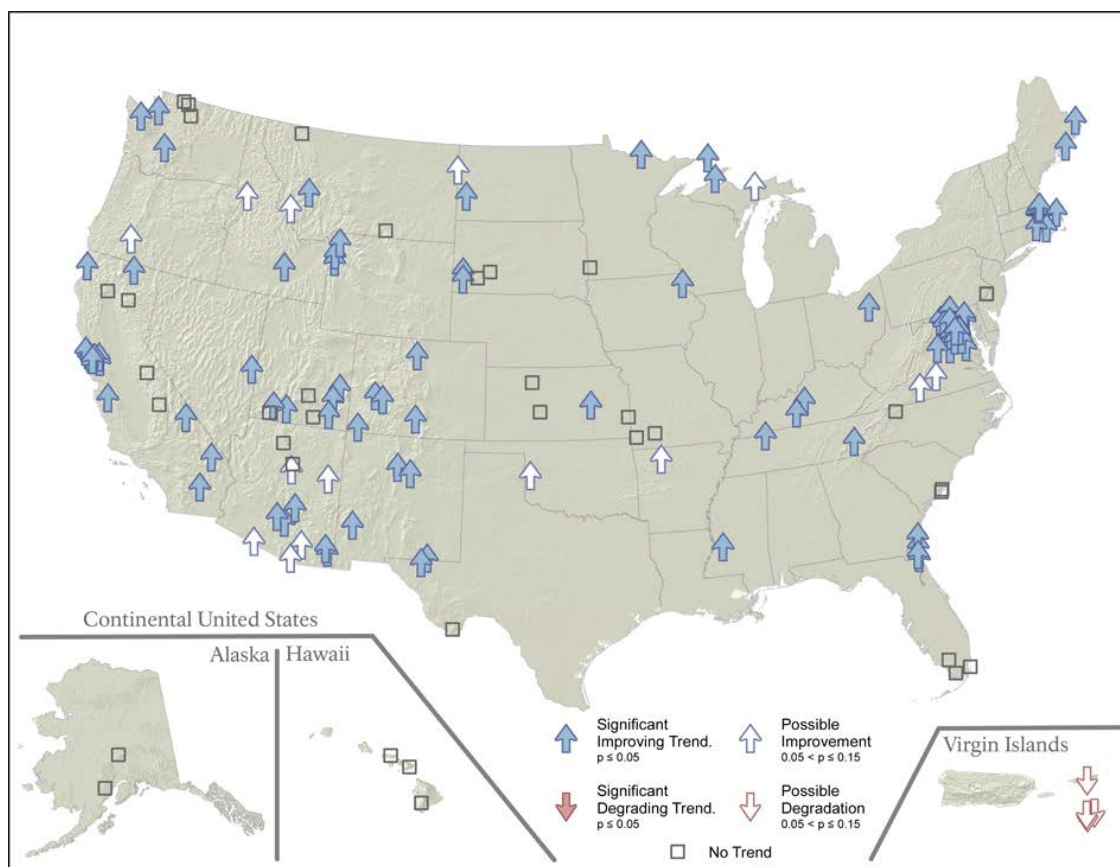


Figure 1. Map of trends in haze index (deciview) on clearest days, 2000–2009.
The Clean Air Act visibility goal requires no visibility degradation on the 20% clearest days.

² Class I areas have the highest level of air quality protection under the law. These areas are defined as national parks over 6,000 acres, wilderness areas over 5,000 acres, and international parks that were in existence when the Clean Air Act (CAA) was amended in 1977. There are 48 units of the National Park System, 21 units of the National Wildlife Refuge System, 88 U.S. Forest Service (USFS) Wilderness Areas, and 1 international park designated as Class I. While the CAA specifically calls out Class I parks for visibility goals, all parks' air quality is to be "preserved, protected, and enhanced." All parks not designated as Class I are Class II.

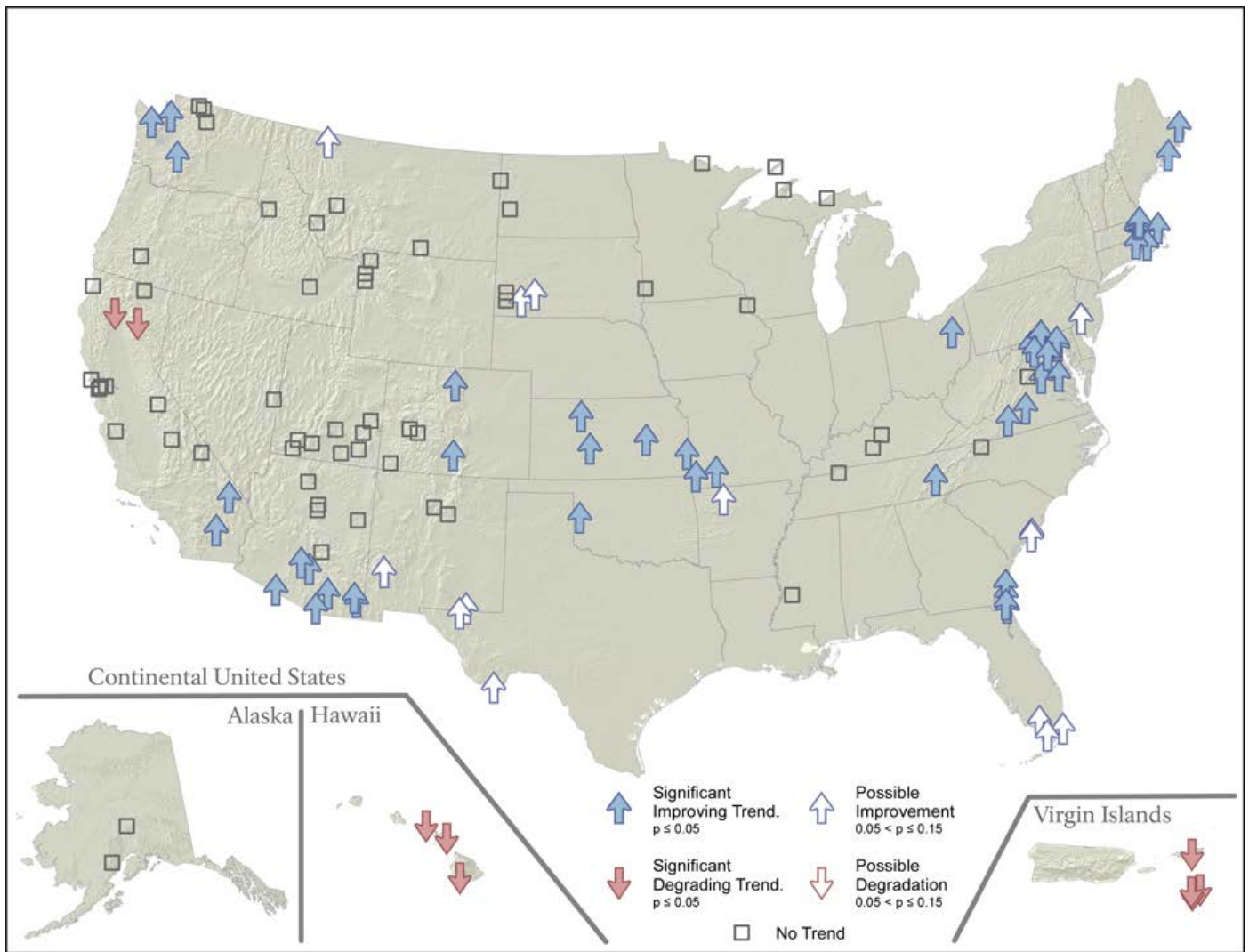


Figure 2. Map of trends in haze index (deciview) on haziest days, 2000–2009.

The Clean Air Act visibility goal requires visibility improvement on the 20% haziest days.

1.3. Ozone Measures

The EPA has established National Ambient Air Quality Standards (NAAQS) for ozone intended to protect the public health and welfare. The ARD evaluated 10-year trends in ozone concentrations using the annual 4th-highest daily maximum 8-hour average ozone concentration in parts per billion (ppb), which is a comparable metric to the one used for NAAQS. ARD calculated 10-year trends for 129 parks with representative ozone data. Of these parks, 36 (27 percent) show significant improving trends. Big Bend National Park, Golden Gate National Recreation Area, and Muir Woods National Monument, however, show significant degrading trends.

The remaining 90 parks (70 percent) show no statistically significant trends. These trends are shown in Figure 3.

The ARD also evaluates ozone 10-year trends using the W126 metric, which focuses on the biological response of vegetation to ozone. The W126 measures cumulative ozone exposure over the growing season in parts per million-hours (ppm-hrs), and is a better predictor of vegetation response than the metric used for the human health standard (more details on how this value is calculated are provided in Appendix C). Of the 132 parks with W126 10-year trends, 33 (25 percent) show significant improving trends and 5 (4 percent) show significant deteriorating trends. The remaining 94 parks (71 percent) show no statistically significant trends. Ozone trends are shown in Figure 4.

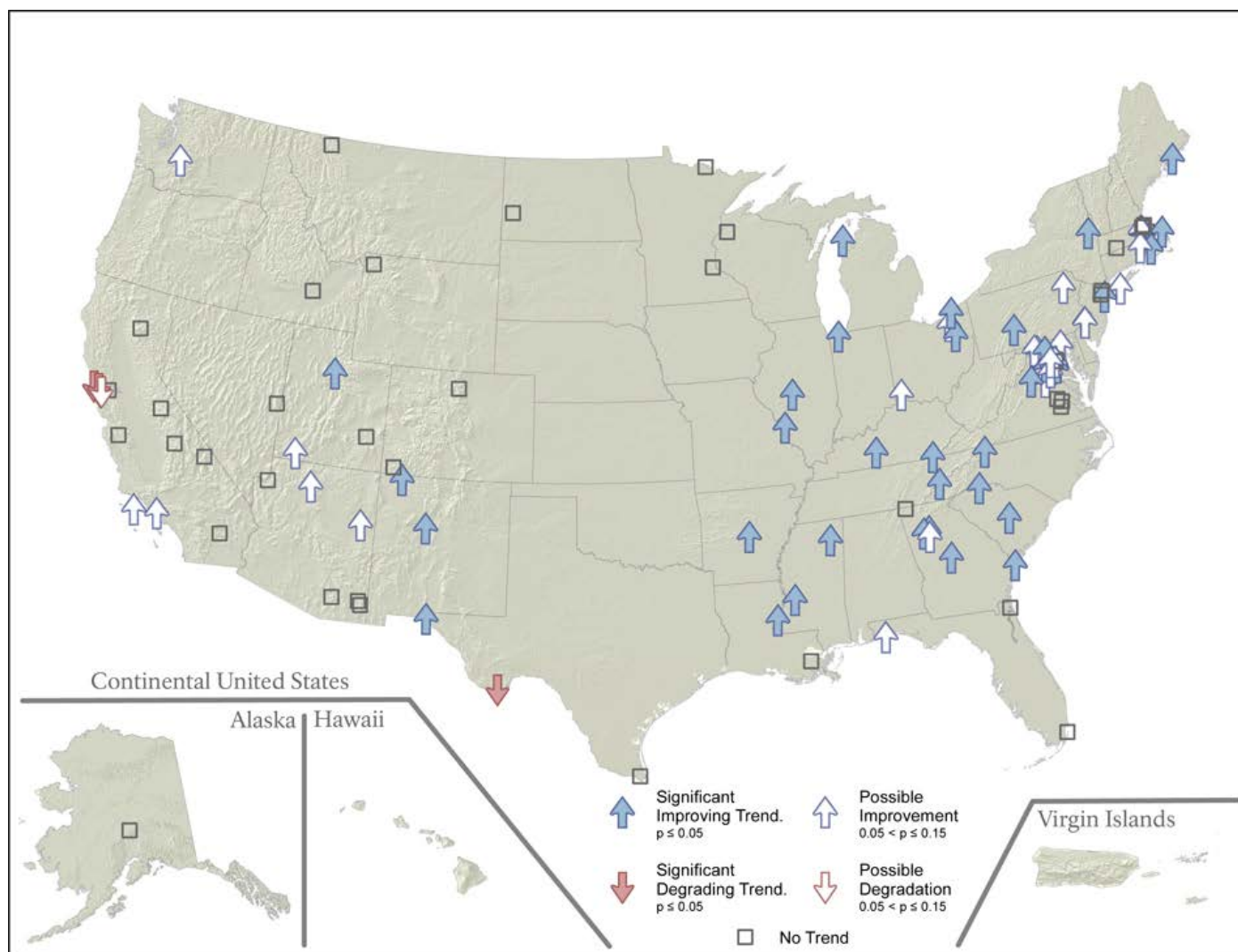


Figure 3. Map of trends in annual 4th-highest daily maximum 8-hour average ozone concentration (ppb/yr), 2000–2009.

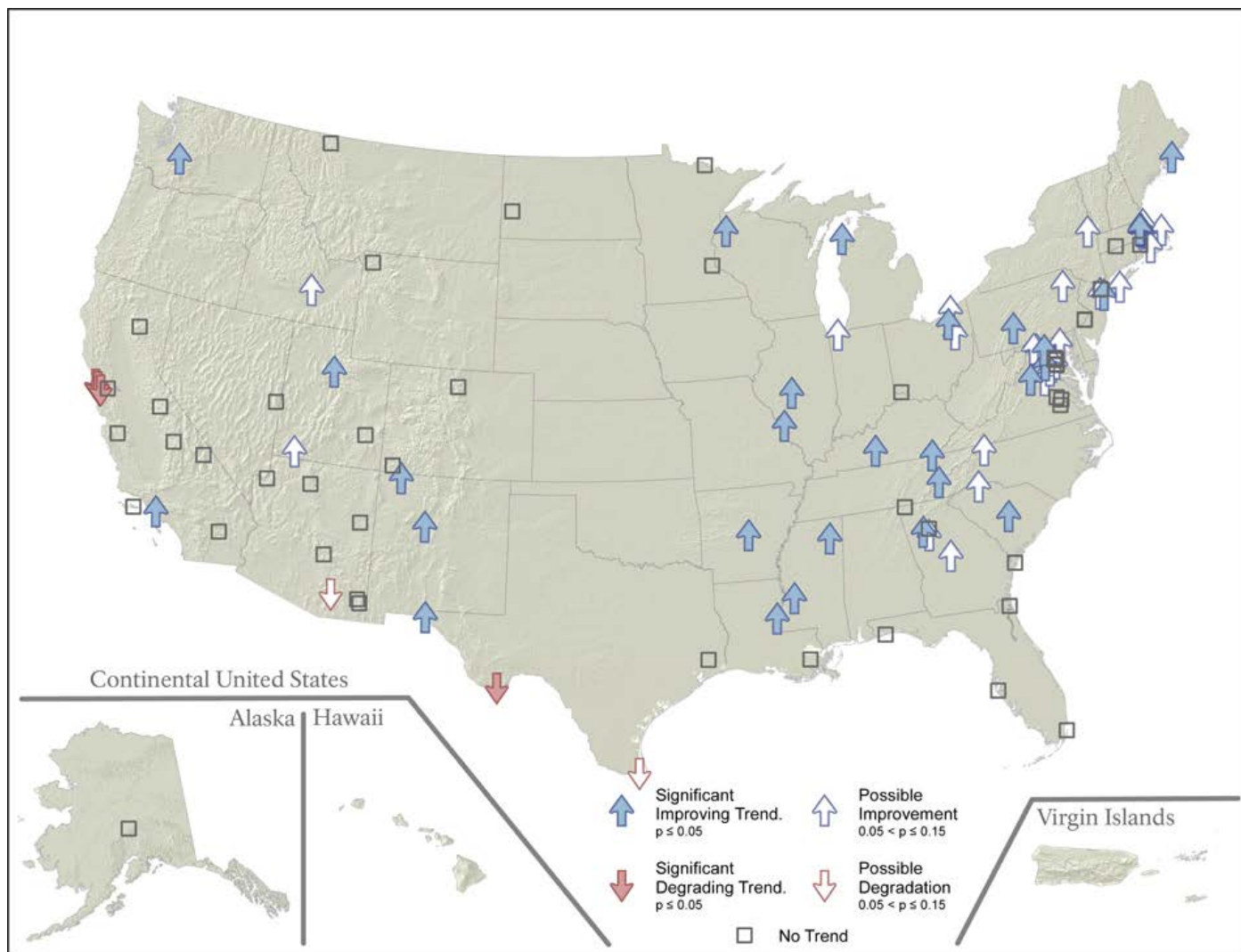


Figure 4. Map of trends in W126 metric* (ppm-hrs/yr), 2000–2009.

*The W126 metric preferentially weights the higher ozone concentrations most likely to affect plants and sums all weighted concentrations during daylight hours over a three month growing season, giving a cumulative metric expressed in ppm-hrs.

1.4. Sulfur and Nitrogen Wet Deposition

When air pollutants such as sulfur and nitrogen are deposited into ecosystems, they may cause acidification or enrichment of soils and surface waters. Ecosystems in national parks can be vulnerable to the effects of airborne pollutant deposition because parks contain sensitive areas, such as high elevation lakes and streams, alpine meadows, sugar maple forests, and desert shrublands.

Although both wet and dry forms of deposition affect ecosystems, for this report, wet deposition alone is used to characterize deposition, as dry deposition measurements are very limited. The ARD calculated 10-year trends for 56 parks that had representative sulfate, nitrate, and ammonium wet deposition data. Trends in wet deposition are evaluated using pollutant concentrations in precipitation

(micro equivalents per liter per year — $\mu\text{eq/L/yr}$) so that yearly variations in precipitation amounts have less influence on trend results. For sulfur wet deposition trends, sulfate concentrations measured in precipitation are trended over a 10-year period. To assess the 10-year trend for total nitrogen wet deposition, nitrogen from nitrate and ammonium are summed to give the total nitrogen concentration in precipitation.

1.4.1. Sulfate Wet Deposition

Sulfate concentrations in precipitation show no statistically significant trends in 39 parks (70 percent) and statistically significant improving trends in 17 parks (30 percent). No parks show statistically significant deteriorating trends. Trends in sulfate concentrations in precipitation are shown in Figure 5.

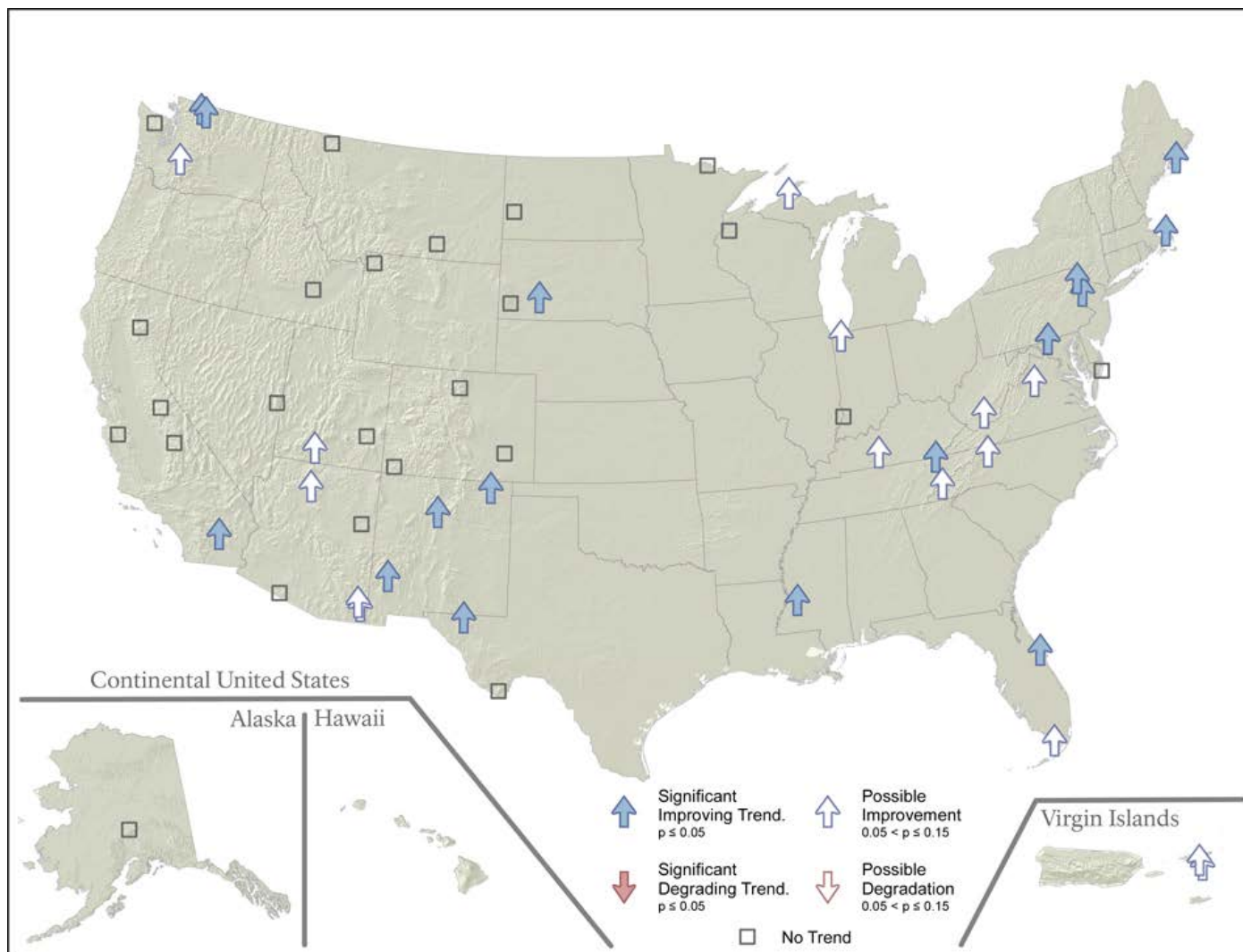


Figure 5. Map of trends in sulfate concentrations in precipitation ($\mu\text{eq/L/yr}$), 2000–2009.

1.4.2. Nitrate, Ammonium, and Nitrogen Wet Deposition

Nitrate concentrations in precipitation show no statistically significant trends in 20 parks (36 percent) and statistically significant improving trends in 36 parks (64 percent). No parks show deteriorating trends in nitrate. Trends in nitrate concentrations in precipitation are shown in Figure 6.

Ammonium concentrations in precipitation show no statistically significant trends in 52 parks (93 percent), with just two parks showing a statistically significant improvement in concentrations (Denali National Park & Preserve and Joshua Tree National Park). Ammonium

concentrations show a significant increasing trend in two parks: Bryce Canyon National Park and George Rogers Clark National Historic Park. Trends in ammonium concentrations in precipitation are shown in Figure 7.

Inorganic nitrogen derived from ammonium and nitrate concentrations in precipitation show no statistically significant trends in 80 parks (93 percent), with 9 parks (16 percent) showing a statistically significant improvement in concentrations. Nitrogen concentration is increasing in one park: George Rogers Clark National Historic Park. Trends in nitrogen concentrations in precipitation are shown in Figure 8.

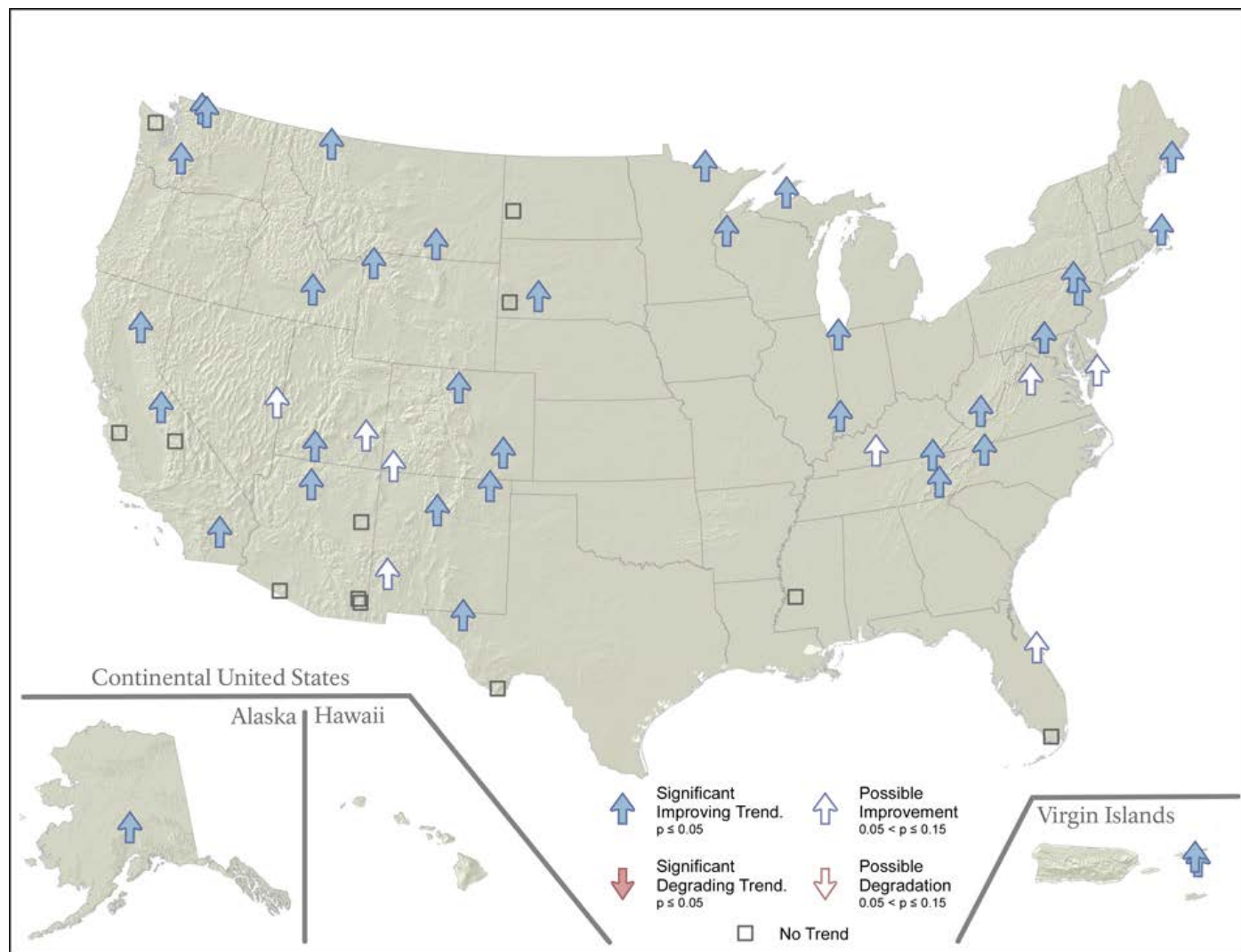


Figure 6. Map of trends in nitrate concentrations in precipitation ($\mu\text{eq/L/yr}$), 2000–2009.

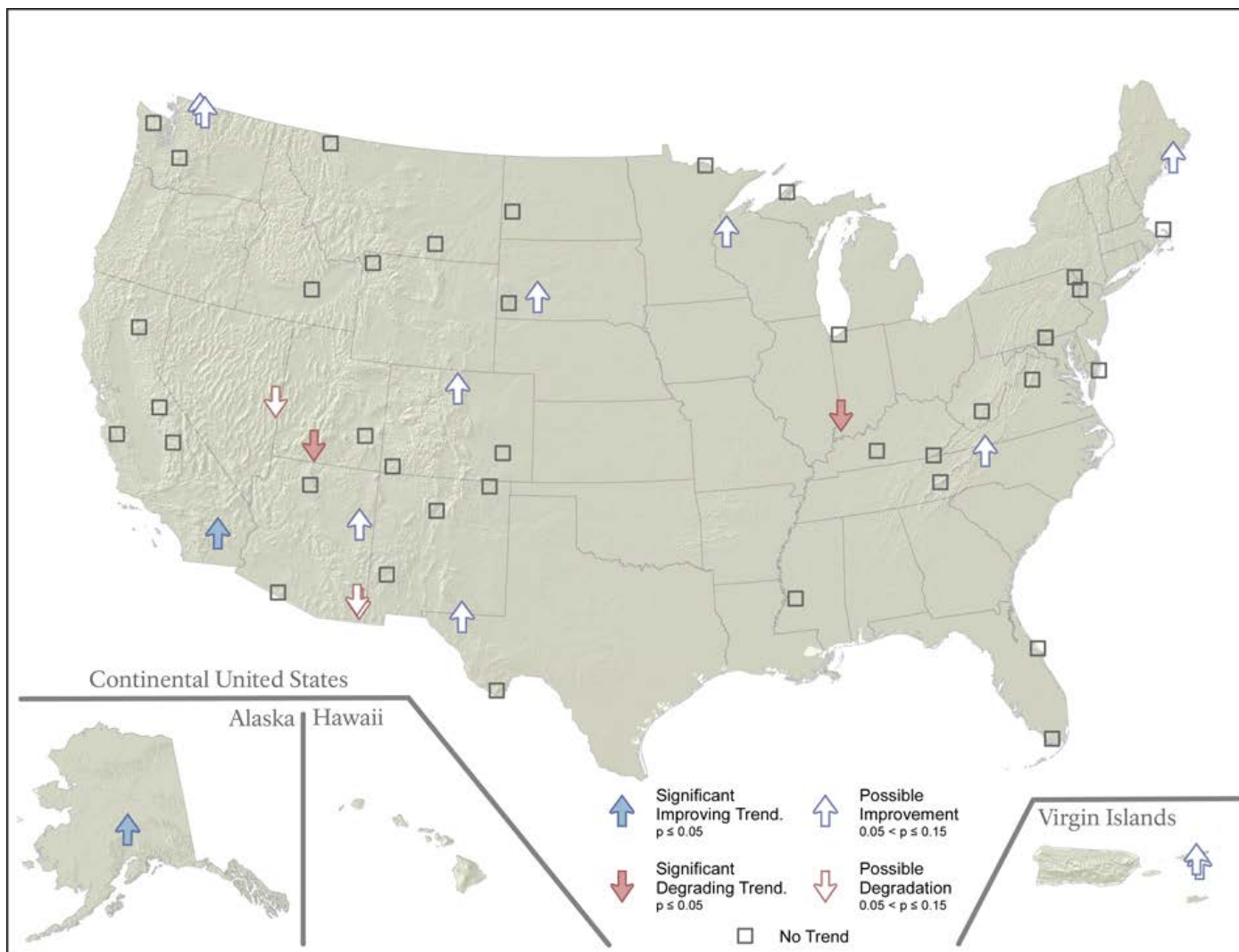


Figure 7. Map of trends in ammonium concentrations in precipitation ($\mu\text{eq/L/yr}$), 2000–2009.

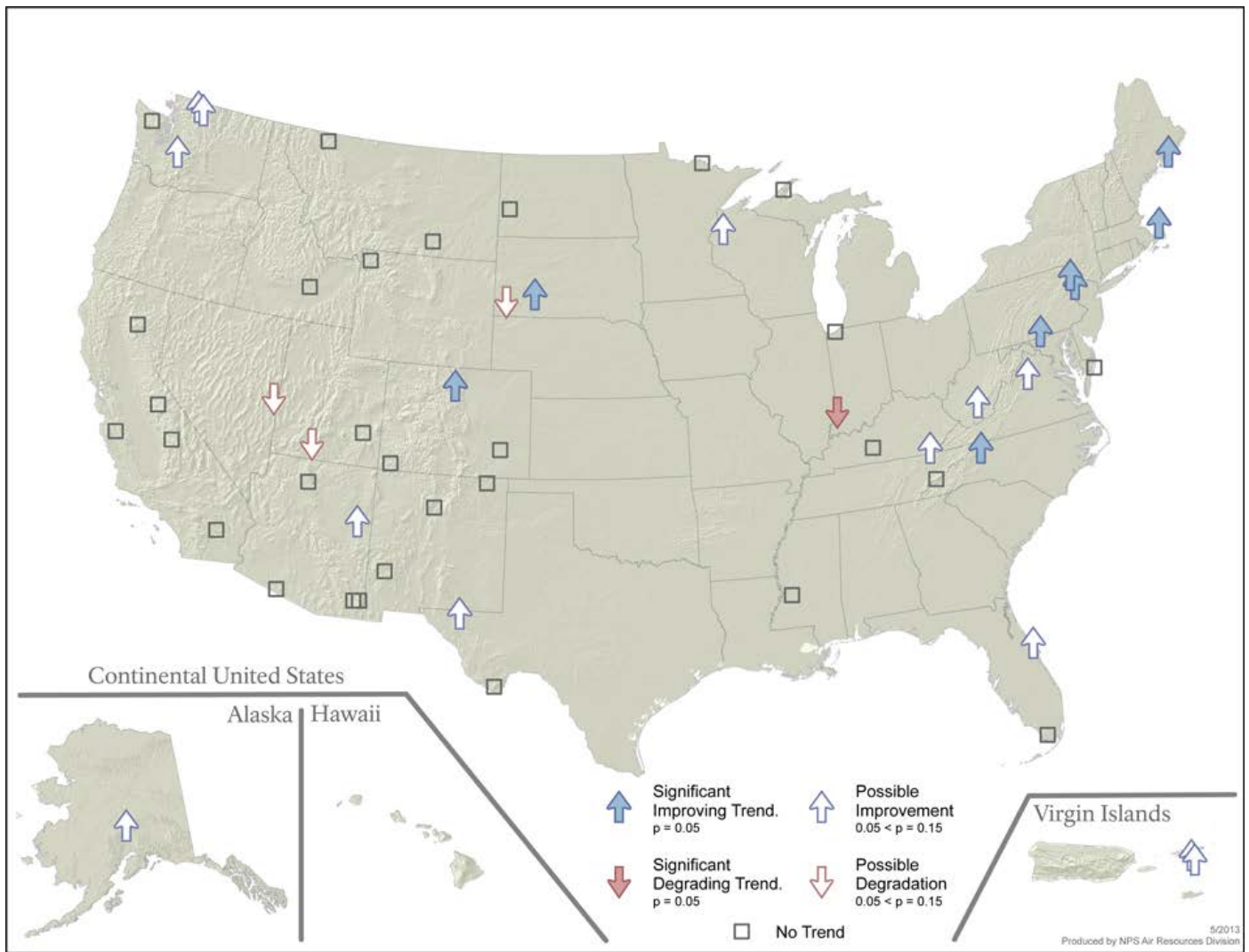


Figure 8. Map of trends in nitrogen (ammonium and nitrate) concentrations in precipitation ($\mu\text{eq/L/yr}$), 2000–2009.

1.5. Mercury Wet Deposition

The NPS also monitors mercury deposition as mercury can bioaccumulate to toxic levels in food webs. Mercury is primarily emitted by the burning of coal in power plants and most often deposited in the inorganic or elemental form; it is converted to an organic form, methylmercury, in the environment. Methylmercury is a toxic form of mercury that enters the food chain and accumulates in organisms. Animals and people who eat fish contaminated with mercury are at greatest risk for mercury exposure.

As with nitrogen and sulfur deposition, dry mercury measurements are very limited; consequently, wet mercury deposition is used to characterize mercury trends. Mercury wet deposition monitoring started more recently than other types of deposition monitoring, but there are now 16 parks with sufficient data records for 10-year trend analysis in mercury concentration in precipitation (nanograms per liter per year —ng/L/yr). Results of the trend analyses are shown

in Table 2. Of the 16 parks, 13 parks (81 percent) show trends that are not statistically significant. Three parks (19 percent), Allegheny Portage National Historic Site, Indiana Dunes National Lakeshore, and Great Smoky Mountains National Park show statistically significant improving trends in mercury concentrations. None of the parks monitored show statistically significant degrading trends in mercury concentration. Trends in mercury concentrations in precipitation are shown in Figure 9.

While measuring atmospheric mercury deposition over time and space is valuable for understanding temporal and spatial trends, atmospheric deposition of mercury is not directly related to methylmercury production and bioaccumulation in ecosystems. This is because the conversion of mercury to methylmercury is controlled by microorganisms that are more active under certain environmental conditions such as the presence of wetlands, high dissolved organic matter, and high sulfate concentrations.



Table 2. Trends in mercury concentrations in precipitation, 2000–2009.				
NPS Unit	Mercury (ng/L/yr)	P-value	First Year of Data	Last Year of Data
Acadia NP	-0.23	0.11	2000	2009
Allegheny Portage Railroad NHS	-0.23	0.04	2000	2009
Cape Cod NS	-0.50	0.14	2004	2009
Congaree NP	-0.37	0.11	2000	2009
Delaware Water Gap NRA	-0.33	0.06	2001	2009
Eisenhower NHS	-0.26	0.13	2001	2009
Everglades NP	-0.10	0.43	2000	2009
Gettysburg NMP	-0.26	0.13	2001	2009
Great Smoky Mountains NP	-0.29	0.05	2002	2009
Hopewell Furnace NHS	-0.10	0.30	2000	2009
Indiana Dunes NL	-0.49	0.01	2001	2009
Mammoth Cave NP	-0.08	0.39	2003	2009
Mesa Verde NP	1.00	0.27	2002	2009
Sequoia & Kings Canyon NPs	0.20	0.23	2004	2009
Shenandoah NP	0.10	0.50	2003	2009
Upper Delaware SRR	-0.33	0.06	2001	2009

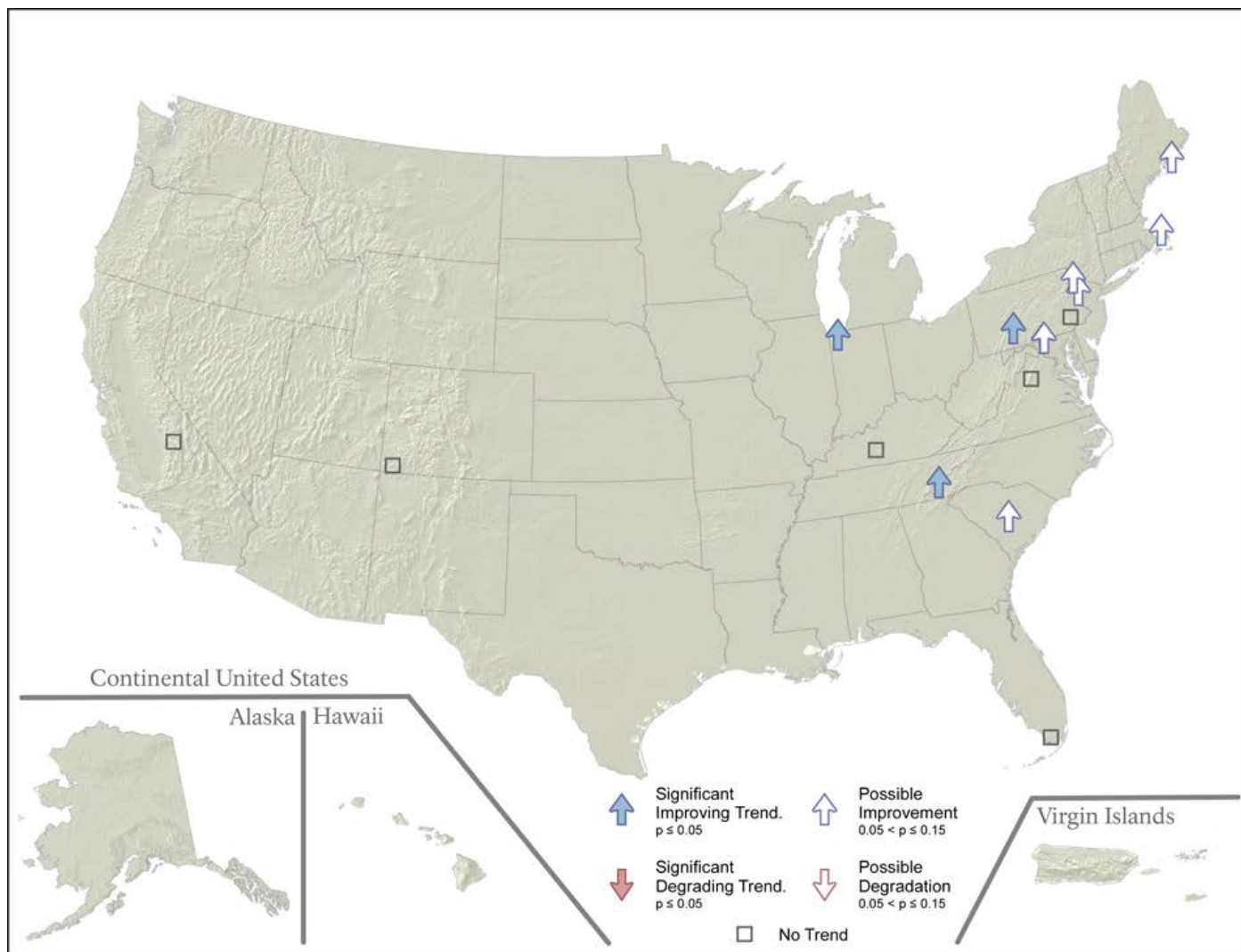


Figure 9. Trends in mercury concentrations in precipitation (ng/liter/yr), 2000–2009.

2. Assessment of Air Quality Conditions

2.1. Introduction

In addition to determining the trends in air quality, the ARD assesses the current condition of the air resources within parks. Although air quality may be improving in a park, its condition may still be of concern.

The ARD uses all available monitoring data over a 5-year period (2005–2009) to generate interpolations for each air quality indicator (visibility, ozone, and wet deposition) in the contiguous United States. Monitors used include NPS, EPA, state, tribal, and local monitors. These interpolations produce estimates of air quality parameters at all parks located within the contiguous United States, including many without on-site monitoring.

Estimates and conditions are not available for most parks in Alaska and the Pacific Islands because data are too sparse to interpolate. On-site monitor data are used to derive the condition category estimates for Denali National Park & Preserve, Lake Clark National Park & Preserve, Virgin Islands National Park, Hawaii Volcanoes National Park, and Haleakala National Park.

Estimates for visibility, ozone, and wet deposition are assigned to one of three condition categories:

- Warrants Significant Concern,
- Warrants Moderate Concern, or
- Indicator is in Good Condition.

The air quality condition results are shown graphically in Figures 10–13 and listed in Appendix B. The condition is represented by the color of the circle, where red represents *Warrants Significant Concern*, yellow represents *Warrants Moderate Concern*, and green represents *Indicator is in Good Condition*.

The procedures for assigning these categories are described below.

Visibility Condition

Air pollution causes haze and reduces visibility. Visibility is measured using the Haze Index³ in deciviews (dv). As the Haze Index increases, the visibility worsens. Conditions for visibility are derived from interpolated estimates of 5-year average visibility⁴ minus average natural visibility⁵:

Visibility Condition = average current visibility – estimated average natural visibility.

Interpolated estimates are used within the contiguous U.S. For certain sites outside the contiguous U.S., visibility condition is based on 5-year averages computed from on-

site data. Visibility data were obtained from the Interagency Monitoring of Protected Visual Environments (IMPROVE) network (<http://vista.cira.colostate.edu/improve/>).

Indicator is in Good Condition category is assigned to parks with visibility less than 2 dv above natural conditions. Parks with visibility ranging from 2 to 8 dv above natural conditions are considered to be in the *Warrants Moderate Concern* category, and parks with visibility greater than 8 dv above natural conditions are considered to be in the *Warrants Significant Concern* category. The deciview ranges of these categories were chosen to reflect the variation in monitored visibility conditions.

Visibility Condition		Average visibility – estimated average natural conditions (dv)
Warrants Significant Concern		> 8
Warrants Moderate Concern		2–8
Indicator is in Good Condition		< 2

Condition Adjustments: Visibility condition assessments are based on interpolated 5-year average haze index values without any adjustments.

Ozone Condition

The EPA's ozone standards are used as a benchmark for rating ozone condition. These standards were revised in 2008 in order to be more protective of human health and welfare. The primary and secondary standards are identical. To attain these standards, the 3-year average of the annual 4th-highest daily maximum 8-hour average ozone concentrations measured at each monitor must not exceed 75 parts per billion (ppb). For parks within the contiguous U.S., ozone condition is estimated from the interpolation of the 5-year averages of 4th-highest daily maximum 8-hour average ozone concentration. For certain sites outside the contiguous U.S., ozone condition is based on 5-year averages computed from on-site data where available. Ozone data were obtained from the EPA Air Quality System (<http://www.epa.gov/ttn/airs/airsaqs/>) and the Clean Air Status and Trends Network (<http://epa.gov/castnet/javaweb/index.html>). Interpolated data cannot be used to assess compliance with the standard, but provide a means to assess ozone condition.

If the resulting 5-year average is greater than or equal to 76 ppb then the condition *Warrants Significant Concern* is assigned to that park. *Warrants Moderate Concern* condition for ozone is assigned to parks with average 5-year 4th-highest daily maximum 8-hour average ozone concentrations from 61 to 75 ppb (concentrations greater than 80 percent of the standard). *Indicator is in Good Condition* is assigned to parks with average 5-year ozone

³ The Haze Index is a measure of visibility derived from calculated light extinction (EPA-454/B-03-005).

⁴ Average visibility is defined as the mean of visibility between the 40th and 60th percentiles

⁵ Natural visibility conditions are those estimated to exist in a given area in the absence of human-caused visibility impairment. The Clean Air Act established a goal of restoring visibility in all Class I areas to natural conditions (EPA-454/B-03-005).

concentrations less than 61 ppb (concentrations less than 80 percent of the standard).

Ozone Condition		Ozone concentration ⁶ (ppb)
Warrants Significant Concern		≥ 76
Warrants Moderate Concern		61–75
Indicator is in Good Condition		≤ 60

Condition Adjustments: For parks that fall within a county designated by the EPA as "nonattainment" (not meeting) for the ozone standards, the ozone condition is adjusted to the *Warrants Significant Concern* category.

Vegetation sensitivity is also considered for ozone condition assessment. Data show that some plant species⁷ 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 National Park, Shenandoah National Park, and Sequoia and Kings Canyon National Parks.

A risk assessment 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 (Kohut 2007). If parks were evaluated at high risk for ozone injury to vegetation, the condition category is adjusted to the next worse condition category.

ARD is considering using a more ecologically relevant metric, the W126, to assess ozone condition in future reports.

Wet Deposition Condition

Deposition of sulfur and nitrogen compounds can acidify sensitive lakes, streams, and soils, disrupt soil nutrient cycling, and affect biodiversity. Conditions of atmospheric deposition are based solely on wet deposition only because dry deposition data are not available for most parks. Wet deposition calculated by multiplying nitrogen⁹ or sulfur¹⁰ concentrations in precipitation by a normalized precipitation amount¹¹ for this assessment. Interpolated

estimates are used within the contiguous U.S. For certain sites outside the contiguous U.S., where interpolations cannot be calculated, and normalized precipitation amounts are not available, 5-year averages of on-site deposition are used where available. Deposition data are obtained from the National Atmospheric Deposition Program (<http://nadp.sws.uiuc.edu/>).

Evidence is not currently available indicating that wet deposition amounts less than 1 kilogram per hectare per year (kg/ha/yr) cause ecosystem harm. Therefore, parks with wet deposition less than 1 kg/ha/yr are assigned *Resource in Good Condition*; parks with 1–3 kg/ha/yr are assigned *Warrants Moderate Concern*; and parks with greater than 3 kg/ha/yr are assigned *Warrants Significant Concern* for deposition.

Deposition Condition		Wet Deposition (kg/ha/yr)
Warrants Significant Concern		> 3
Warrants Moderate Concern		1–3
Indicator is in Good Condition		< 1

Condition Adjustments: National assessments have identified ecosystems and resources in national parks at risk for acidification and excess nitrogen enrichment. The reports provide a relative risk assessment of acidification and nutrient enrichment impacts from atmospheric sulfur and nitrogen deposition for 270 parks in 32 inventory and monitoring networks. If park ecosystems are ranked very high in sensitivity¹² to acidification or nutrient enrichment effects from atmospheric deposition relative to all inventory and monitoring parks (Sullivan et al. 2011a; Sullivan et al. 2011b), the condition category is adjusted to the next worse condition category.

⁶ "Ozone concentration" represents the 4th-highest daily maximum 8-hour average ozone concentration averaged over five years.

⁷ Lists of ozone sensitive species, by park, are available from NPSpecies (<https://irma.nps.gov/App/Species/Search/grpsplst/qrys/moss/lytosvt>).

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/permits/aris/networks/ozone_risk.cfm.

⁹ Total nitrogen is estimated using molecular weight ratios to calculate the nitrogen portions of NO₃ (NO₃ * 0.22581) and NH₄ (NH₄ * 0.77778).

¹⁰ Wet sulfur deposition includes sulfate (SO₄). Total sulfur is estimated using molecular weight ratios to calculate the sulfur portion (SO₄ * 0.3338).

¹¹ Normalized 30-year precipitation values from the PRISM model is used to calculate deposition in order to minimize interannual variation in deposition caused by interannual fluctuations in precipitation (<http://www.ocs.orst.edu/prism/>).

¹² Ecosystem sensitivity relative ratings to acidification from atmospheric deposition were based on percent sensitive vegetation types, number of high-elevation lakes, length of low-order streams, length of high-elevation streams, average slope, and acid-sensitive areas within the park (Sullivan et al. 2011a). Ecosystem sensitivity relative ratings to nutrient enrichment effects from atmospheric nitrogen deposition were based on percent sensitive vegetation types and number of high-elevation lakes within the park (Sullivan et al. 2011b).

2.2. Visibility Condition Results

Figure 10 shows the visibility conditions at parks. Only Denali National Park & Preserve in Alaska falls into the *Indicator is in Good Condition* category. Most of the 156 parks in the *Warrants Moderate Concern* category are

located in the western U.S., with a few in the upper Midwest and the Northeast. The 189 parks in the *Warrants Significant Concern* category are found mostly in the eastern and central U.S., with 5 located in California and 1 in Arizona.

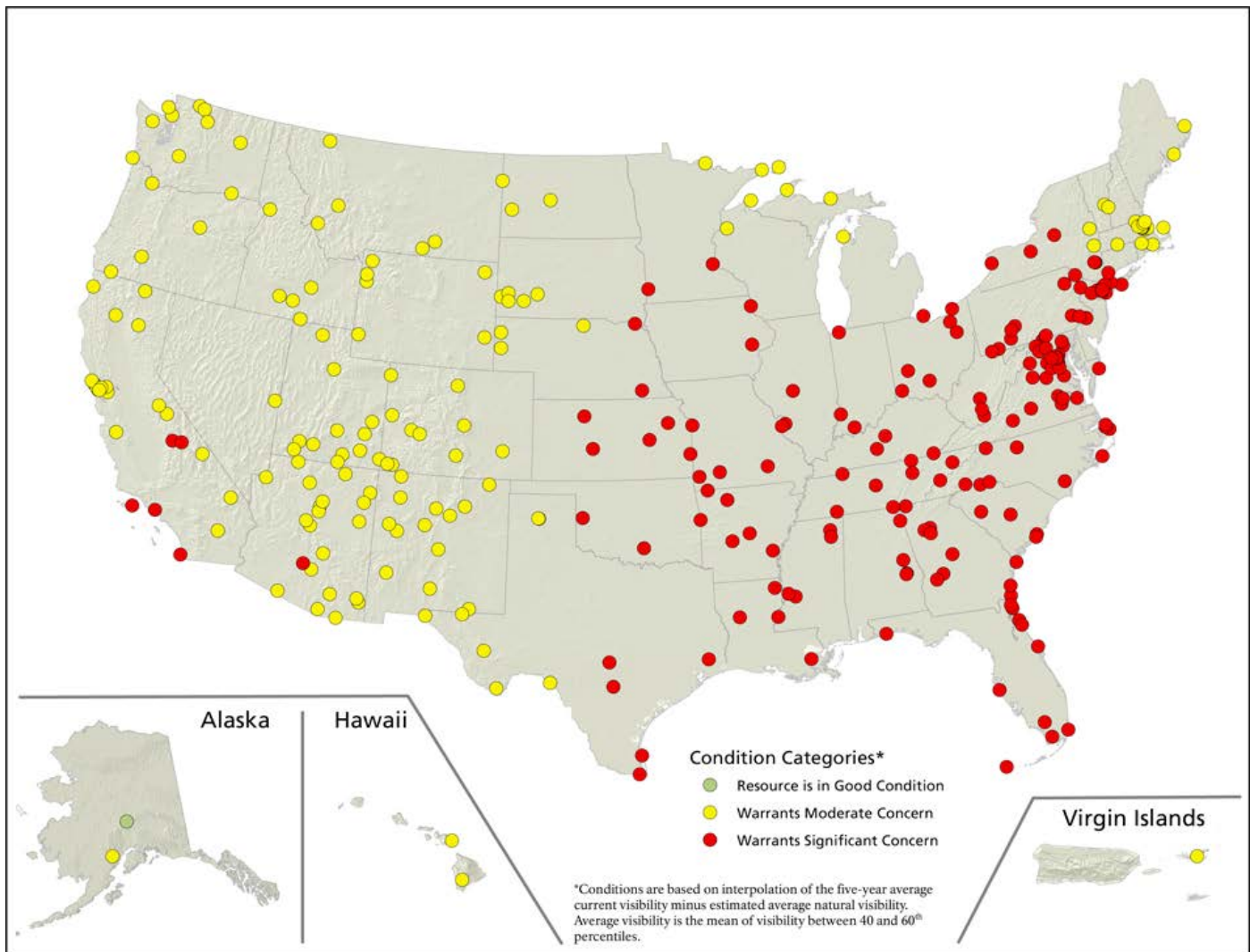


Figure 10. Map of air quality condition assessments for visibility, 2005–2009.

Condition assessments are based on interpolation of the 5-year average current visibility minus estimated average natural visibility in deciviews (dv).

2.3. Ozone Condition Results

Figure 11 shows the ozone conditions at parks. Only 10 parks fall in the *Indicator is in Good Condition* category, which are located in Alaska, North Dakota, Washington, Montana, and the northern coast of California. There are

190 parks that fall in the *Warrants Moderate Concern* category; these parks are located throughout the U.S. The 142 parks in the *Warrants Significant Concern* category are concentrated largely in the eastern U.S. and California, with a few located near the Great Lakes region and eastern Texas.

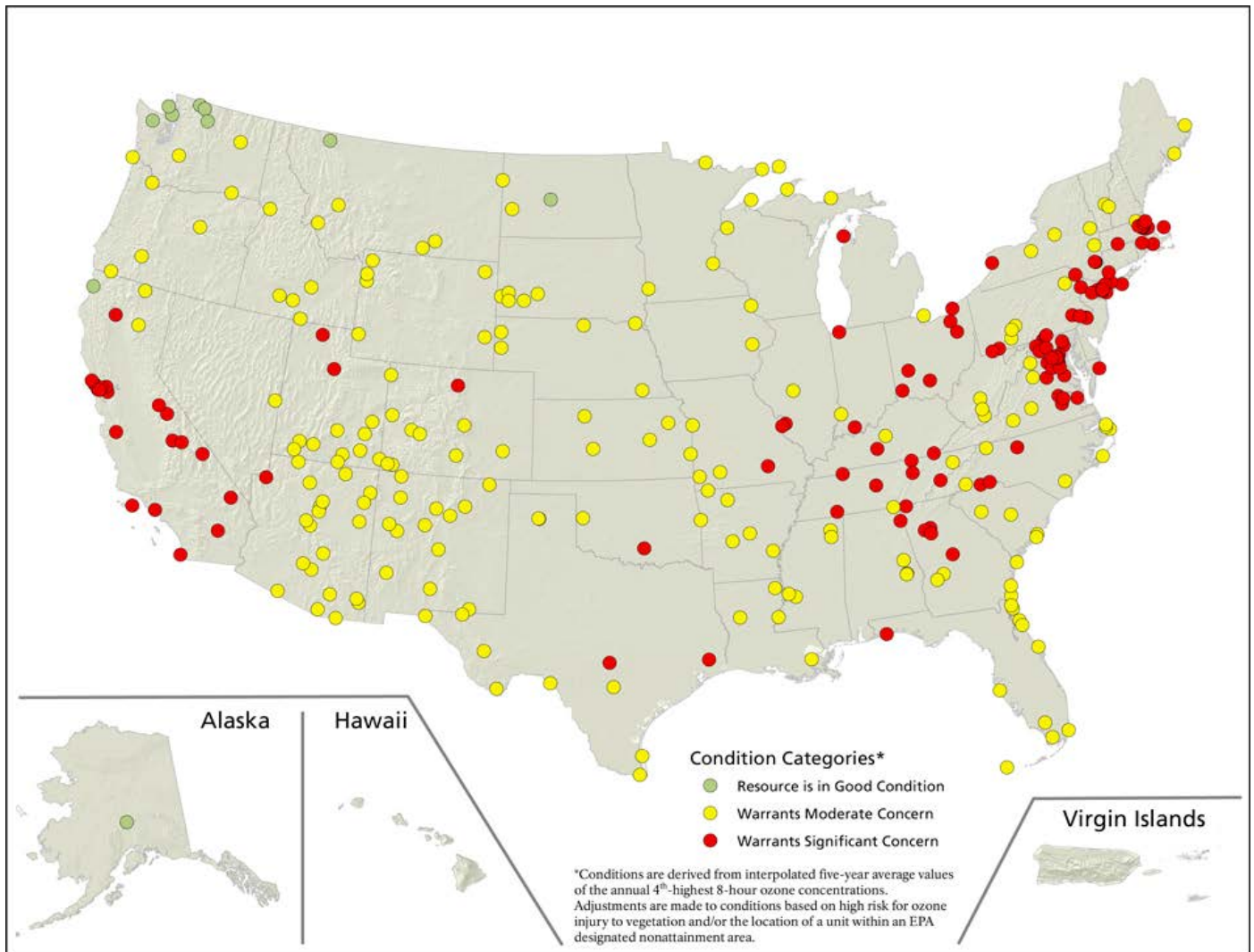


Figure 11. Map of air quality condition assessments for ozone, 2005–2009.

Condition assessments derived from interpolations of the mean annual 4th-highest daily maximum 8-hour average ozone concentrations in parts per billion (ppb).

2.4. Wet Deposition Condition Results

Sulfur wet deposition conditions for parks are shown in Figure 12. Only 20 parks fall into the *Indicator is in Good Condition*. There are 83 parks that fall into the *Warrants Moderate Concern* categories and are located largely in the western U.S., along with a few in the Midwest, Texas, and Maine. There are 206 parks in the *Warrants Significant Concern* category; they are found in the eastern U.S., western U.S., Midwest, Texas, and Maine.

Nitrogen wet deposition conditions for parks are shown in Figure 13. Only 19 parks fall into the *Indicator is in*

Good Condition category and are primarily located in the western U.S. There are 84 parks that fall into the *Warrants Moderate Concern* category; these are located in the western U.S., Texas, South Dakota, North Dakota, Maine, Florida, Georgia, South Carolina, Massachusetts, and Virgin Islands. The other 240 parks falling into the *Warrants Significant Concern* category are located throughout the U.S.

Deposition condition variations within a relatively small geographic area can be due to elevation variations in precipitation amounts (resulting in higher deposition) or due to differences in ecosystem sensitivity.

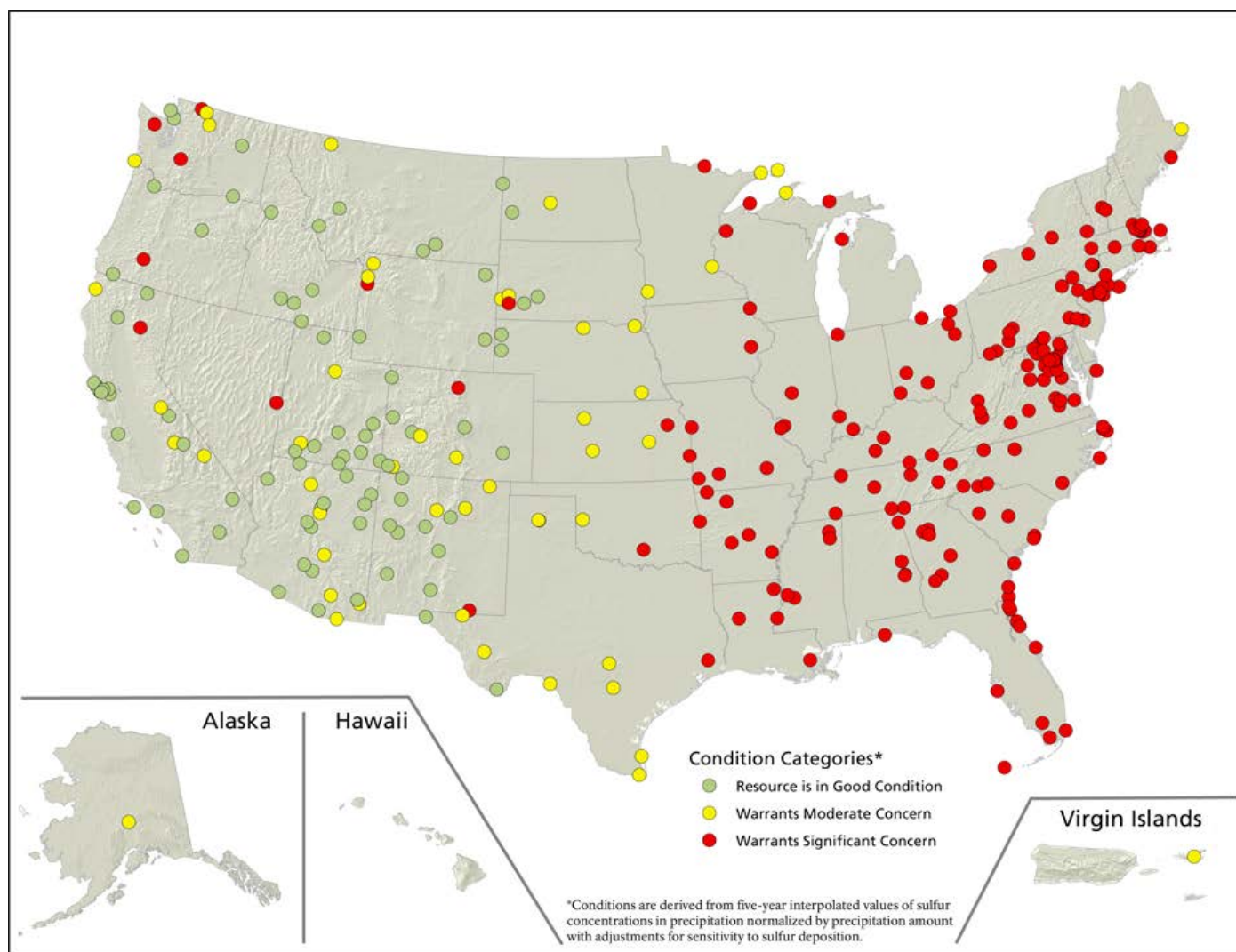


Figure 12. Map of air quality condition assessments for sulfur wet deposition, 2005–2009.

Condition assessments derived from 5-year interpolations of sulfur wet deposition concentrations in kilograms per hectare per year (kg/ha/yr).

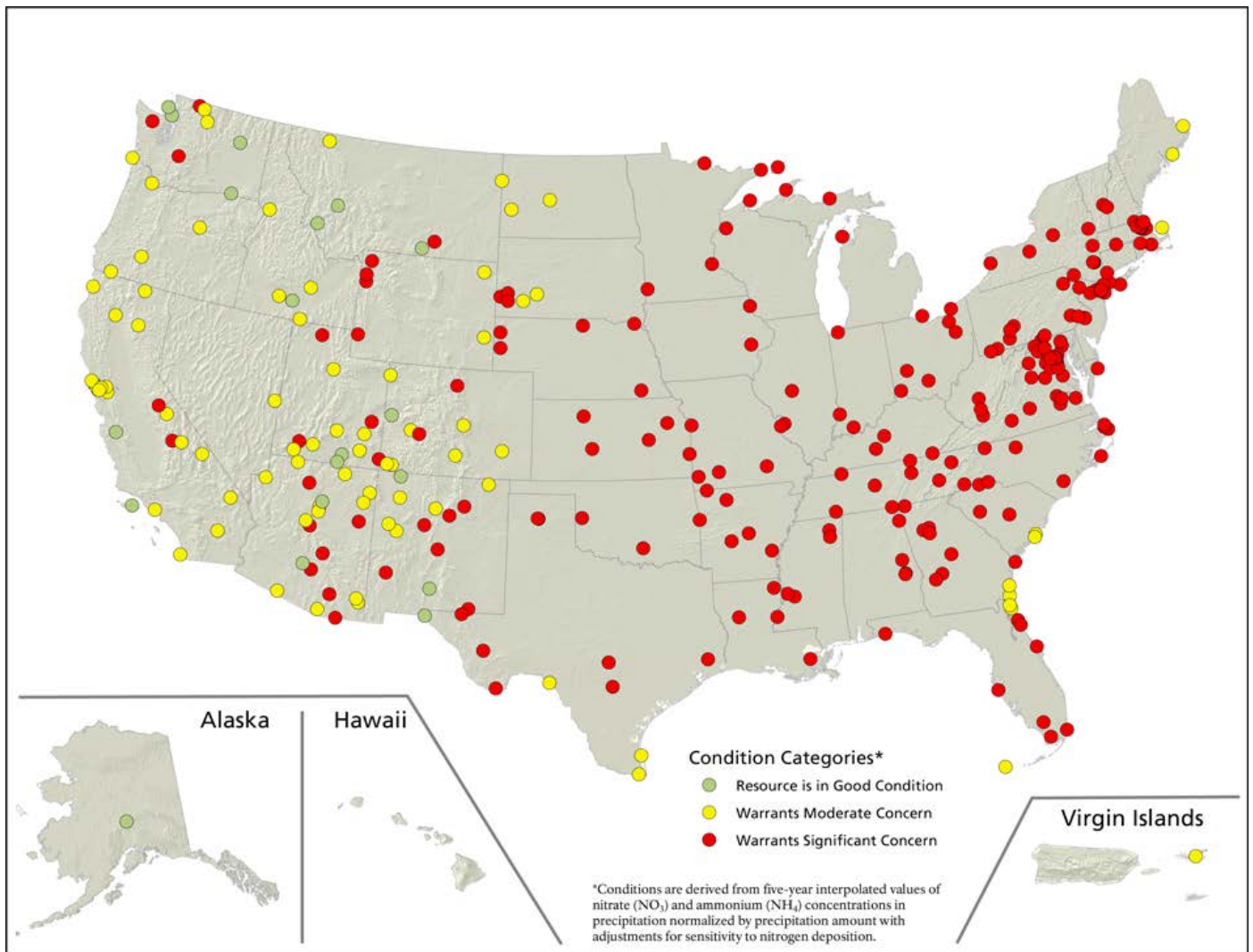


Figure 13. Map of air quality condition assessments for nitrogen wet deposition, 2005–2009.

Condition assessments derived from 5-year interpolations of nitrate and ammonium wet deposition concentrations in kilograms per hectare per year (kg/ha/yr).

Appendix A: Trend Results, 2000–2009

Trends in individual park air quality for 2000–2009 are shown in Table A. In this table, red indicates a degrading trend and blue indicates an improving trend. Statistically significant trends, shown with dark 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 > 0.05 and ≤ 0.15); these parks are indicated by light blue (improving) and pink (degrading) backgrounds. Trend slopes indicate the annual change in visibility, deposition, and ozone. Table A is available with p -values at http://nature.nps.gov/air/Pubs/pdf/gpra/AQ_Trends_In_Parks_2013_508appendix.pdf.

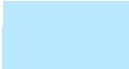
	Improving air quality trend, statistically significant ($p \leq 0.05$)		Improving air quality trend, not significant ($0.05 < p \leq 0.15$)
	Degrading air quality trend, statistically significant ($p \leq 0.05$)		Degrading air quality trend, not significant ($0.05 < p \leq 0.15$)

Table A. Trend results (2000–2009).								
NPS Unit	Visibility		Wet Deposition				Ozone	
	Clear Days (dv/yr)	Hazy Days (dv/yr)	Ammonium ($\mu\text{eq/L/yr}$)	Nitrate ($\mu\text{eq/L/yr}$)	Nitrogen ($\mu\text{eq/L/yr}$)	Sulfate ($\mu\text{eq/L/yr}$)	4th-Highest 8-Hour (ppb/yr)	Maximum 3-Month W126 (ppm-hrs)
Abraham Lincoln Birthplace NHP	-0.25	-0.40						
Acadia NP	-0.16	-0.30	-0.18	-0.99	-0.33	-0.98	-1.80	-0.54
Adams NHP	-0.19	-0.49					-1.50	-0.60
Allegheny Portage Railroad NHS							-3.20	-1.50
Antietam NB	-0.35	-0.37					-1.30	-0.89
Appalachian NST	0.10	-0.20					-3.10	-2.00
Appomattox Court House NHP	-0.23	-0.58						
Arches NP	-0.12	-0.01						
Arlington House, The Robert E. Lee Memorial	-0.26	-0.37					-1.40	-0.94
Assateague Island NS			-0.18	-0.72	-0.13	-0.73		
Aztec Ruins NM							-2.40	-2.30
Badlands NP	-0.05	-0.15						
Bandelier NM	-0.13	-0.20	-0.23	-1.20	-0.42	-0.78		
Bent's Old Fort NHS			0.33	-0.66	0.16	-0.10		
Big Bend NP	-0.04	-0.28	0.33	-0.16	0.52	-0.64	0.40	0.62
Big Cypress N PRES	0.00	-0.79						
Big Hole NB	-0.07	-0.05						
Big Thicket N PRES								-0.35
Bighorn Canyon NRA	0.00	-0.37						
Biscayne NP	0.00	-0.79					0.00	0.09
Black Canyon Of The Gunnison NP	-0.15	-0.03						
Blue Ridge PKWY	0.10	-0.34	-0.28	-0.59	-0.74	-0.85	-1.40	-0.65

Table A. Trend results (2000–2009).								
NPS Unit	Visibility		Wet Deposition				Ozone	
	Clear Days (dv/yr)	Hazy Days (dv/yr)	Ammonium (µeq/L/yr)	Nitrate (µeq/L/yr)	Nitrogen (µeq/L/yr)	Sulfate (µeq/L/yr)	4th-Highest 8-Hour (ppb/yr)	Maximum 3-Month W126 (ppm-hrs)
Booker T Washington NM	-0.23	-0.58						
Boston African American NHS	-0.19	-0.49					-1.50	-0.60
Boston Harbor Islands NRA	-0.19	-0.49					-1.30	-0.69
Boston NHP	-0.19	-0.49					-1.50	-0.60
Bryce Canyon NP	-0.13	0.15	0.53	-0.50	0.37	-0.42		
Buck Island Reef NM	0.16	0.27						
Buffalo NR	-0.26	-0.25						
Canaveral NS			-0.10	-0.27	-0.12	-0.97		
Canyonlands NP	-0.12	-0.01	0.43	-0.60	0.09		-0.57	-0.58
Cape Cod NS	-0.19	-0.49	-0.16	-0.80	-0.32	-1.10	-2.80	-0.43
Capitol Reef NP	-0.12	0.15						
Capulin Volcano NM			0.20	-0.66	-0.01	-0.62		
Carlsbad Caverns NP	-0.15	-0.30						
Carter G. Woodson Home NHS							-1.40	-0.92
Casa Grande Ruins NM	-0.48	-0.63						
Castle Clinton NM							-1.00	-0.53
Catoctin Mountain Park	-0.35	-0.75						
Cedar Breaks NM	-0.13	0.15						
Chamizal N MEM							-1.30	-0.76
Channel Islands NP							-1.00	-0.10
Charles Pinckney NHS	-0.03	-0.30						
Chattahoochee River NRA							-2.30	-1.20
Chesapeake & Ohio Canal NHP	-0.35	-0.37					-1.30	-0.89
Chickamauga & Chattanooga NMP							-0.33	0.55
Chiricahua NM	-0.13	-0.28	0.55	-0.40	0.34	-0.50	-0.25	0.03
Christiansted NHS	0.16	0.27						
Clara Barton NHS	-0.26	-0.37					-1.40	-0.93
Congaree NP							-1.20	-0.81
Constitution Gardens	-0.26	-0.37					-1.40	-0.92
Cowpens NB							-2.30	-1.50
Crater Lake NP	-0.03	-0.20						
Craters Of The Moon NM & PRES	-0.23	-0.29	-0.11	-0.68	-0.23	0.05	-0.60	-0.71
Cumberland Gap NHP			-0.21	-1.10	-0.39	-1.90	-2.60	-1.70
Cumberland Island NS	-0.26	-0.50						
Curecanti NRA	-0.15	-0.03						
Cuyahoga Valley NP							-2.00	-1.00
De Soto N MEM								-0.13
Death Valley NP	-0.11	0.08					-0.25	-0.61
Delaware Water Gap NRA			-0.18	-0.93	-0.37	-1.40		

Table A. Trend results (2000–2009).

NPS Unit	Visibility		Wet Deposition				Ozone	
	Clear Days (dv/yr)	Hazy Days (dv/yr)	Ammonium (µeq/L/yr)	Nitrate (µeq/L/yr)	Nitrogen (µeq/L/yr)	Sulfate (µeq/L/yr)	4th-Highest 8-Hour (ppb/yr)	Maximum 3-Month W126 (ppm-hrs)
Denali NP & PRES	0.00	-0.04	-0.10	-0.18	-0.11	-0.08	0.50	0.13
Ebey's Landing NH RES	-0.25	-0.62						
Edgar Allan Poe NHS	-0.03	-0.33					-1.50	-0.21
Effigy Mounds NM	-0.40	-0.05						
Eisenhower NHS	-0.35	-0.75	-0.25	-1.20	-0.42	-1.90		
Eugene O'Neill NHS	-0.24	-0.24						
Everglades NP	0.00	-0.79	0.16	0.00	0.13	-0.26		
Fire Island NS							-1.80	-0.65
First Ladies NHS	-0.30	-0.67					-2.00	-0.90
Ford's Theatre NHS	-0.26	-0.37					-1.40	-0.92
Fort Bowie NHS	-0.13	-0.28	0.55	-0.40	0.34	-0.50	-0.25	0.03
Fort Caroline N MEM	-0.26	-0.50						
Fort Donelson NB	-0.34	-0.46						
Fort Frederica NM	-0.26	-0.50						
Fort Larned NHS	-0.30	-0.72						
Fort McHenry NM & Historic Shrine	-0.26	-0.37						
Fort Point NHS	-0.24	-0.24					0.43	0.05
Fort Pulaski NM							-1.00	-0.30
Fort Scott NHS	-0.23	-0.63						
Fort Sumter NM	-0.03	-0.30						
Fort Union Trading Post NHS	-0.08	0.01						
Fort Washington Park							-1.80	-1.20
Franklin Delano Roosevelt Memorial	-0.26	-0.37					-1.40	-0.92
Frederick Douglass NHS							-1.20	-0.29
Frederick Law Olmsted NHS	-0.19	-0.49					-1.50	-0.60
Fredericksburg & Spotsylvania NMP	-0.26	-0.37					-0.86	-0.79
Gateway NRA							-2.40	-1.70
General Grant N MEM							-1.10	-0.31
George Rogers Clark NHP			0.70	-0.45	0.50	-0.75		
George Washington Birthplace NM	-0.26	-0.37						
George Washington Carver NM	-0.23	-0.63						
George Washington Memorial PKWY	-0.26	-0.37					-1.60	-0.97
Gettysburg NMP	-0.35	-0.75	-0.25	-1.20	-0.42	-1.90		
Gila Cliff Dwellings NM	-0.14	-0.23	-0.32	-0.58	-0.29	-0.60		
Glacier NP	-0.10	-0.35	0.06	-0.16	0.04	-0.03	0.11	0.02
Glen Canyon NRA	0.01	0.15						
Golden Gate NRA	-0.24	-0.24					0.71	0.09
Governors Island NM							-1.00	-0.53

Table A. Trend results (2000–2009).

NPS Unit	Visibility		Wet Deposition				Ozone	
	Clear Days (dv/yr)	Hazy Days (dv/yr)	Ammonium (µeq/L/yr)	Nitrate (µeq/L/yr)	Nitrogen (µeq/L/yr)	Sulfate (µeq/L/yr)	4th-Highest 8-Hour (ppb/yr)	Maximum 3-Month W126 (ppm-hrs)
Grand Canyon NP	0.01	0.02	-0.05	-0.86	-0.31	-0.46	-0.56	-0.71
Grand Teton NP	-0.13	-0.08						
Grant-Kohrs Ranch NHS	-0.16	-0.24						
Great Basin NP	-0.20	0.00	0.43	-0.33	0.27	-0.20	-0.33	-0.28
Great Egg Harbor River	-0.03	-0.33						
Great Sand Dunes NP & PRES	-0.15	-0.35						
Great Smoky Mountains NP	-0.35	-0.33	0.05	-0.56	-0.10	-0.91	-1.60	-0.69
Guadalupe Mountains NP	-0.15	-0.30	-0.40	-0.78	-0.51	-1.90		
Gulf Islands NS							-1.40	-0.38
Haleakala NP	0.00	0.28						
Hamilton Grange N MEM							-1.10	-0.31
Hampton NHS	-0.26	-0.37					-1.80	-1.10
Harpers Ferry NHP	-0.35	-0.37						
Hawaii Volcanoes NP	-0.02	1.60						
Hohokam Pima NM	-0.48	-0.63						
Independence NHP	-0.03	-0.33					-1.50	-0.21
Indiana Dunes NL			-0.12	-0.90	-0.32	-0.87	-2.30	-1.20
Isle Royale NP	-0.16	-0.10						
James A Garfield NHS							-2.10	-1.30
Jean Lafitte NHP & PRES							-0.60	0.07
Jefferson National Expansion Memorial							-1.70	-1.30
John D Rockefeller Jr Memorial PKWY	-0.13	-0.20						
John F Kennedy NHS	-0.19	-0.49					-1.50	-0.60
John Muir NHS	-0.24	-0.24					-0.43	-0.27
Joshua Tree NP	-0.18	-0.49	-1.70	-1.10	-0.36	-1.20	-1.00	0.09
Kalaupapa NHP	0.00	0.28						
Kennesaw Mountain NBP							-2.00	-1.60
Keweenaw NHP	-0.16	-0.10	-0.02	-0.66	-0.14	-0.60		
Korean War Veterans Memorial	-0.26	-0.37					-1.40	-0.92
Lake Chelan NRA	-0.02	0.08						
Lake Clark NP & PRES	0.04	-0.18						
Lake Mead NRA							-0.25	-0.13
Lassen Volcanic NP	-0.03	0.27	-0.10	-0.20	-0.03	0.00	-0.25	-0.31
Lava Beds NM	-0.10	-0.14						
Lincoln Home NHS							-1.70	-0.66
Lincoln Memorial	-0.26	-0.37					-1.40	-0.92
Little Bighorn Battlefield NM			-0.17	-0.35	-0.20	-0.13		
Little Rock Central High School NHS							-1.40	-1.20

Table A. Trend results (2000–2009).

NPS Unit	Visibility		Wet Deposition				Ozone	
	Clear Days (dv/yr)	Hazy Days (dv/yr)	Ammonium (µeq/L/yr)	Nitrate (µeq/L/yr)	Nitrogen (µeq/L/yr)	Sulfate (µeq/L/yr)	4th-Highest 8-Hour (ppb/yr)	Maximum 3-Month W126 (ppm-hrs)
Longfellow NHS	-0.19	-0.49					-1.50	-0.60
Lyndon Baines Johnson Memorial Grove	-0.26	-0.37					-1.40	-0.94
Maggie L Walker NHS							-1.00	-0.86
Mammoth Cave NP	-0.25	-0.40	-0.03	-0.62	0.22	-1.40	-1.90	-1.00
Manassas NBP	-0.26	-0.37					-2.10	-1.10
Martin Luther King Jr NHS							-2.10	-0.88
Martin Luther King, Jr. Memorial	-0.26	-0.37					-1.40	-0.92
Mary McLeod Bethune Council House NHS							-1.40	-0.92
Mesa Verde NP	-0.19	-0.08	0.07	-0.40	-0.22	-0.57	0.00	-0.38
Minuteman Missile NHS	-0.05	-0.15	-0.43	-0.67	-0.36	-0.43		
Mississippi NRRRA							-0.77	-0.27
Mojave N PRES	-0.18	-0.49						
Monocacy NB	-0.26	-0.37					-1.70	-1.40
Mount Rainier NP	-0.17	-0.36	-0.02	-0.15	-0.04	-0.08	-1.20	-0.31
Mount Rushmore N MEM	-0.16	-0.08						
Muir Woods NM	-0.24	-0.24					0.71	0.09
Natchez NHP							-1.70	-0.94
Natchez Trace PKWY	-0.49	-0.33	-0.17	-0.21	-0.25	-0.83	-2.00	-2.00
National Mall & Memorial Parks	-0.26	-0.37					-1.40	-0.94
Natural Bridges NM	-0.12	-0.01						
New Bedford Whaling NHP	-0.19	-0.49					-2.40	-0.66
New River Gorge NR			-0.25	-1.20	-0.41	-1.20		
Nez Perce NHP	-0.06	-0.05						
Nicodemus NHS	-0.30	-0.72						
North Cascades NP	-0.02	0.08	-0.10	-0.27	-0.11	-0.20		
Ocmulgee NM							-2.40	-0.93
Olympic NP	-0.25	-0.30	0.00	-0.03	-0.02	0.05		
Organ Pipe Cactus NM	-0.08	-0.23	0.15	-0.27	0.38	-0.30		
Palo Alto Battlefield NHP							0.00	0.09
Pecos NHP	-0.13	-0.20						
Pennsylvania Avenue NHS	-0.26	-0.37					-1.40	-0.92
Petersburg NB							-0.71	-0.60
Petrified Forest NP	-0.10	0.05	-1.90	-0.74	-2.90	0.80	-1.00	-0.12
Petroglyph NM							-0.75	-0.87
Pictured Rocks NL	-0.18	-0.16						
Pinnacles NP	-0.19	-0.05	0.07	0.00	0.06	-0.08	-0.67	-0.39
Pipestone NM	-0.17	-0.25						
Piscataway Park							-1.80	-1.20

Table A. Trend results (2000–2009).								
NPS Unit	Visibility		Wet Deposition				Ozone	
	Clear Days (dv/yr)	Hazy Days (dv/yr)	Ammonium (µeq/L/yr)	Nitrate (µeq/L/yr)	Nitrogen (µeq/L/yr)	Sulfate (µeq/L/yr)	4th- Highest 8-Hour (ppb/yr)	Maximum 3-Month W126 (ppm-hrs)
Point Reyes NS	-0.24	-0.24						
President's Park (White House)	-0.26	-0.37					-1.40	-0.92
Prince William Forest Park	-0.26	-0.37					-1.80	-1.40
Redwood NSP	-0.10	0.00						
Richmond NBP							-0.71	-0.60
Rock Creek Park	-0.26	-0.37					-1.40	-0.92
Rocky Mountain NP	-0.05	-0.23	-0.28	-0.48	-0.32	-0.14	-1.00	-1.20
Roger Williams N MEM	-0.38	-0.70					-2.30	-0.68
Rosie the Riveter WWII Home Front NHP	-0.24	-0.24						
Ross Lake NRA	-0.02	0.08	-0.10	-0.27	-0.11	-0.20		
Saguaro NP	-0.17	-0.36					-0.25	0.69
Saint Croix Island IHS	-0.23	-0.49						
Saint Croix NSR			-1.00	-1.00	-1.00	-0.68	-0.88	-0.50
Salem Maritime NHS	-0.19	-0.49					-1.70	-0.54
Salt River Bay NHP & Ecological PRES	0.16	0.27						
San Francisco Maritime NHP	-0.24	-0.24					0.43	0.05
Santa Monica Mountains NRA							-1.00	-0.63
Saratoga NHP							-1.50	-0.58
Saugus Iron Works NHS	-0.19	-0.49					-1.70	-0.54
Sequoia & Kings Canyon NPs	-0.11	-0.24	0.38	0.04	-0.16	0.01	-0.83	0.07
Shenandoah NP	-0.32	-0.34	-0.29	-0.53	-0.38	-1.30	-1.70	-1.50
Sleeping Bear Dunes NL							-1.80	-1.10
Springfield Armory NHS							-0.33	-0.65
Statue Of Liberty NM							-1.00	-0.53
Steamtown NHS							-1.70	-0.62
Sunset Crater Volcano NM	0.01	0.02						
Tallgrass Prairie N PRES	-0.24	-0.60						
Thaddeus Kosciuszko N MEM	-0.03	-0.33					-1.50	-0.21
Theodore Roosevelt Island Park	-0.26	-0.37					-1.40	-0.94
Theodore Roosevelt NP	-0.16	-0.06	-0.31	-0.35	-0.37	-0.11	0.06	0.01
Thomas Jefferson Memorial	-0.26	-0.37					-1.40	-0.92
Thomas Stone NHS	-0.26	-0.37						
Timpanogos Cave NM							-1.50	-1.10
Timucuan Ecological & Historic PRES	-0.26	-0.50					0.13	0.24
Tonto NM	-0.18	-0.14						-1.20
Tumacácori NHP	-0.17	-0.36						
Tupelo NB							-2.00	-2.00
Upper Delaware SRR			-0.18	-0.93	-0.37	-1.40		

Table A. Trend results (2000–2009).

NPS Unit	Visibility		Wet Deposition				Ozone	
	Clear Days (dv/yr)	Hazy Days (dv/yr)	Ammonium (µeq/L/yr)	Nitrate (µeq/L/yr)	Nitrogen (µeq/L/yr)	Sulfate (µeq/L/yr)	4th-Highest 8-Hour (ppb/yr)	Maximum 3-Month W126 (ppm-hrs)
Vietnam Veterans Memorial	-0.26	-0.37					-1.40	-0.92
Virgin Islands Coral Reef NM			-0.08	-0.15	-0.08	-0.40		
Virgin Islands NP	0.16	0.27	-0.08	-0.15	-0.08	-0.40		
Voyageurs NP	-0.12	0.09	-0.23	-0.90	0.17	-0.41	-0.31	-0.10
Walnut Canyon NM	-0.10	-0.10						
Washington Monument	-0.26	-0.37					-1.40	-0.92
Washita Battlefield NHS	-0.20	-0.52						
Whiskeytown NRA	0.08	0.27						
William Howard Taft NHS							-1.10	-0.68
Wilson's Creek NB	-0.23	-0.37						
Wind Cave NP	-0.16	-0.08	0.97	-0.20	1.90	0.23		
Wolf Trap NP for the Performing Arts	-0.26	-0.37					-1.40	-0.93
Yellowstone NP	-0.13	-0.20	-0.12	-0.28	-0.16	0.00	-0.14	-0.32
Yosemite NP	-0.13	-0.01	-0.19	-0.24	-0.16	-0.03	-0.40	-0.98

Appendix B: Air Quality Trends and Conditions Summary Table

In Table B, the condition is represented by the color of the circle, where red represents *Warrants Significant Concern*, yellow represents *Warrants Moderate Concern*, and green represents *Indicator is in Good Condition*.

Trends in Table B are represented by arrows. All improving (up arrows) and deteriorating (down arrows) trends have at least 95% probability of being correct (those with p-values ≤ 0.05). Statistically significant (p-value ≤ 0.05) trends with

zero slope are represented by flat arrows. Parameters with no statistically significant trend (p-value ≥ 0.05) are also represented by flat arrows. The procedures for assigning these categories are described in Section 1. The absence of an arrow indicates that data for trend calculations are not available for a given park and parameter. Table B is available in text format at http://nature.nps.gov/air/Pubs/pdf/gpra/AQ_Trends_In_Parks_2013_508appendix.pdf.

Table B. Trend results (2000–2009) and condition assessments (2005–2009).				
NPS Unit	Condition and Trend Symbol			
	Visibility	Wet Nitrogen Deposition	Wet Sulfur Deposition	Ozone
Abraham Lincoln Birthplace NHP				
Acadia NP				
Adams NHP				
African Burial Ground NM				
Agate Fossil Beds NM				
Alibates Flint Quarries NM				
Allegheny Portage Railroad NHS				
Amistad NRA				
Andersonville NHS				
Andrew Johnson NHS				
Antietam NB				
Apostle Islands NL				
Appomattox Court House NHP				
Arches NP				
Arkansas Post N MEM				
Arlington House, The Robert E. Lee Memorial				
Assateague Island NS				

Table B. Trend results (2000–2009) and condition assessments (2005–2009).

NPS Unit	Condition and Trend Symbol			
	Visibility	Wet Nitrogen Deposition	Wet Sulfur Deposition	Ozone
Aztec Ruins NM				
Badlands NP				
Bandelier NM				
Bent's Old Fort NHS				
Big Bend NP				
Big Cypress N PRES				
Big Hole NB				
Big South Fork NRRRA				
Big Thicket N PRES				
Bighorn Canyon NRA				
Biscayne NP				
Black Canyon Of The Gunnison NP				
Blue Ridge PKWY				
Bluestone NSR				
Booker T Washington NM				
Boston African American NHS				
Boston Harbor Islands NRA				
Boston NHP				
Brices Cross Roads NBS				
Brown V Board Of Education NHS				
Bryce Canyon NP				
Buffalo NR				
Cabrillo NM				

Table B. Trend results (2000–2009) and condition assessments (2005–2009).

NPS Unit	Condition and Trend Symbol			
	Visibility	Wet Nitrogen Deposition	Wet Sulfur Deposition	Ozone
Canaveral NS				
Cane River Creole NHP				
Canyon De Chelly NM				
Canyonlands NP				
Cape Cod NS				
Cape Hatteras NS				
Cape Lookout NS				
Capitol Reef NP				
Capulin Volcano NM				
Carl Sandburg Home NHS				
Carlsbad Caverns NP				
Carter G. Woodson Home NHS				
Casa Grande Ruins NM				
Castillo De San Marcos NM				
Castle Clinton NM				
Catoctin Mountain Park				
Cedar Breaks NM				
Cedar Creek & Belle Grove NHP				
Chaco Culture NHP				
Chamizal N MEM				
Channel Islands NP				
Charles Pinckney NHS				
Chattahoochee River NRA				

Table B. Trend results (2000–2009) and condition assessments (2005–2009).

NPS Unit	Condition and Trend Symbol			
	Visibility	Wet Nitrogen Deposition	Wet Sulfur Deposition	Ozone
Chesapeake & Ohio Canal NHP				
Chickamauga & Chattanooga NMP				
Chickasaw NRA				
Chiricahua NM				
City Of Rocks N RES				
Clara Barton NHS				
Colonial NHP				
Colorado NM				
Congaree NP				
Constitution Gardens				
Coronado N MEM				
Cowpens NB				
Crater Lake NP				
Craters Of The Moon NM & PRES				
Cumberland Gap NHP				
Cumberland Island NS				
Curecanti NRA				
Cuyahoga Valley NP				
Dayton Aviation Heritage NHP				
De Soto N MEM				
Death Valley NP				
Delaware Water Gap NRA				
Denali NP & PRES				

Table B. Trend results (2000–2009) and condition assessments (2005–2009).

NPS Unit	Condition and Trend Symbol			
	Visibility	Wet Nitrogen Deposition	Wet Sulfur Deposition	Ozone
Devils Postpile NM				
Devils Tower NM				
Dinosaur NM				
Dry Tortugas NP				
Ebey's Landing NH RES				
Edgar Allan Poe NHS				
Effigy Mounds NM				
Eisenhower NHS				
El Malpais NM				
El Morro NM				
Eleanor Roosevelt NHS				
Eugene O'Neill NHS				
Everglades NP				
Federal Hall N MEM				
Fire Island NS				
First Ladies NHS				
Flight 93 N MEM				
Florissant Fossil Beds NM				
Ford's Theatre NHS				
Fort Bowie NHS				
Fort Caroline N MEM				
Fort Davis NHS				
Fort Donelson NB				

Table B. Trend results (2000–2009) and condition assessments (2005–2009).

NPS Unit	Condition and Trend Symbol			
	Visibility	Wet Nitrogen Deposition	Wet Sulfur Deposition	Ozone
Fort Frederica NM				
Fort Laramie NHS				
Fort Larned NHS				
Fort Matanzas NM				
Fort McHenry NM & Historic Shrine				
Fort Necessity NB				
Fort Point NHS				
Fort Pulaski NM				
Fort Raleigh NHS				
Fort Scott NHS				
Fort Smith NHS				
Fort Stanwix NM				
Fort Sumter NM				
Fort Union NM				
Fort Union Trading Post NHS				
Fort Vancouver NHS				
Fort Washington Park				
Fossil Butte NM				
Franklin Delano Roosevelt Memorial				
Frederick Douglass NHS				
Frederick Law Olmsted NHS				
Fredericksburg & Spotsylvania NMP				
Friendship Hill NHS				

Table B. Trend results (2000–2009) and condition assessments (2005–2009).

NPS Unit	Condition and Trend Symbol			
	Visibility	Wet Nitrogen Deposition	Wet Sulfur Deposition	Ozone
Gateway NRA				
Gauley River NRA				
General Grant N MEM				
George Rogers Clark NHP				
George Washington Birthplace NM				
George Washington Carver NM				
George Washington Memorial PKWY				
Gettysburg NMP				
Gila Cliff Dwellings NM				
Glacier NP				
Glen Canyon NRA				
Golden Gate NRA				
Golden Spike NHS				
Governors Island NM				
Grand Canyon NP				
Grand Portage NM				
Grand Teton NP				
Grant-Kohrs Ranch NHS				
Great Basin NP				
Great Sand Dunes NP & PRES				
Great Smoky Mountains NP				
Greenbelt Park				
Guadalupe Mountains NP				

Table B. Trend results (2000–2009) and condition assessments (2005–2009).

NPS Unit	Condition and Trend Symbol			
	Visibility	Wet Nitrogen Deposition	Wet Sulfur Deposition	Ozone
Guilford Courthouse NMP				
Gulf Islands NS				
Hagerman Fossil Beds NM				
Haleakala NP				
Hamilton Grange N MEM				
Hampton NHS				
Harpers Ferry NHP				
Harry S Truman NHS				
Hawaii Volcanoes NP				
Herbert Hoover NHS				
Hohokam Pima NM				
Home Of Franklin D Roosevelt NHS				
Homestead NM of America				
Hopewell Culture NHP				
Hopewell Furnace NHS				
Horseshoe Bend NMP				
Hot Springs NP				
Hovenweep NM				
Hubbell Trading Post NHS				
Independence NHP				
Indiana Dunes NL				
Isle Royale NP				
James A Garfield NHS				

Table B. Trend results (2000–2009) and condition assessments (2005–2009).

NPS Unit	Condition and Trend Symbol			
	Visibility	Wet Nitrogen Deposition	Wet Sulfur Deposition	Ozone
Jean Lafitte NHP & PRES				
Jefferson National Expansion Memorial				
Jewel Cave NM				
Jimmy Carter NHS				
John D Rockefeller Jr Memorial PKWY				
John Day Fossil Beds NM				
John F Kennedy NHS				
John Muir NHS				
Johnstown Flood N MEM				
Joshua Tree NP				
Kennesaw Mountain NBP				
Keweenaw NHP				
Kings Mountain NMP				
Knife River Indian Villages NHS				
Korean War Veterans Memorial				
Lake Chelan NRA				
Lake Clark NP & PRES				
Lake Mead NRA				
Lake Meredith NRA				
Lake Roosevelt NRA				
Lassen Volcanic NP				
Lava Beds NM				
Lewis and Clark NHP				

Table B. Trend results (2000–2009) and condition assessments (2005–2009).

NPS Unit	Condition and Trend Symbol			
	Visibility	Wet Nitrogen Deposition	Wet Sulfur Deposition	Ozone
Lincoln Boyhood N MEM				
Lincoln Home NHS				
Lincoln Memorial				
Little Bighorn Battlefield NM				
Little River Canyon N PRES				
Little Rock Central High School NHS				
Longfellow NHS				
Lowell NHP				
Lyndon B Johnson NHP				
Lyndon Baines Johnson Memorial Grove				
Maggie L Walker NHS				
Mammoth Cave NP				
Manassas NBP				
Manzanar NHS				
Marsh - Billings - Rockefeller NHP				
Martin Luther King Jr NHS				
Martin Luther King, Jr. Memorial				
Martin Van Buren NHS				
Mary McLeod Bethune Council House NHS				
Mesa Verde NP				
Minidoka NHS				
Minute Man NHP				
Minuteman Missile NHS				

Table B. Trend results (2000–2009) and condition assessments (2005–2009).

NPS Unit	Condition and Trend Symbol			
	Visibility	Wet Nitrogen Deposition	Wet Sulfur Deposition	Ozone
Mississippi NRR				
Missouri NRR				
Mojave N PRES				
Monocacy NB				
Montezuma Castle NM				
Moore's Creek NB				
Morristown NHP				
Mount Rainier NP				
Mount Rushmore N MEM				
Muir Woods NM				
Natchez NHP				
Natchez Trace PKWY				
National Mall & Memorial Parks				
Natural Bridges NM				
Navajo NM				
New Bedford Whaling NHP				
New River Gorge NR				
Nez Perce NHP				
Nicodemus NHS				
Ninety Six NHS				
Niobrara NSR				
North Cascades NP				
Obed WSR				

Table B. Trend results (2000–2009) and condition assessments (2005–2009).

NPS Unit	Condition and Trend Symbol			
	Visibility	Wet Nitrogen Deposition	Wet Sulfur Deposition	Ozone
Ocmulgee NM				
Olympic NP				
Oregon Caves NM				
Organ Pipe Cactus NM				
Ozark NSRs				
Padre Island NS				
Palo Alto Battlefield NHP				
Pea Ridge NMP				
Pecos NHP				
Pennsylvania Avenue NHS				
Perry's Victory & International Peace Memorial				
Petersburg NB				
Petrified Forest NP				
Petroglyph NM				
Pictured Rocks NL				
Pinnacles NP				
Pipe Spring NM				
Pipestone NM				
Piscataway Park				
Point Reyes NS				
Poverty Point NM				
President's Park (White House)				
Prince William Forest Park				

Table B. Trend results (2000–2009) and condition assessments (2005–2009).

NPS Unit	Condition and Trend Symbol			
	Visibility	Wet Nitrogen Deposition	Wet Sulfur Deposition	Ozone
Rainbow Bridge NM				
Redwood NSP				
Richmond NBP				
Rock Creek Park				
Rocky Mountain NP				
Roger Williams N MEM				
Rosie the Riveter WWII Home Front NHP				
Ross Lake NRA				
Russell Cave NM				
Sagamore Hill NHS				
Saguaro NP				
Saint Croix Island IHS				
Saint Croix NSR				
Saint Paul's Church NHS				
Saint-Gaudens NHS				
Salem Maritime NHS				
Salinas Pueblo Missions NM				
San Antonio Missions NHP				
Sand Creek Massacre NHS				
San Francisco Maritime NHP				
San Juan Island NHP				
Santa Monica Mountains NRA				
Saratoga NHP				

Table B. Trend results (2000–2009) and condition assessments (2005–2009).

NPS Unit	Condition and Trend Symbol			
	Visibility	Wet Nitrogen Deposition	Wet Sulfur Deposition	Ozone
Saugus Iron Works NHS				
Scotts Bluff NM				
Sequoia & Kings Canyon NPs				
Shenandoah NP				
Shiloh NMP				
Sleeping Bear Dunes NL				
Springfield Armory NHS				
Statue Of Liberty NM				
Steamtown NHS				
Stones River NB				
Sunset Crater Volcano NM				
Tallgrass Prairie N PRES				
Thaddeus Kosciuszko N MEM				
Theodore Roosevelt Birthplace NHS				
Theodore Roosevelt Inaugural NHS				
Theodore Roosevelt Island Park				
Theodore Roosevelt NP				
Thomas Edison NHP				
Thomas Jefferson Memorial				
Thomas Stone NHS				
Timpanogos Cave NM				
Timucuan Ecological & Historic PRES				
Tonto NM				

Table B. Trend results (2000–2009) and condition assessments (2005–2009).

NPS Unit	Condition and Trend Symbol			
	Visibility	Wet Nitrogen Deposition	Wet Sulfur Deposition	Ozone
Tumacácori NHP				
Tupelo NB				
Tuskegee Airmen NHS				
Tuskegee Institute NHS				
Tuzigoot NM				
Ulysses S Grant NHS				
Upper Delaware SRR				
Valley Forge NHP				
Vanderbilt Mansion NHS				
Vicksburg NMP				
Vietnam Veterans Memorial				
Virgin Islands NP				
Voyageurs NP				
Walnut Canyon NM				
Washington Monument				
Washita Battlefield NHS				
Weir Farm NHS				
Whiskeytown NRA				
White Sands NM				
Whitman Mission NHS				
William Howard Taft NHS				
Wilson's Creek NB				
Wind Cave NP				

Table B. Trend results (2000–2009) and condition assessments (2005–2009).

NPS Unit	Condition and Trend Symbol			
	Visibility	Wet Nitrogen Deposition	Wet Sulfur Deposition	Ozone
Wolf Trap NP for the Performing Arts				
Women's Rights NHP				
Wright Brothers N MEM				
Wupatki NM				
Yellowstone NP				
Yosemite NP				
Yucca House NM				
Zion NP				

Appendix C: 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:

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

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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