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National Park Service Air Quality Analysis Methods

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Rocky Mountain National Park
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1. Introduction and Summary

Understanding air quality and its impacts on both human health and the environment can be a challenge. Air masses have dynamic and complex chemical composition and often travel great distances before crossing park boundaries affecting human health, visibility of park landscapes, and ecosystem health. Fortunately, the National Park Service and others in nationwide monitoring networks across the US are actively collecting information about ozone, visibility, particulate matter, nitrogen and sulfur deposition, as well as atmospheric mercury. The National Park Service Air Resources Division (NPS-ARD) estimates air quality conditions for all parks in the contiguous US by compiling and analyzing these data from across the country. NPS-ARD also evaluates air quality trends and provides information on the composition of particulate matter affecting visibility and of deposition for parks where representative monitoring data are available. A consistent service-wide approach to these analyses allows NPS-ARD to provide specific air quality information for over 350 national park units.

This document summarizes the data analysis methods used by the NPS-ARD to evaluate air quality for NPS units. These evaluations are useful for park planning, research, and assessing the effectiveness of efforts to reduce air pollution. Park specific condition and trend data products are available at: https://www.nature.nps.gov/air/data/products/parks/index.cfm.

2. Estimating Air Conditions for Parks

2.1. Background

Spatial interpolation is used to estimate air quality conditions across the country. This approach provides information for areas without onsite air quality monitoring, a necessity because of limited monitoring locations. Results from spatial interpolations provide parks, decision makers, and the public the opportunity to explore past and current air quality conditions for ozone, visibility, and atmospheric deposition at individual parks.

NPS-ARD estimates air quality conditions for all parks in the contiguous US using the Inverse Distance Weighting (IDW) interpolation method[1] and data from national air quality monitoring networks. Monitoring data are too sparse for the geospatial estimation method in Alaska, Hawaii, Puerto Rico and Virgin Islands. For this reason, on-site or nearby representative monitor data[2] are used to derive measured averages for Christiansted NHS, Denali NP & PRES, Gates of the Arctic NP & PRES, Haleakala NP, Hawaii Volcanoes NP, Honouliuli NM, Katmai NP & PRES, Kenai Fjords NP, Klondike Gold Rush NHP, Lake Clark NP & PRES, Salt River Bay NHP & Ecological PRES, San Juan NHS, Virgin Islands NP, and Virgin Islands Coral Reef NM.

2.2. Ozone Estimates

2.2.1. Overview

Ozone is monitored across the US through air quality monitoring networks operated by the NPS, Environmental Protection Agency (EPA), states, and others. Aggregated hourly ozone concentration data are acquired from the EPA Air Quality System (AQS) database. Note that prior to 2012, monitoring data for selected sites were obtained from the EPA Clean Air Status and Trends Network (CASTNet) database.

2.2.2. Parameters

Ground-level ozone is evaluated by calculating two statistics using hourly ozone concentration data from monitoring sites across the country[3]:

- 4th-highest daily maximum 8-hour average ozone concentrations[4]
    - The daily maximum 8-hour average ozone concentration for a given day is the highest of the 17 consecutive 8-hour averages, beginning with the 8-hour period spanning from 7:00 a.m. to 3:00 p.m. and ending with the 8-hour period from 11:00 p.m. to 7:00 a.m. the following day (i.e., the 8-hour averages for 7:00 a.m. to 11:00

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[1] See Appendix A for IDW methods.

[2] See Appendix B for a list of representative monitoring sites for NPS units.

[3] See Appendix C for acquisition and calculation details.

[4] Methods for calculating 4th-highest daily max 8-hour average concentration are derived from 40 CFR Appendix U to Part 50 section 3 “Data Reporting and Data Handling Conventions”. See Appendix C for more information.

p.m.). The 4th-highest daily maximum 8-hour average ozone concentration within in a calendar year is reported in parts per billion (ppb).

- 3-month maximum 12-hour W126 index[5]
    - The W126 index preferentially weighs the higher ozone concentrations most likely to affect plants and sums all of the weighted concentrations during daylight hours (8 a.m. to 8 p.m.). The highest 3-month period that occurs during the growing season (March–September) is reported in parts per million-hours (ppm-hrs).

2.2.3. Estimates

Each of these statistics is averaged over a 5-year period at all monitoring sites with at least 3-years of complete annual data. Annual completeness criteria are different for the two ozone statistics (see Appendix C for details).

The 5-year averages are then interpolated across all monitoring locations using an IDW method to estimate 5-year average values for the contiguous US. For individual parks, the maximum values within park boundaries are reported from this national-scale analysis.

2.3. Visibility Estimates

2.3.1. Overview

Visibility is monitored throughout the US by the Interagency Monitoring of Protected Visual Environments (IMPROVE) network. Every third day, 24-hour particulate samples are collected and analyzed for chemical composition. These data are used to calculate total visibility impairment as expressed by the haze index[6] in deciviews (dv).

2.3.2. Parameters

Visibility is evaluated using the following three statistics from monitoring sites across the country:

- Haze index on clearest days
    - The 20 percent of sampled days where visibility is most clear.
- Haze index on haziest days
    - The 20 percent of sampled days where visibility is most limited.
- Haze index on mid-range days
    - Mid-range days are sampled days where visibility is between the 40^{th} and 60^{th} percentiles.

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[5] See Appendix C for W126 index calculation methods.

[6] Haze index (HI) is a measure of visibility designed so that uniform changes in the haze index correspond to uniform incremental changes in visual perception, across the entire range of conditions from pristine to highly impaired. Haze index [in units of deciview (dv)] is calculated directly from the total light extinction [bext expressed in inverse megameters (Mm-1)] as follows: HI = 10 ln (bext/10) (EPA-454/B-03-005).

2.3.3. Estimates

Each of these statistics is averaged over a 5-year period at each monitoring site with at least 3-years of complete annual data. The 5-year averages are then interpolated across all monitoring locations using an IDW method to estimate 5-year average values for the contiguous US. For individual parks, the maximum values within park boundaries are reported from this national-scale analysis.

2.4. Wet Deposition Estimates

2.4.1. Overview

Atmospheric wet deposition is monitored across the United States as part of the National Atmospheric Deposition Program/National Trends Network (NADP/NTN) for nitrogen and sulfur wet deposition and the NADP/Mercury Deposition Network (MDN) for mercury wet deposition.

2.4.2. Parameters

Atmospheric wet deposition is evaluated for ammonium, nitrate, sulfate, nitrogen, sulfur, and mercury using the following six statistics from monitoring sites across the country:

- Ammonium (NH_4^+)
    - annual precipitation-weighted mean concentrations reported in milligrams/liter (mg/L)
- Nitrate (NO_3^-)
    - annual precipitation-weighted mean concentrations reported in mg/L
- Sulfate (SO_4^{2-})
    - annual precipitation-weighted mean concentrations reported in mg/L
- Nitrogen (N)
    - annual nitrogen precipitation weighted mean concentrations, reported in mg/L, are calculated by summing the nitrogen portions from nitrate and ammonium concentrations. Molecular weight ratios are used to calculate the nitrogen portions of nitrate (NO_3^- concentration * 0.22581) and ammonium (NH_4^+ concentration * 0.77778).
- Sulfur (S)
    - annual sulfur precipitation-weighted mean concentrations, reported in mg/L, is the sulfur portion from sulfate. Molecular weight ratio is used to calculate the sulfur portion of sulfate (SO_4^{2-} concentration * 0.3338).
- Mercury (Hg)
    - annual precipitation-weighted mean concentration, reported in nanograms per liter (ng/L)

2.4.3. Estimates

Nitrogen and Sulfur

Annual ammonium, nitrate, sulfate, nitrogen, and sulfur precipitation weighted mean concentrations are averaged over a 5-year period at monitoring sites with at least 3 years of annual data that meet the following meteorological season completeness criteria[7]:

- Seasonal criterion 1: Percentage of time during the meteorological season for which valid samples are available ≥ 50%.
- Seasonal criterion 2: Percentage of time during the meteorological season for which valid precipitation amounts are available ≥ 75%.
- Seasonal criterion 3: Percentage of the total measured precipitation associated with valid samples ≥ 50% for the meteorological season.

The 5-year averages are then interpolated across all monitoring locations using an IDW method to estimate 5-year average values for the contiguous US. For individual parks, minimum and maximum values within park boundaries are reported from this national-scale analysis.

Wet sulfate, nitrate, nitrogen, and sulfur depositions are calculated by multiplying estimated 5-year average concentrations (milligrams per liter [mg/L]) by normalized precipitation[8] (centimeters [cm]) and dividing by 10. Reporting units for wet deposition are kilograms per hectare per year (kg/ha/yr).

Mercury

Annual mercury precipitation weighted mean concentrations are averaged over a 3-year period at monitoring sites with at least 2 years of annual data that meet the nitrogen and sulfur meteorological season completeness criteria discussed above. The 3-year averages are then interpolated across all monitoring locations using an IDW method to estimate 3-year average values for the contiguous US. For individual parks, minimum and maximum values within park boundaries are reported from this national-scale analysis.

Wet mercury deposition is calculated by multiplying estimated 3-year average concentrations (nanograms per liter [ng/L]) by normalized precipitation (cm) and dividing by 100. Reporting units for wet mercury deposition are micrograms per square meter per year (µg/m^2/yr).

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[7] Meteorological season completeness criteria are based on completeness criteria 1, 2, and 3 used in Lehmann et al. 2005.

[8] Normalized 30-year (1981–2010) precipitation values from the PRISM Climate Group (2014) are used to calculate deposition to minimize interannual variation in deposition caused by fluctuations in precipitation (http://www.ocs.orst.edu/prism/). Note that the PRISM data are resampled to match the resolution of the IDW (i.e. 2.5 km).

3. Status Assessment

3.1. Overview

Air quality status assessments of *Warrants Significant Concern*, *Warrants Moderate Concern*, or *Resource is in Good Condition*, provide a quick snapshot of the air quality conditions in parks. Status assessments are on based NPS-ARD benchmarks compared to estimated air quality conditions discussed in Section 2. NPS-ARD uses seven specific measures to evaluate air quality status at NPS units (see Table 1).

Table 1. Indicators and specific measures for air quality status assessments.

Indicator of air quality	Specific measure
Ozone: human health	4th-highest daily maximum 8-hour average ozone concentration
Ozone: vegetation health	3-month maximum 12-hour W126
Visibility	Visibility minus natural condition on mid-range days
Sulfur	Wet deposition
Nitrogen	Wet deposition
Mercury	Wet deposition and predicted methylmercury concentration
Particulate matter	$PM_{2.5}$ annual, $PM_{2.5}$ 24-hour, and PM_{10} 24-hour

For each of the specific measures of air quality identified above, except predicted methylmercury concentration and particulate matter, data from national air quality monitoring networks are evaluated using spatial interpolation to derive estimated conditions for all locations in the contiguous US. (See section 2 for condition methods).

The conditions are compared to established benchmarks and assigned one of three status categories:

1. Warrants Significant Concern,
2. Warrants Moderate Concern, or
3. Resource is in Good Condition.

Benchmarks for specific measures of air quality have been established using regulatory standards and best available scientific knowledge as described in the following sections.

In the air quality summary tables, the status is indicated by the color of the circle, where red is *Warrants Significant Concern*, yellow is *Warrants Moderate Concern*, and green is *Resource is in Good Condition*.

In some cases, status categories are adjusted based on risk assessments or other information to improve representation of park air quality status.

Procedures for assigning status categories are described in the following sections.

3.2. Ozone Status

3.2.1. Human Health Risk

Breathing ground-level ozone can result in a number of human health effects including chest pain, respiratory irritation, and reduced lung function. The primary National Ambient Air Quality Standard (NAAQS) for ground-level ozone is set by the EPA and is based on human health effects. The 2008 NAAQS for ozone was set at 75 ppb for the 3-year average of the 4th-highest daily maximum 8-hour average ozone concentration[9]. On October 1, 2015, the EPA strengthened the national ozone standard by setting the new level at 70 ppb. The NPS-ARD benchmarks for the human health risk from ozone status are based on the updated Air Quality Index (AQI) breakpoints.

The status for human health risk from ozone is based on the estimated 5-year average of the 4th-highest daily maximum 8-hour average ozone concentration[10] compared to benchmarks (see Table 2). Ozone concentrations greater than or equal to 71 ppb are assigned a *Warrants Significant Concern* status. Ozone concentrations from 55–70 ppb are assigned *Warrants Moderate Concern* status. A *Resource is in Good Condition* status is identified when ozone concentrations are less than or equal to 54 ppb.

Table 2. Benchmarks for human health ozone status (2015 ozone standard). Status category is based on the 5-year average of the estimated annual 4th-highest daily maximum 8-hour average ozone concentration (or measured, for locations outside the contiguous US).

Status category	Ozone concentration (ppb)
Warrants significant concern	≥ 71
Warrants moderate concern	55–70
Resource is in good condition	≤ 54

Note that status assessments for end-years prior to 2014 used NPS-ARD benchmarks that were developed for the 2008 ozone standard (Table 3).

[9] The 4th-highest daily maximum 8-hour average ozone concentration calculations are based on EPA's data reporting and handling conventions found in 40 CFR Part 50, Appendix P to Part 50 - Interpretation of the Primary and Secondary National Ambient Air Quality Standards for Ozone (40 C.F.R. 50 App. P).See Appendix C for acquisition and calculation methods of ozone statistics.

[10] Refer to section 2.2 for specifics on ozone estimate derivation and Appendix A for additional information about the geospatial estimation method. For locations outside the contiguous US, measured values from representative monitors are used.

Table 3. Benchmarks for human health ozone status for 2009 to 2013 end years (2008 standard). Status category is based on the 5-year average of the estimated annual 4th-highest daily maximum 8-hour average ozone concentration (or measured, for locations outside the contiguous US).

Status category	Ozone concentration (ppb)
Warrants significant concern	≥ 76
Warrants moderate concern	61–75
Resource is in good condition	≤ 60

Status Adjustments: The human health ozone status assessments for end-years prior to 2014 had adjustments based on nonattainment area designation. In instances where the NPS unit fell within an area designated by the EPA as nonattainment for the 2008 ground-level ozone standard, the ozone condition was elevated to the *Warrants Significant Concern* category. See Appendix D for NPS units that are in designated non-attainment area(s) for the 2008 standard[11].

3.2.2. Vegetation Health Risk

In addition to being a concern to the health of park staff and visitors, long-term exposures to ground-level ozone can cause injury to ozone-sensitive plants[12] (Bell *In Review*). The W126 metric[13] is a biologically relevant measure that focuses on plant response to ozone exposure. This measure is a better predictor of vegetation response than the metric used for the human health standard. The W126 metric equation preferentially weights the higher ozone concentrations that are more likely to cause plant damage. It sums all of the weighted concentrations during daylight hours as this is when the majority of gas exchange occurs between plants and the atmosphere. The highest 3-month period that occurs during the growing season is reported in parts per million-hours (ppm-hrs).

NPS-ARD benchmarks for the W126 metric are based on information in EPA's *Policy Assessment for the Review of the ozone National Ambient Air Quality Standards* (EPA 2014), which outlines use of the W126 metric for assessing plant response to ground-level ozone. This document also compiled the latest scientific evidence about impacts to vegetation from ground-level ozone. Research has found that for a W126 value of:

- ≤ 7 ppm-hrs, tree seedling biomass loss is ≤ 2 % per year in sensitive species; and
- ≥13 ppm-hrs, tree seedling biomass loss is 4–10 % per year in sensitive species.

The NPS-ARD recommends a W126 of < 7 ppm-hrs to protect most sensitive trees and vegetation.

[11] EPA nonattainment area designation shapefiles are obtained from: http://www.epa.gov/airquality/greenbook/gis_download.html.

[12] For a list of ozone-sensitive plants in NPS units visit: https://irma.nps.gov/NPSpecies/Reports/Systemwide/Ozone-Sensitive%20Species%20in%20a%20Park.

[13] See Appendix C for calculation methods for the ozone W126 statistic.

The status for vegetation health risk from ozone is based on the estimated 5-year average of the 3-month 12-hour W126 index[14] compared to benchmarks (see Table 4). A W126 index greater than 13 ppm-hrs is assigned a *Warrants Significant Concern* status. A W126 index from 7–13 ppm-hrs is assigned *Warrants Moderate Concern* status. A *Resource is in Good Condition* status is identified when W126 index is less than 7 ppm-hrs.

Table 4. Benchmarks for vegetation health risk from ozone exposure status. Status category is based on the 5-year average of the estimated maximum 3-month 12-hour W126 (or measured, for locations outside the contiguous US).

Status category	**W126 (ppm-hrs)**
Warrants significant concern	> 13
Warrants moderate concern	7–13
Resource is in good condition	< 7

3.3. Visibility Status

Pollutant particles in the atmosphere – from both natural and human-caused sources (e.g., power plants, dust) – scatter and absorb light, creating a haze that impairs how far and how well we can see. The Regional Haze Rule established a national goal to return visibility to natural conditions[15] in Class I areas[16]. The NPS-ARD recommends a visibility benchmark of less than 2 dv above natural conditions for all NPS units, regardless of Class designation. The NPS-ARD chose benchmarks to reflect the variation in visibility conditions across the monitoring network.

The status for visibility is based on the estimated 5-year average on mid-range days minus the estimated natural visibility on mid-range days[17] compared to benchmarks (see Table 5). A result greater than 8 dv is assigned a *Warrants Significant Concern* status. A result from 2–8 dv is assigned

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[14] Refer to section 2.2 for specifics on ozone estimate derivation and Appendix A for additional information about the geospatial estimation method. For locations outside the contiguous US, measured values from representative monitors are used. For locations outside the contiguous US, measured values from representative monitors are used.

[15] Natural visibility conditions are those estimated to exist in a given area in the absence of human caused visibility impairment (EPA-454/B-03-005). See Appendix E for estimated average natural visibility on mid-range days in NPS units.

[16] Class I areas have the highest level of air quality protection under the law. These areas are defined as national parks larger than 6,000 acres or wilderness areas over 5,000 acres that were in existence when the Clean Air Act was amended in 1977. There are 48 Class I areas in the National Park System.

[17] Refer to section 2.3 for specifics on visibility estimate derivation and Appendix A for additional information about the geospatial estimation method. For locations outside the contiguous US, measured values from representative monitors are used. For locations outside the contiguous US, measured values from representative monitors are used.

Warrants Moderate Concern status. A *Resource is in Good Condition* status is identified when the result is less than 2 dv.

Table 5. Benchmarks for visibility status. Status category is based on a 5-year average of estimated visibility on mid-range days minus natural condition of mid-range days (or measured, for locations outside the contiguous US).

Status category	Visibility (dv)
Warrants significant concern	> 8
Warrants moderate concern	2–8
Resource is in good condition	< 2

3.4. Atmospheric Deposition Status

3.4.1. Nitrogen and Sulfur Wet Deposition

Airborne pollutants are deposited to the earth's surface through a process called atmospheric deposition. Pollutants that are removed from the atmosphere with rain, snow, or other precipitation are wet deposition; pollutants that are removed by gravitational settling or simply depositing to the surface are categorized as dry deposition. Total deposition includes both wet and dry deposition. Nitrogen and sulfur compounds in air pollution (e.g., from industry, vehicles, agriculture, oil and gas development) can deposit into ecosystems and cause acidification, excess fertilization (eutrophication), and changes in soil and water chemistry that can affect community composition and alter biodiversity.

Assessment of nitrogen and sulfur atmospheric deposition status is based on wet deposition. Wet deposition is used as a surrogate for total deposition, because wet deposition is the most widely monitored source of nitrogen and sulfur deposition data available. While ecosystems respond to total (wet and dry) deposition together, NPS-ARD selected a wet deposition threshold of 1.0 kg/ha/yr wet deposition of nitrogen or sulfur as the level below which natural ecosystems are likely protected from harm. This level is based on studies linking early stages of aquatic health decline correlated with 1.0 kg/ha/yr wet deposition of nitrogen both in the Rocky Mountains (Baron et al 2011), and in the Pacific Northwest (Schibely et al 2014).

The condition status for nitrogen or sulfur atmospheric deposition is based on the maximum estimated[18] 5-year average of wet deposition compared to benchmarks, in order to protect the most sensitive resources (see Table 6). Deposition is often the highest at high elevations because of the increase in precipitation with elevation. Sensitive resources are also often found at the highest

[18] Refer to section 2.4 for specifics on wet deposition estimate derivation and Appendix A for additional information about the geospatial estimation method. For locations outside the contiguous US, measured values from representative monitors are used. For locations outside the contiguous US, measured values from representative monitors are used.

elevations, where shallow soils and exposed bedrock provide little chemical buffering and short growing seasons limit the amount of nutrient uptake by plants.

Table 6. Benchmarks for nitrogen and sulfur deposition status. Status category is based on a 5-year average of estimated nitrogen or sulfur wet deposition (or measured, for locations outside the contiguous US).

Status category	Wet deposition (kg/ha/yr)
Warrants significant concern	> 3
Warrants moderate concern	1–3
Resource is in good condition	< 1

Wet deposition greater than 3 kg/ha/yr is assigned a *Warrants Significant Concern* status. Wet deposition from 1–3 kg/ha/yr is assigned *Warrants Moderate Concern* status. A *Resource is in Good Condition* status is identified when wet deposition is less than less than 1 kg/ha/yr.

Status adjustments: Nitrogen or sulfur deposition status is adjusted based on results from national assessment reports that identified ecosystems and resources at risk to acidification and nitrogen enrichment in national parks. These reports provide a relative risk assessment of acidification and nutrient enrichment impacts from atmospheric nitrogen and sulfur deposition for parks in 32 inventory & monitoring networks. If park ecosystems are ranked “very high” in sensitivity[19] to acidification or nutrient enrichment effects from atmospheric deposition relative to all inventory & monitoring parks (Sullivan et al. 2011a; Sullivan et al. 2011b), the condition category is adjusted to the next most conservative condition category (see Appendix F for a list of parks with status adjustments).

Note that the methodology for nitrogen and sulfur deposition condition assessments will be improved in coming years by using total deposition estimates and established critical loads[20]. This will allow conditions to be set based on exceedance of a threshold of sulfur or nitrogen deposition known to negatively impact an ecosystem component within the park.

3.4.2. Mercury Deposition

Elevated levels of mercury and other airborne toxic pollutants in aquatic and terrestrial food webs, can act as neurotoxins in biota. The NPS-ARD assesses mercury status according to the mercury risk

[19] Ecosystem sensitivity 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). Ratings for 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).

[20] A critical load is defined as a level of deposition below which harmful effects to the ecosystem are not expected.

status assessment matrix. In certain instances, in-park data on mercury and/or other toxic contaminants in biota can be applied to adjust the status.

The ARD mercury status assessment matrix is the resultant product of two conditions:

1. estimated 3-year average mercury wet deposition; and
2. predicted surface water methylmercury concentrations.

The 1st condition represents atmospheric wet mercury inputs, while the 2nd condition represents the landscape sensitivity to mercury methylation. It is important to consider both mercury deposition inputs and ecosystem susceptibility to mercury methylatation when assessing mercury status because atmospheric inputs of elemental or inorganic mercury must be methylated before it is biologically available and able to accumulate in food webs. Thus, mercury condition cannot be assessed according to mercury wet deposition (1st condition) alone. Other factors like environmental conditions conducive to mercury methylation (e.g., dissolved organic carbon, wetlands, pH) must also be considered (2nd condition).

Condition of atmospheric mercury deposition is based on the maximum estimated 3-year average of wet deposition[21]. The wet deposition value is assigned a *Very Low* to *Very High* rating based on the benchmarks in Table 7.

Table 7. Benchmarks for mercury deposition rating. Rating is based on 3-year average of estimated mercury wet deposition (or measured, for locations outside the contiguous US).

Rating	Mercury deposition (μg/m^2/yr)
Very low	< 3
Low	≥ 3 and < 6
Moderate	≥ 6 and < 9
High	≥ 9 and < 12
Very high	≥ 12

Conditions of predicted methylmercury concentration (nanograms per liter [ng/L]) in surface water are obtained from a model. This model predicts surface water methylmercury concentrations for hydrologic units throughout the US based on relevant water quality characteristics (pH, sulfate, and total organic carbon) and wetland abundance (USGS 2015). The predicted methylmercury concentration at a park is the highest value derived from the hydrologic units that intersect the park.

[21] Refer to section 2.4 for specifics on wet deposition estimate derivation and Appendix A for additional information about the geospatial estimation method. For locations outside the contiguous US, measured values from representative monitors are used. For locations outside the contiguous US, measured values from representative monitors are used.

This highest value is then assigned a rating from *Very Low* to *Very High* based on benchmarks in Table 8.

Table 8. Benchmarks for predicted methylmercury concentration rating.

Rating	Predicted methylmercury concentration (ng/L)
Very low	< 0.038
Low	≥ 0.038 and < 0.053
Moderate	≥ 0.053 and < 0.075
High	≥ 0.075 and < 0.12
Very high	≥ 0.12

Ratings for mercury wet deposition and predicted methylmercury concentration are then considered concurrently in the mercury status assessment matrix below to identify one of three park-specific mercury status categories: *Warrants Significant Concern* (red circles). *Resource is in Good Condition* (green circles), *Warrants Significant Concern* (yellow circles), and

Table 9. Mercury status assessment matrix. Reference Table 7 for wet deposition ratings and Table 8 for predicted methylmercury ratings.

Status	*Wet deposition* **very low**	*Wet deposition* **low**	*Wet deposition* **moderate**	*Wet deposition* **high**	*Wet deposition* **very high**
Predicted Methylmercury **very low**	green	green	green	yellow	yellow
Predicted Methylmercury **low**	green	green	yellow	yellow	yellow
Predicted Methylmercury **moderate**	green	yellow	yellow	yellow	red
Predicted Methylmercury **high**	yellow	yellow	yellow	red	red
Predicted Methylmercury **very high**	yellow	yellow	red	red	red

Mercury wet deposition or predicted methylmercury concentration ratings may not be reported due to spatial gaps in NADP/MDN sites and/or incompleteness of predicted methylmercury concentrations. If an NPS unit does not have a rating for either category, a mercury status is not assigned unless the status adjustment guidelines apply (see below).

Status adjustments: Mercury status and confidence are adjusted based on measured mercury concentrations in park wildlife as compared with established thresholds and fish consumption guidelines. Data on biota must be credible and available in at least three biotic compartments (e.g., fish, songbirds, dragonfly larvae), with an ideal sample size of N=15 or more per compartment and multiple sampling sites (N>3 per 1,000 square miles). See Appendix G for a list of parks with status adjustments.) Mercury status cannot be assessed on fish consumption guidance alone.

Mercury condition status assessments have been generated for 2013, 2014, and 2015 end-years. However, they are not currently available online. Also, note that this is an interim methodology that will be improved in the coming years by using measured mercury concentrations in park wildlife and established thresholds.

4. Particulate Matter

The particulate matter condition is based on the NAAQS for $PM_{2.5}$ and PM_{10}, which are established by the EPA to protect human health. The $PM_{2.5}$ primary standard is 12 micrograms per cubic meter (µg/m^3) annually (3-year average of weighted annual mean) and 35 µg/m^3 for 24-hours (3-year average of the 98th percentile of 24-hour concentrations). The primary and secondary NAAQS for PM_{10} is 150 µg/m^3 for 24-hours (not to be exceeded more than once per year over 3 years). EPA AQI breakpoints were used to develop benchmarks.

The status for particulate matter is based on comparing measured 3-year averages (98th percentile of 24-hour $PM_{2.5}$ concentration, weighted annual mean 24-hour $PM_{2.5}$ concentrations, and 2nd maximum 24-hour PM_{10}) [22] to benchmarks (see Table 10). The measurement with the most conservative status category determines the overall particulate matter status.

Table 10. Benchmarks for particulate matter status. Particulate matter concentrations are averaged over 3-years and are expressed in micrograms per cubic meter (µg/m^3).

Condition category	98th percentile 24-hour $PM_{2.5}$ concentration	Weighted annual mean 24-hour $PM_{2.5}$ concentration	2nd maximum 24-hour PM_{10} concentration
Warrants significant concern	≥ 35.5	≥ 12.5	≥ 155
Warrants moderate concern	12.1–35.4	4.1–12.4	55–154
Resource is in good condition	≤ 12.0	≤ 4	≤ 54

Particulate matter conditions are currently generated by the NPS-ARD on a case by case basis as needed. National assessments using 2016 end year will be available online in 2018.

[22] Measured values are derived from representative sites that are within 10 kilometers of the park boundaries.

5. Trend Assessment

A non-parametric regression technique called the Kendall-Theil method[23] is used to determine statistically significant trends. Short-term trends are computed from data collected over a 10-year period at on-site or nearby representative monitors (see Appendix B for a list of representative sites). Short-term trends are calculated for sites that have at least 6 years of annual data and an annual value for the end year of the reporting period.

Long-term trends are computed from the entire monitoring record at on-site monitors or nearby representative monitors. Long-term trends are calculated for sites that have at least 60 percent of annual data, no data gaps greater than 4 years, and an annual value for the reporting end year.

In the air quality summary tables, only the short-term trends are reported and are represented by arrows. All improving (up arrows) and deteriorating (down arrows) trends have at least 90% probability of being correct (those with p-values ≤ 0.10). Statistically significant (p-value ≤ 0.10) trends with zero slope are represented by flat arrows. Parameters with no statistically significant trend (p-value ≥ 0.10) are also represented by flat arrows.

5.1. Ozone

The annual 4th-highest daily maximum 8-hour average ozone concentrations (ppb) are used to calculate ozone trends relevant to human health. Ozone trends relevant to vegetation are based on the annual 3-month maximum 12-hour W126 statistic. For a year to be considered in trend analyses, it must meet annual completeness criteria. Annual completeness criteria are different for the two ozone statistics (see Appendix C for details).

Ozone trends are computed for parks with a representative ozone monitor that is within 10 km of park boundaries. Monitors operated by NPS take precedence over other nearby monitors. In cases where the park has more than one monitor operated by the NPS, the monitor with the longest monitoring history is selected to represent the park. There are a handful of representative monitors that are no longer the closest monitor within a 10 km radius but are retained as the representative monitor to maintain consistent historic trend records. See Appendix B for a list of representative ozone monitoring sites.

5.2. Visibility

Visibility trends are computed from the haze index values on the 20% haziest days and the 20% clearest days, consistent with visibility goals in the Regional Haze Rule, which include improving visibility on the haziest days and allowing no deterioration on the clearest days. Although the CAA legislation provides special protection for NPS areas designated as Class I, the NPS applies these standard visibility metrics to all units of the NPS. If the haze index trend on the 20% clearest days is

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[23] Kendal-theil methods for computing the trend line and test for significance are explained in *Statistical Methods in Water Resources* section "10.1 Kendall-Theil Robust Line" available at http://pubs.usgs.gov/twri/twri4a3/.

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.

Trends are computed for parks with assigned representative monitors. The same monitors that are selected to represent Class I areas as part of the Regional Haze Rule are used to calculate visibility trends for Class I parks. For all other parks, representative IMPROVE monitoring sites were selected based the following criteria: within +/- 100 feet or 10% of maximum and minimum elevation of the park and at a distance of no more than 150 kilometers. IMPROVE representative monitors are not assigned to parks with a land-use status of urban.[24]

5.3. Atmospheric Deposition

5.3.1. Nitrogen and Sulfur

Wet deposition trends are evaluated using pollutant concentrations in precipitation (micro equivalents/liter) so that yearly variations in precipitation amounts do not influence trend analyses. For nitrogen wet deposition trends, nitrogen concentration in precipitation is trended over a 10-year period and entire data record for each reporting year. Nitrogen concentration is calculated by summing the nitrogen portions of nitrate and ammonium concentrations in precipitation[25]. For sulfur wet deposition trends, sulfate concentrations measured in precipitation are trended over a 10-year period and the entire data record for each reporting year. For a year to be considered in the trend analysis it must meet the same meteorological season completeness criteria as used for calculating 5-year averages (see section 2.4.3).

Nitrogen and sulfur trends are computed for parks with a representative NADP/NTN wet deposition monitor that is within 16 km of park boundaries. Gates of the Arctic NP & PRES is an exception to the distance criteria because the representative monitor (NADP/NTN ID: AK06) is operated by NPS but located 26 km outside park boundaries for accessibility reasons. See Appendix B for a list of NADP/NTN representative monitoring sites.

5.3.2. Mercury

Wet mercury deposition trends are evaluated using pollutant concentrations in precipitation (micro equivalents/liter) so that yearly variations in precipitation amounts do not influence trend analyses. Mercury concentrations in precipitation are trended over a 10-year period and the entire data record for each reporting year. For a year to be considered in the trend analysis, it must meet the same meteorological season completeness criteria as used for sulfur and nitrogen (see section 2.4.3).

Mercury trends are computed for parks with a representative NADP/MDN wet deposition monitor that is within 16 km of park boundaries. Gates of the Arctic NP & PRES is an exception to the distance criteria because the representative monitor (NADP/MDN ID: AK06) is operated by NPS but

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[24] National Land Cover Database 2011 edition retrieved from http://www.mrlc.gov/nlcd06_data.php was used to categorize NPS units as urban, suburban, and rural.

[25] Molecular weight ratios are used to calculate the nitrogen portions of nitrate (NO_3) and ammonium (NH_4): (NH_4 concentration * 0.77778) and (NO_3 concentration * 0.22581).

located 26 km outside park boundaries for accessibility reasons. See Appendix B for a list of NADP/MDN representative monitoring sites.

6. Degree of Confidence in Status and Trend

6.1. Confidence in Status

The degree of confidence for each status assessment is based on how well the nearest monitoring site(s) represents air quality for a park. The representativeness of a monitor depends on the pollutant, network, distance from the park, and local site characteristics. The degree of confidence is rated as either *High* or *Medium*: the confidence is *High* if estimates are based on interpolated data from on-site or nearby monitors, and *Medium* if estimates are based on interpolated data from more distant monitors. Status assessments for parks that are in the non-contiguous US are based on measured values at representative monitors and have a *High* degree of confidence. *Low* confidence is not assigned for ozone, visibility, nitrogen deposition, sulfur deposition, or particulate matter status assessments.

For mercury status assessments that are based on wet mercury deposition and predicted methylmercury concentrations, *Low* confidence is applied. *High* or *Medium* confidence is applied to the mercury condition status in select NPS units where credible data exists in multiple biotic components (e.g., fish, songbirds, dragonfly larvae), with an ideal sample size of N=15 or more per compartment and multiple sampling sites (N>3 per 1000 square miles). See Appendix G for confidence mercury status adjustments.

In air quality summary tables, the degree of confidence in assigned condition status is represented by the thickness of the outside line of the status symbol (circle). A thick outline represents *High* confidence, a thin outline represents *Medium* confidence, and a dashed outline represents *Low* confidence.

6.2. Confidence in Trend

The degree of confidence for all available air quality trend analyses is rated *High* because trends are only computed for parks with an on-site or representative monitor.

7. Overall Air Quality Status and Trend

Available air quality status assessments and trends at each NPS unit are rolled into a single air quality status and trend.

7.1. Overall Air Quality Status

To determine the combined condition status, each *Warrants Significant Concern* (red) symbol is assigned zero points, each *Warrants Moderate Concern* (yellow) symbol is assigned 50 points, and each *Resource is in Good Condition* (green) symbol, 100 points. The average is calculated from all of the status assessments and applied the scale below (Table 11) to determine the overall air quality status.

Table 11. Scale for overall air quality status.

Status score	Overall air quality status	Overall air quality status symbol color
0–33	Warrants significant concern	(red circle)
34–66	Warrants moderate concern	(yellow circle)
67–100	Resource is in good condition	(green circle)

Note that for end years 2009–2013, NPS units that were in EPA designated ozone or particulate matter nonattainment areas were automatically placed in the *Warrants Significant Concern* condition category (see Appendix D: Parks in EPA Designated Nonattainment Areas). Starting with end year 2014, the overall condition status is no longer adjusted based on nonattainment designation.

7.2. Overall Air Quality Trend

To determine the overall trend, subtract the total number of deteriorating trend (up arrow) symbols from the total number of improving trend (up arrow) symbols (Table 12). If the result is 3 or greater, the overall trend is improving (up arrow). If the result is -3 or lower, the overall trend is deteriorating (down arrow). If the result is between 2 and -2, the overall trend is unchanging (horizontal double-headed arrow). If there are no trends reported for any of the specific measures, the overall condition symbol will not show a trend arrow.

Table 12. Scale for overall air quality trend.

Trend score	Overall air quality trend	Overall air quality trend symbol
≤ - 3	Deteriorating	⇩
-2 to < 2	Unchanging	⇔
≥ 3	Improving	⇧

7.3. Degree of Confidence for Overall Status

The degree of confidence in the overall status is assigned a *High* rating only when all individual indicators have *High* confidence ratings. In all other instances, the overall degree of confidence is rated as *Medium*.

8. Chemical Composition of Haze and Deposition

8.1. Haze

Speciated fine particulate matter and total mass are measured every third day at IMPROVE monitoring sites situated to represent air quality at 155 Class I areas and other rural environments. These data are used to estimate the contribution of the major chemical species to ambient particulate matter and in turn their contribution to haze (i.e., visibility impairment). The particulate matter constituents are ammonium sulfate, ammonium nitrate, organic mass, elemental carbon, fine soil, fine sea salt, and coarse mass.

Visibility impairment is reported as either light extinction or deciview. Light extinction has units of inverse megameters [1/Mm] and is a measure of the loss of image forming light from scenic features to the observer due to scattering and absorption by particles and gases per unit length. Light extinction is dependent on the optical properties of the particulate matter and varies by its chemical constituents. For example, a given quantity of ammonium sulfate will scatter more light than the same quantity of soil particles.

Composition and visibility data are grouped by haziest days (i.e., sampled days with the highest 20% of aerosol calculated light extinction) and clearest days (i.e., sampled days with the lowest 20% of aerosol calculated light extinction) in each year and averaged over 1 or 5-year periods. The average clearest and haziest sampled days are compared to the respective natural visibility conditions on clearest and haziest days.

8.2. Nitrogen and Sulfur Deposition

The composition of inorganic nitrogen deposition (kg/ha/yr) is reported as the sum of annual and 5-year average wet and dry chemical components. Ammonium and nitrate wet nitrogen deposition data are from representative NADP/NTN sites and are based on the measured precipitation amount at the monitoring site. Dry nitrogen deposition data on nitric acid, ammonium, and nitrate are modeled from measurements at representative CASTNET sites. All components are converted to nitrogen and then summed.

The composition of sulfur deposition (kg/ha/yr) is reported as the sum of annual and 5-year average wet and dry chemical components. Wet sulfur deposition is determined by converting sulfate deposition to sulfur from representative NADP/NTN sites and is based on the measured precipitation amount at the monitoring site. Dry sulfur deposition data on sulfur dioxide and sulfate are modeled from measurements at representative CASTNET sites. All components are converted to sulfur and then summed.

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Appendix A: Geospatial Estimation Method

Because of variable distribution of air quality monitoring sites across the US, there is a need to use spatial interpolation to estimate air quality measures in non-monitored locations or locations with multiple monitors. NPS-ARD uses Inverse Distance Weighting (IDW) to estimate air quality measures for NPS units within the contiguous US based on available monitoring data.

IDW, as applied by NPS-ARD, uses a weighted average from the 12 closest air quality monitoring sites for a given parameter to estimate air quality conditions for all locations across the contiguous US. The weight given to each monitor is a decreasing function of distance. The monitor's influence on estimated values diminishes with the inverse distance-squared (i.e., $1/distance^2$) from locations. The closer a monitoring site is, the more influence, or weight, it has in the averaging process. For example, if a park has an air quality monitoring site within park boundaries, that monitor will have more influence than monitoring sites outside park boundaries. The output is a continuous raster surface with a 2.5 km resolution covering the contiguous US. For individual parks, the minimum and maximum values within park boundaries are reported from this national analysis. For parks with surface area less than 12.5 square kilometers (i.e. less than two grid cells), the centroid value is reported from this analysis.

Uncertainty in spatial interpolation is an unavoidable part of the process. Because inverse distance weighting is a deterministic technique, it does not take into account the arrangement of the monitoring sites. Higher levels of uncertainty can be expected when looking at regions with large topographic variability, near urban and industrial areas, and in regions isolated from monitoring sites. For example, air quality estimates in urban areas where monitors are clustered or in rural areas where monitors are sparse may be less representative of the air quality within a park.

Appendix B: List of Representative Monitors

Trends are computed for parks with assigned representative monitors.

Ozone

Ozone trends are computed for parks with a representative ozone monitor that is within 10 km of park boundaries. Monitors operated by NPS take precedence over other nearby monitors. In cases where the park has more than one monitor operated by the NPS, the monitor with the longest monitoring history is selected to represent the park. There are a handful of representative monitors that are no longer the closest monitor within a 10 km radius but are retained as the representative monitor to maintain a consistent historic record of trends.

Visibility

Trends are computed for parks with assigned representative monitors. The same monitors that are selected to represent Class I areas as part of the Regional Haze Rule are used to calculate visibility trends for Class I parks. For all other parks, representative IMPROVE monitoring sites were selected based the following criteria: within +/- 100 feet or 10% of maximum and minimum elevation of the park and at a distance of no more than 150 kilometers. IMPROVE representative monitors are not assigned to parks with a land-use status of urban.[26]

Wet Deposition

Nitrogen, sulfur, and mercury wet deposition trends are computed for parks with a representative NADP/NTN or NADP/MDN wet deposition monitor that is within 16 km of park boundaries. Gates of the Arctic NP & PRES is an exception to the distance criteria because the representative monitor (NADP/NTN ID: AK06) is operated by NPS but located 26 km outside park boundaries for accessibility reasons.

[26] National Land Cover Database 2011 edition retrieved from http://www.mrlc.gov/nlcd06_data.php was used to categorize NPS units as urban, suburban, and rural.

Table A. Representative air quality monitors for NPS units.

Park Name	Ozone	Visibility	Wet Nitrogen & Sulfur	Dry Nitrogen & Sulfur	Mercury
Abraham Lincoln Birthplace NHP	–	MACA1	–	–	–
Acadia NP	230090102	ACAD1	ME98	ACA416	ME98
Adams NHP	250250041	–	–	–	–
Agate Fossil Beds NM	311651001	WICA1	–	–	–
Allegheny Portage Railroad NHS	420210011	FRRE1	PA13	–	PA13
Antietam NB	240430009	–	–	–	–
Appomattox Court House NHP	–	JARI1	–	–	–
Arches NP	–	CANY1	–	–	–
Arlington House, The Robert E. Lee N MEM	510130020	WASH1	–	–	–
Assateague Island NS	240471001	BRIG1	MD18	–	–
Aztec Ruins NM	350450009	–	–	–	–
Badlands NP	460710001	BADL1	–	–	–
Bandelier NM	–	BAND1	NM07	–	–
Bent's Old Fort NHS	–	–	CO01	–	–
Big Bend NP	480430101	BIBE1	TX04	BBE401	–
Big Cypress N PRES	–	EVER1	–	–	FL97
Big Hole NB	–	SULA1	–	–	–
Big South Fork NRRA	–	MACA1	–	–	–
Big Thicket N PRES	483739991	–	–	–	–
Bighorn Canyon NRA	–	NOCH1	–	–	–
Biscayne NP	120860029	EVER1	–	–	–
Black Canyon Of The Gunnison NP	–	WEMI1	–	–	–
Blue Ridge PKWY	370110002	SHRO1	NC45	–	–
Booker T Washington NM	–	JARI1	–	–	–
Boston African American NHS	250250042	–	–	–	–
Boston Harbor Islands NRA	250250041	–	–	–	–
Boston NHP	250250042	–	–	–	–
Brown V Board Of Education NHS	201770013	–	–	–	KS03
Bryce Canyon NP	–	BRCA1	UT99	–	–
Buffalo NR	–	UPBU1	AR16	–	–
Cabrillo NM	060731010	–	–	–	–
Canaveral NS	–	–	FL99	–	–
Canyon De Chelly NM	–	PEFO1	–	–	–
Canyonlands NP	490370101	CANY1	UT09	CAN407	–
Cape Cod NS	250010002	CACO1	MA01	–	MA01
Cape Hatteras NS	–	SWAN1	–	–	–
Cape Lookout NS	–	SWAN1	–	–	–

Park Name	Ozone	Visibility	Wet Nitrogen & Sulfur	Dry Nitrogen & Sulfur	Mercury
Capitol Reef NP	–	CAPI1	–	–	–
Capulin Volcano NM	–	–	NM12	–	–
Carl Sandburg Home NHS	–	GRSM1	–	–	–
Carlsbad Caverns NP	350153001	GUMO1	–	–	–
Carter G. Woodson Home NHS	110010043	WASH1	–	–	MD99
Castle Clinton NM	340170006	–	–	–	–
Catoctin Mountain Park	–	–	MD07	–	–
Cedar Breaks NM	–	BRCA1	–	–	–
Chaco Culture NHP	–	BAND1	–	–	–
Chamizal N MEM	481410044	–	–	–	–
Channel Islands NP	061112003	–	–	–	–
Charles Young Buffalo Soldiers NM	390570006	–	–	–	–
Chattahoochee River NRA	131350002	–	–	–	–
Chesapeake & Ohio Canal NHP	110010043	WASH1	–	–	–
Chickamauga & Chattanooga NMP	470654003	–	–	–	–
Chiricahua NM	040038001	CHIR1	AZ98	CHA467	–
Christiansted NHS	–	VIIS1	–	–	–
City Of Rocks N RES	–	JARB1	–	–	–
Clara Barton NHS	510595001	WASH1	–	–	–
Colorado NM	080771001	CANY1	–	–	–
Congaree NP	450790021	ROMA1	–	–	SC19
Constitution Gardens	510130020	WASH1	–	–	–
Coronado N MEM	–	CHIR1	–	–	–
Cowpens NB	450210002	–	–	–	–
Crater Lake NP	–	CRLA1	–	–	–
Craters Of The Moon NM & PRES	160230101	CRMO1	ID03	–	ID03
Cumberland Gap NHP	470259991	GRSM1	TN04	–	–
Curecanti NRA	–	WEMI1	–	–	–
Cuyahoga Valley NP	391530020	–	–	–	–
Dayton Aviation Heritage NHP	390230003	–	–	–	–
De Soto N MEM	120814012	CHAS1	–	–	–
Death Valley NP	060270101	DEVA1	–	DEV412	–
Delaware Water Gap NRA	340410007	–	PA72	–	PA72
Denali NP & PRES	020680003	DENA1	AK03	DEN417	–
Devils Postpile NM	–	KAIS1	–	–	–
Devils Tower NM	–	THBA1	–	–	–
Dinosaur NM	490471002	FLTO1	–	–	–
Dry Tortugas NP	–	EVER1	–	–	–

Park Name	Ozone	Visibility	Wet Nitrogen & Sulfur	Dry Nitrogen & Sulfur	Mercury
Edgar Allan Poe NHS	421010004	–	–	–	–
Eisenhower NHS	–	–	PA00	–	PA00
El Malpais NM	–	BALD1	–	–	–
Everglades NP	–	EVER1	FL11	EVE419	FL11
Fire Island NS	361030009	–	–	–	–
First Ladies NHS	391510016	–	–	–	–
First State NHP	100031010	–	–	–	–
Flight 93 N MEM	–	FRRE1	–	–	–
Florissant Fossil Beds NM	–	GRSA1	–	–	–
Ford's Theatre NHS	110010043	WASH1	–	–	–
Fort Bowie NHS	–	CHIR1	AZ98	–	–
Fort Larned NHS	–	CEBL1	–	–	–
Fort McHenry NM & Historic Shrine	245100054	–	–	–	–
Fort Point NHS	060750005	–	–	–	–
Fort Pulaski NM	130510021	–	–	–	–
Fort Raleigh NHS	–	SWAN1	–	–	–
Fort Smith NHS	401359021	–	–	–	–
Fort Sumter NM	–	ROMA1	–	–	–
Fort Union NM	–	BAND1	–	–	–
Fort Union Trading Post NHS	–	MELA1	–	–	–
Fort Washington Park	510590030	WASH1	–	–	MD99
Fossil Butte NM	–	BOLA1	–	–	–
Franklin Delano Roosevelt Memorial	510130020	WASH1	–	–	–
Frederick Douglass NHS	110010041	WASH1	–	–	MD99
Frederick Law Olmsted NHS	250250042	–	–	–	–
Fredericksburg & Spotsylvania NMP	–	WASH1	–	–	–
Gates Of The Arctic NP & PRES	–	GAAR1	AK06	–	–
Gateway NRA	360850067	–	–	–	–
Gauley River NRA	–	JARI1	–	–	–
General Grant N MEM	360610135	–	–	–	NY06
George Rogers Clark NHP	180839991	–	IN22	–	–
George Washington Birthplace NM	–	WASH1	–	–	–
George Washington Carver NM	–	ELDO1	–	–	–
George Washington Memorial PKWY	510130020	WASH1	–	–	–
Gettysburg NMP	420019991	–	PA00	–	PA00
Gila Cliff Dwellings NM	–	GICL1	NM01	–	–
Glacier Bay NP & PRES	–	–	–	–	AK05
Glacier NP	300298001	GLAC1	MT05	GLR468	MT05

Park Name	Ozone	Visibility	Wet Nitrogen & Sulfur	Dry Nitrogen & Sulfur	Mercury
Glen Canyon NRA	–	CANY1	–	–	–
Golden Gate NRA	060750005	–	–	–	–
Governors Island NM	340170006	–	–	–	–
Grand Canyon NP	040058001	GRCA2	AZ03	GRC474	–
Grand Teton NP	560390008	YELL2	WY94	–	–
Grant-Kohrs Ranch NHS	–	MONT1	–	–	–
Great Basin NP	320330101	GRBA1	NV05	GRB411	–
Great Sand Dunes NP & PRES	–	GRSA1	–	–	–
Great Smoky Mountains NP	470090101	GRSM1	TN11	GRS420	TN11
Greenbelt Park	240330030	WASH1	MD99	–	MD99
Guadalupe Mountains NP	–	GUMO1	TX22	–	–
Guilford Courthouse NMP	370810013	–	–	–	–
Gulf Islands NS	121130015	BRIS1	–	–	–
Haleakala NP	–	HACR1	–	–	–
Hamilton Grange N MEM	360610135	–	–	–	NY06
Hampton NHS	240051007	–	–	–	–
Hawaii Volcanoes NP	–	HAVO1	–	HVT424	–
Herbert Hoover NHS	–	LASU2	–	–	–
Honouliuli National Monument	150030010	–	–	–	–
Hopewell Furnace NHS	–	–	PA60	–	PA60
Horseshoe Bend NMP	–	BIRM1	–	–	–
Hovenweep NM	–	MEVE1	–	–	–
Independence NHP	421010004	–	–	–	–
Indiana Dunes NL	181270024	–	IN34	–	IN34
Isle Royale NP	–	ISLE1	–	–	–
James A Garfield NHS	390850003	–	–	–	–
Jean Lafitte NHP & PRES	220550007	BRIS1	–	–	–
Jefferson National Expansion Memorial	295100085	–	–	–	–
John D Rockefeller Jr Memorial PKWY	–	YELL2	–	–	–
John Day Fossil Beds NM	–	STAR1	–	–	–
John F Kennedy NHS	250250042	–	–	–	–
John Muir NHS	060130002	–	–	–	–
Joshua Tree NP	060719002	JOSH1	CA67	JOT403	–
Katmai NP & PRES	–	TUXE1	AK97	–	–
Kenai Fjords NP	–	TUXE1	–	–	–
Kennesaw Mountain NBP	130670003	–	–	–	–
Keweenaw NHP	–	ISLE1	MI99	–	–
Kings Mountain NMP	450210003	–	–	–	–

Park Name	Ozone	Visibility	Wet Nitrogen & Sulfur	Dry Nitrogen & Sulfur	Mercury
Klondike Gold Rush NHP	530330080	OLYM1	–	–	–
Korean War Veterans Memorial	110010043	WASH1	–	–	–
Lake Chelan NRA	–	NOCA1	–	–	–
Lake Clark NP & PRES	–	TUXE1	–	–	–
Lake Mead NRA	320030601	GRCA2	–	–	–
Lassen Volcanic NP	060893003	LAVO1	CA96	LAV410	–
Lava Beds NM	–	LABE1	–	–	–
Lincoln Home NHS	171670014	–	–	–	–
Lincoln Memorial	110010043	WASH1	–	–	–
Little Bighorn Battlefield NM	–	–	MT00	–	–
Little Rock Central High School NHS	051190007	–	–	–	–
Longfellow NHS	250250042	–	–	–	–
Lowell NHP	250170009	–	–	–	–
Lyndon Baines Johnson Memorial Grove N MEM	510130020	WASH1	–	–	–
Maggie L Walker NHS	510870014	–	–	–	–
Mammoth Cave NP	210610501	MACA1	KY10	MAC426	KY10
Manassas NBP	511530009	–	–	–	–
Manzanar NHS	–	OWVL1	–	–	–
Marsh - Billings - Rockefeller NHP	–	PMRF1	–	–	–
Martin Luther King Jr NHS	131210055	–	–	–	–
Martin Luther King, Jr. Memorial	110010043	WASH1	–	–	–
Mary McLeod Bethune Council House NHS	110010043	–	–	–	MD99
Mesa Verde NP	080830101	MEVE1	CO99	MEV405	CO99
Minuteman Missile NHS	–	BADL1	SD08	–	–
Mississippi NRRA	–	–	–	–	MN98
Missouri NRR	–	BLMO1	–	–	–
Mojave N PRES	060711001	JOSH1	–	–	–
Monocacy NB	240210037	–	–	–	–
Mount Rainier NP	530530012	MORA1	WA99	MOR409	–
Mount Rushmore N MEM	–	WICA1	–	–	–
Muir Woods NM	060410001	–	–	–	–
Natchez NHP	280010004	–	–	–	–
Natchez Trace PKWY	280810005	SIPS1	MS10	–	–
National Mall	110010043	–	–	–	–
National Mall & Memorial Parks	110010043	WASH1	–	–	–
Natural Bridges NM	–	CANY1	–	–	–
Navajo NM	–	GRCA2	–	–	–

Park Name	Ozone	Visibility	Wet Nitrogen & Sulfur	Dry Nitrogen & Sulfur	Mercury
New Bedford Whaling NHP	250051006	–	–	–	–
New River Gorge NR	–	JARI1	WV04	–	–
Nez Perce NHP	–	HECA1	–	–	–
Nicodemus NHS	–	CEBL1	–	–	–
North Cascades NP	–	NOCA1	WA19	NCS415	–
Ocmulgee NM	130210012	–	–	–	–
Olympic NP	530090013	OLYM1	WA14	OLY421	WA03
Organ Pipe Cactus NM	–	ORPI1	AZ06	–	–
Ozark NSRs	–	MING1	–	–	–
Palo Alto Battlefield NHP	480610006	–	–	–	–
Pea Ridge NMP	–	HEGL1	–	–	–
Pecos NHP	–	BAND1	–	–	–
Pennsylvania Avenue NHS	110010043	WASH1	–	–	–
Petersburg NB	510360002	–	–	–	–
Petrified Forest NP	040170119	PEFO1	AZ97	PET427	–
Petroglyph NM	350010027	BOAP1	–	–	–
Pictured Rocks NL	–	SENE1	–	–	–
Pinnacles NP	060690003	PINN1	CA66	PIN414	–
Pipestone NM	–	BLMO1	–	–	–
Piscataway Park	510590030	WASH1	–	–	MD99
Point Reyes NS	–	PORE1	–	–	–
President's Park (White House)	110010043	WASH1	–	–	–
Prince William Forest Park	511790001	–	–	–	–
Pullman NM	170310032	–	–	–	–
Redwood NSP	–	REDW1	–	–	CA20
Richmond NBP	510870014	WASH1	–	–	–
Rock Creek Park	110010043	WASH1	–	–	–
Rocky Mountain NP	080690007	ROMO1	CO98	ROM406	–
Roger Williams N MEM	440071010	–	–	–	–
Rosie the Riveter WWII Home Front NHP	060131004	–	–	–	–
Ross Lake NRA	–	NOCA1	WA19	–	–
Saguaro NP	040190021	SAGU1	–	–	–
Saint Croix NSR	–	–	WI37	–	–
Saint Paul's Church NHS	360050133	–	–	–	NY06
Salem Maritime NHS	250092006	–	–	–	–
Salinas Pueblo Missions NM	–	WHIT1	–	–	–
Salt River Bay NHP & Ecological PRES	–	VIIS1	–	–	–
San Francisco Maritime NHP	060750005	–	–	–	–

Park Name	Ozone	Visibility	Wet Nitrogen & Sulfur	Dry Nitrogen & Sulfur	Mercury
Santa Monica Mountains NRA	060370113	–	–	–	–
San Juan NHS	720330008			–	
Saratoga NHP	360910004	–	–	–	–
Saugus Iron Works NHS	250092006	–	–	–	–
Scotts Bluff NM	–	CRES1	–	–	–
Sequoia & Kings Canyon NPs	061070009	SEQU1	CA75	SEK430	CA75
Shenandoah NP	511130003	SHEN1	VA28	SHN418	VA28
Sleeping Bear Dunes NL	260190003	SENE1	–	–	MI29
Springfield Armory NHS	250130008	–	–	–	–
Statue Of Liberty NM	340170006	–	–	–	–
Steamtown NHS	420692006	–	–	–	–
Sunset Crater Volcano NM	–	SYCA1	–	–	–
Tallgrass Prairie N PRES	–	TALL1	–	–	–
Thaddeus Kosciuszko N MEM	421010004	–	–	–	–
Theodore Roosevelt Birthplace NHS	360610135	–	–	–	–
Theodore Roosevelt Island Park	510130020	WASH1	–	–	–
Theodore Roosevelt NP	380070002	THRO1	ND00	THR422	–
Thomas Edison NHP	340130003	–	–	–	–
Timucuan Ecological & Historic PRES	120310077	–	–	–	–
Tonto NM	040070010	TONT1	–	–	–
Tule Springs Fossil Beds NM	320030075	–	–	–	–
Tumacácori NHP	–	SAGU1	–	–	–
Tupelo NB	280810005	–	–	–	–
Upper Delaware SRR	–	–	PA72	–	PA72
Valley Forge NHP	420910013	–	–	–	–
Vietnam Veterans Memorial	510130020	WASH1	–	–	–
Virgin Islands Coral Reef NM	–	–	VI01	–	–
Virgin Islands NP	–	VIIS1	VI01	VII423	–
Voyageurs NP	271370034	VOYA2	MN32	VOY413	–
Walnut Canyon NM	–	SYCA1	–	–	–
Washington Monument	110010043	–	–	–	–
Whiskeytown NRA	–	TRIN1	–	–	–
White Sands NM	–	BOAP1	–	–	–
William Howard Taft NHS	390610040	–	–	–	–
Wilson's Creek NB	–	HEGL1	–	–	–
Wind Cave NP	460330132	WICA1	SD04	WNC429	–
Wolf Trap NP for the Performing Arts	510595001	–	–	–	–
Wright Brothers N MEM	–	SWAN1	–	–	–

Park Name	Ozone	Visibility	Wet Nitrogen & Sulfur	Dry Nitrogen & Sulfur	Mercury
Wupatki NM	–	IKBA1	–	–	–
Yellowstone NP	560391011	YELL2	WY08	YEL408	WY08
Yosemite NP	060430003	YOSE1	CA99	YOS404	–
Zion NP	490530130	ZICA1	–	–	–

Appendix C: Acquisition and Calculation of Ozone Statistics

4th Highest Daily Max 8-Hour Average Ozone Concentration Calculation Methods

2015 Ozone Standard Methods Used for 2014 and Later End-Years

1. For a given ozone monitor, obtain all valid hourly ozone concentration data and calculate daily maximum 8-hour average ozone concentrations for the entire period of data collection within a calendar year using the instructions from 40 CFR Appendix U to Part 50[27] section 3 “Data Reporting and Data Handling Conventions” (a)-(d):

    a. Hourly average ozone concentrations shall be reported in parts per million (ppm) to the third decimal place, with additional digits to the right of the third decimal place truncated. Each hour shall be identified using local standard time (LST).

    b. Moving 8-hour averages shall be computed from the hourly ozone concentration data for each hour of the year and shall be stored in the first, or start, hour of the 8-hour period. An 8-hour average shall be considered valid if at least 6 of the hourly concentrations for the 8-hour period are available. In the event that only 6 or 7 hourly concentrations are available, the 8-hour average shall be computed on the basis of the hours available, using 6 or 7, respectively, as the divisor. In addition, in the event that 5 or fewer hourly concentrations are available, the 8-hour average shall be considered valid if, after substituting zero for the missing hourly concentrations, the resulting 8-hour average is greater than the level of the National Ambient Air Quality Standard (NAAQS), or equivalently, if the sum of the available hourly concentrations is greater than 0.567 ppm. The 8-hour averages shall be reported to three decimal places, with additional digits to the right of the third decimal place truncated. Hourly ozone concentrations that have been approved under § 50.14 as having been affected by exceptional events shall be counted as missing or unavailable in the calculation of 8-hour averages.

    c. The daily maximum 8-hour average ozone concentration for a given day is the highest of the 17 consecutive 8-hour averages beginning with the 8-hour period from 7:00 a.m. to 3:00 p.m. and ending with the 8-hour period from 11:00 p.m. to 7:00 a.m. the following day (i.e., the 8-hour averages for 7:00 a.m. to 11:00 p.m.). Daily maximum 8- hour average ozone concentrations shall be determined for each day with ambient ozone monitoring data, including days outside the ozone monitoring season if those data are available.

    d. A daily maximum 8-hour average ozone concentration shall be considered valid if valid 8-hour averages are available for at least 13 of the 17 consecutive 8-hour periods starting from 7:00 a.m. to 11:00 p.m. In addition, in the event that fewer than 13 valid 8-hour averages are available, a daily maximum 8-hour average ozone

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[27] Available at https://www.ecfr.gov/cgi-bin/text-idx?SID=97ce708ece8e53188d6bf48fe4ad9f36&mc=true&node=pt40.2.50&rgn=div5#ap40.2.50_119.u

> concentration shall also be considered valid if it is greater than the level of the NAAQS. Hourly ozone concentrations that have been approved under § 50.14 as having been affected by exceptional events shall be included when determining whether these criteria have been met.

2. For annual values: Report the fourth highest maximum 8-hour average ozone concentration for each year. Annual 4th highest daily maximum 8-hour average ozone concentrations must meet minimum data completeness requirements in order to be considered valid. This requirement is met if valid daily maximum 8-hour average ozone concentrations are available for at least 75% of the days within the ozone monitoring season[28] in any one calendar year. Note that all available monitoring data from a site are used to calculate daily maximum 8-hour average ozone concentrations. Ozone monitoring seasons are only used to evaluate annual completeness criteria. Also, note that if a monitoring site has multiple co-located instruments (i.e. an AQS ID with multiple Parameter Occurrence Codes [POCs]), use 4th highest daily maximum 8-hour average ozone concentration from the POC that has the highest annual completeness criteria for that year. Report annual concentration values in parts per billion (ppb).
3. For a 5-year average: Average annual values from each of the 5 calendar years. End year of the 5-year averaging period is the reporting year. Three of the five annual values must be valid in order to calculate the 5-year average. Round the 5-year average to the nearest tenth decimal (e.g. 68.343 to 68.3 or 60.362 to 60.4).

2008 Ozone Standard Methods Used for 2009–2013 End-Years

1. For a given ozone monitor, obtain all valid hourly ozone concentration data and calculate daily maximum 8-hour average ozone concentrations for the entire period of data collection within a calendar year using the instructions from 40 CFR Appendix P to Part 50[29] section 2.1 "Data Reporting and Handling Conventions":

> *Computing 8-hour averages.* Hourly average concentrations shall be reported in parts per million (ppm) to the third decimal place, with additional digits to the right of the third decimal place truncated. Running 8-hour averages shall be computed from the hourly ozone concentration data for each hour of the year and shall be stored in the first, or start, hour of the 8-hour period. An 8-hour average shall be considered valid if at least 75% of the hourly averages for the 8-hour period are available. In the event that only 6 or 7 hourly averages are available, the 8-hour average shall be computed on the basis of the hours available using 6 or 7 as the divisor. 8-hour periods with

[28] Ozone monitoring seasons are retrieved from the EPA (https://aqs.epa.gov/aqsweb/documents/codetables/ozone_seasons.html). Note that the 2008 ozone seasons will not be valid for the 2015 ozone standard. Some ozone monitors have received ozone season waivers and are not found in the online table noted above. See section "Monitors with Ozone Monitoring Season Waivers" in Appendix C for list of ozone monitors with ozone season waivers.

[29] Available at https://www.gpo.gov/fdsys/pkg/CFR-2011-title40-vol2/xml/CFR-2011-title40-vol2-part50-appP.xml

three or more missing hours shall be considered valid also, if, after substituting one-half the minimum detectable limit for the missing hourly concentrations, the 8-hour average concentration is greater than the level of the standard. The computed 8-hour average ozone concentrations shall be reported to three decimal places (the digits to the right of the third decimal place are truncated, consistent with the data handling procedures for the reported data).

Daily maximum 8-hour average concentrations. (a) There are 24 possible running 8-hour average ozone concentrations for each calendar day during the ozone monitoring season. The daily maximum 8-hour concentration for a given calendar day is the highest of the 24 possible 8-hour average concentrations computed for that day. This process is repeated, yielding a daily maximum 8-hour average ozone concentration for each calendar day with ambient ozone monitoring data. Because the 8-hour averages are recorded in the start hour, the daily maximum 8-hour concentrations from two consecutive days may have some hourly concentrations in common. Generally, overlapping daily maximum 8-hour averages are not likely, except in those non-urban monitoring locations with less pronounced diurnal variation in hourly concentrations.

(b) An ozone monitoring day shall be counted as a valid day if valid 8-hour averages are available for at least 75% of possible hours in the day (i.e., at least 18 of the 24 averages). In the event that less than 75% of the 8-hour averages are available, a day shall also be counted as a valid day if the daily maximum 8-hour average concentration for that day is greater than the level of the standard.

2. For annual values: Report the fourth highest maximum 8-hour average ozone concentration for each year. Annual 4th highest daily maximum 8-hour average ozone concentrations must meet minimum data completeness requirements in order to be considered valid. This requirement is met if valid daily maximum 8-hour average ozone concentrations are available for at least 75% of the days within the ozone monitoring season[30] in any one calendar year. Note that all available monitoring data from a site are used to calculate daily maximum 8-hour average ozone concentrations. Ozone monitoring seasons are only used to evaluate annual completeness criteria.
3. For a 5-year average: Average annual values from each of the 5 calendar years. End year of the 5-year averaging period is the reporting year. Three of the five annual values must be valid in order to calculate the 5-year average. Round the 5-year average to the nearest tenth decimal (e.g. 68.343 to 68.3 or 60.362 to 60.4).

[30] Ozone monitoring seasons are retrieved from the EPA (https://aqs.epa.gov/aqsweb/documents/codetables/ozone_seasons.html). Note that the 2008 ozone seasons will not be valid for the 2015 ozone standard. Some ozone monitors have received ozone season waivers and are not found in the online table noted above. See section "Monitors with Ozone Monitoring Season Waivers" in Appendix C for list of ozone monitors with ozone season waivers.

W126 Calculation Methods

The W126 metric evaluates risk to vegetation health based on exposure. The W126 metric equation uses a sigmoidal function to preferentially weight the higher ozone concentrations that are more likely to cause plant damage. It sums all of the weighted concentrations during daylight hours as this is when the majority of gas exchange occurs between plants and the atmosphere.

Methods for 2014 and Later End-Years

The following steps outline the methodology used to calculate the W126 index for 2014 and later status and trend assessments.

1. For a given ozone monitor, obtain the 12 hourly ozone concentrations (ppm) for the daytime hours spanning from 8 a.m. to 8 p.m. It should be noted that the hourly data are timestamped with the beginning hour; therefore, the hourly data used are actually the 12 hours labeled 8 a.m. to 7 p.m. Retain all decimal digits through the last step.
2. Transform hourly concentration values to weighted concentration values using the following formula, where ozone is the hourly ozone concentration in ppm:

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

3. Sum the 12 hourly weighted concentration values for each day to derive the Daily Index (D.I.) value reported in ppm-hr.

$$D = .\sum_{i=8a}^{7p} W126$$

4. Sum all of the D.I. values for each month to derive monthly values (ppm-hrs). This is the monthly index (M.I) value:

$$M.I. = \sum_{j=1}^{n} D.I.$$

Where:
n = the number of days in the calendar month

5. Determine whether the M.I. values meet the monthly percent completeness criterion by adding the number of hourly values (8am to 8pm) in the month and dividing that sum by the number of possible reporting hours (8am to 8pm) for the month. Multiply by 100. If the result is 50 or greater, then the completeness criterion is met. If the result is less than 50, then the month should be excluded.

6. M.I. values with 50 to 100% completeness are adjusted for missing data. Multiply the number of days in the calendar month by 12 and divide by the number of reported hourly values (8am to 8pm) in the month. Multiply the result from step 4 by this ratio. (Note: If the data are 100% complete, the ratio is 1.)

$$M.I._{adjusted} = M.I. * (n*12)/v$$

Where:
n = the number of days in the calendar month
v=the number of possible reporting hours (8am to 7pm) for the month

7. Sum the M.I. values for every consecutive 3-month period.

8. Determine whether the 3-month period meets the 75 percent completeness criterion by adding the number of hourly values (8am to 8pm) in the 3 month period and dividing that sum by the number of possible reporting hours (8am to 8pm) for the 3 months. Multiply by 100. If the result is 75 or greater, then the completeness criterion is met. If the result is less than 75, then the 3 month period should be excluded.

9. Determine whether the season meets the 75 percent completeness criterion by adding the number of hourly values (8am to 8pm) in the March to September growing season and dividing that sum by the number of possible reporting hours (8am to 8pm) for the growing season. Multiply by 100. If the result is 60 or greater, then the completeness criterion is met. If the result is less than 60, then the year should be excluded from calculations, i.e. stop at this step.

10. For each calendar year, report the highest 3-month sum from March to September. Retain all decimal digits. Also, note that if a monitoring site has multiple co-located instruments (i.e. an AQS ID with multiple Parameter Occurrence Codes [POCs]), use 3-month max from the POC that has the highest annual completeness criteria for that year.

11. For annual W126 index values: Round the reported 3-month max for each calendar year to the nearest tenth decimal (e.g. 10.343 to 10.3 or 10.362 to 10.4). Note that all decimal digits are retained until this step. Report annual W126 index values in parts per million-hours (ppm-hrs).

12. For a 5-year average: Average non-rounded 3-month maximum values from each of the 5 calendar years (i.e. do not use rounded annual year values from step 11 to derive this 5-year average). End year of the 5-year averaging period is the reporting year. Three of the five annual values must be valid in order to calculate the 5-year average.

Methods for 2009 to 2013 End-Years

The following steps outline the methodology used to calculate the W126 index for 2009–2013 status and trend assessments.

1. For a given ozone monitor, obtain 12 hour concentrations (ppm) from 8 a.m. to 8 p.m. Note that the hourly data are timestamped with the beginning hour. Therefore, the hourly data used are actually the 12 hours labeled 8 a.m. to 7 p.m.
2. Convert hourly data in ppb to ppm and truncate all to 3 decimals.
3. Transform hourly concentration values to weighted concentration values using the following formula, where ozone is the hourly ozone concentration in ppm:

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

4. Sum the 12 hourly weighted concentration values for each day to derive the Daily Index (D.I.) value reported in ppm-hr.

$$D \quad = \sum_{i=8a}^{7p} W126$$

5. Sum all of the D.I. values for each month to derive monthly values (ppm-hrs). This is the monthly index (M.I) value:

$$M.I. = \sum_{j=1}^{n} D.I.$$

Where:
n = the number of days in the calendar month

6. Determine whether the M.I. values meet the 75 percent completeness criterion by adding the number of hourly values (8am to 7pm) in the month and dividing that sum by the number of possible reporting hours (8am to 7pm) for the month. Multiply by 100. If the result is 75 or greater, then the completeness criterion is met. If the result is less than 75, then the month should be excluded.
7. M.I. values with 75 to 100% completeness are adjusted for missing data. Multiply the number of days in the calendar month by 12 and divide by the number of reported hourly values (8am to 8pm) in the month. Multiply the result from step 4 by this ratio. (Note: If the data are 100% complete, the ratio is 1.)

$$M.I._{adjusted} = M.I. * (n*12)/v$$

Where:
n = the number of days in the calendar month
v=the number of possible reporting hours
(8am to 7pm) for the month

8. Truncate monthly index to 3 decimals.

9. Sum the M.I. values for every consecutive 3-month period.

10. For annual W126 index values: Report the highest 3-month sum for each calendar year. Truncate the reported 3-month max for each calendar year to the nearest tenth decimal (e.g. 10.343 to 10.3).

11. For a 5-year average: Average truncated 3-month maximum values from each of the 5 calendar years. End year of the 5-year averaging period is the reporting year. Three of the five annual values must be present in order to calculate the 5-year average.

Monitors with Ozone Monitoring Season Waivers

Although all available monitoring data are used to calculate annual ozone statistics, ozone monitoring seasons are used to determine if the data meet completeness criteria. States can petition the EPA's regional office to waive ozone monitoring season requirements for specific monitors. Below is a list of all ozone monitors that have received ozone season waivers under the 2008 ozone standard monitoring season requirements. All of the waivers are in EPA Region 9: Arizona, California, and Nevada. The last two columns indicate the year the waiver first took effect and the year the waiver ended for each monitor (2016 for all current waivers). These waivers will not apply to the 2015 ozone standard monitoring season requirements that take effect in 2017. States with existing waivers will need to pursue new waivers through the EPA.

Table B. Ozone monitors with ozone monitoring season waivers. Data source: B. Wells, EPA (e-mail communication, October 26, 2016).

Site ID	Begin day	End day	Begin year	End year
040051008	1-Mar	31-Oct	2008	2014
040070010	1-Mar	31-Oct	2002	2014
040079993	1-Apr	31-Oct	1998	2016
040128000	1-Apr	31-Oct	2012	2014
040131003	1-Apr	31-Oct	2003	2016
040131010	1-Apr	31-Oct	2000	2016
040132001	1-Apr	31-Oct	2000	2016
040133004	1-Apr	31-Oct	2000	2016
040133006	1-Apr	31-Oct	2000	2016
040133009	1-Apr	31-Oct	2000	2016
040134004	1-Apr	31-Oct	2000	2016
040134005	1-Apr	31-Oct	2002	2016
040134007	1-Apr	31-Oct	2002	2016
040134008	1-Apr	31-Oct	2001	2016
040134010	1-Apr	31-Oct	2003	2016
040134011	1-Apr	31-Oct	2004	2016
040137003	1-Apr	31-Oct	2003	2015
040137022	1-Apr	31-Oct	2005	2015
040137024	1-Apr	31-Oct	2006	2015
040139508	1-Apr	31-Oct	2000	2016
040139701	1-Apr	31-Oct	2000	2016
040139706	1-Apr	31-Oct	1999	2016
040139805	1-Apr	31-Oct	2000	2016
040139993	1-Apr	31-Oct	1998	2016
040213007	1-Apr	31-Oct	2002	2016
040213009	1-Apr	31-Oct	2002	2016
040213010	1-Apr	31-Oct	2002	2016

Site ID	Begin day	End day	Begin year	End year
040217001	1-Apr	31-Oct	2002	2015
040217030	1-Apr	31-Oct	2012	2016
040218001	1-Mar	31-Oct	2001	2014
040250005	1-Apr	31-Oct	2002	2016
040258033	1-Mar	31-Oct	2008	2014
040270005	1-Apr	31-Oct	1997	2016
040270006	1-Apr	31-Oct	2003	2016
040278011	1-Mar	31-Oct	2008	2014
060010005	1-Apr	30-Nov	2001	2016
060010006	1-Apr	30-Nov	1998	2016
060012001	1-Apr	30-Nov	1998	2016
060132007	1-Apr	30-Nov	2012	2016
060170012	1-May	31-Oct	2000	2016
060675003	1-Apr	31-Oct	1997	2016
060770009	1-May	31-Oct	2001	2016
060850002	1-Apr	30-Nov	1998	2016
060851001	1-Apr	30-Nov	2013	2016
060851002	1-Apr	30-Nov	1998	2016
060852005	1-Apr	30-Nov	1998	2016
060852006	1-Apr	30-Nov	1998	2016
060852007	1-Apr	30-Nov	2001	2016
060950002	1-Apr	30-Nov	1998	2016
060950005	1-Apr	30-Nov	2002	2016
061090006	1-May	31-Oct	1998	2016
320010002	1-Apr	31-Oct	2005	2015
320190006	1-Apr	31-Oct	2005	2015
325100002	1-Apr	31-Oct	2005	2016
325100004	1-Apr	31-Oct	2002	2016
325100006	1-Apr	31-Oct	2013	2016
325100020	1-Apr	31-Oct	2013	2015

Appendix D: Parks in EPA Designated Nonattainment Areas

For end-years 2009–2013, the human health ozone status was adjusted based on nonattainment designation. If an NPS unit was located within an area designated by the EPA as nonattainment for the ground-level ozone standard the ozone condition was adjusted to the *Warrants Significant Concern* status. For end-years 2009–2013, the overall air quality condition status was also adjusted to the *Warrants Significant Concern* status when an NPS unit fell within an EPA designated nonattainment area for either the 2008 ground-level ozone, fine ($PM_{2.5}$) particulate matter, or coarse (PM_{10}) particulate matter standards.

Table C. NPS units in EPA designated nonattainment areas for ozone and particulate matter standards as of 2017. Note: Great Smoky Mountains NP was previously in nonattainment for the 2008 ozone primary health standard but was re-designated as attainment in 2015. As a result, the ozone condition was adjusted to *Warrants Significant Concern* status in 2013.

Park Name	2008 Ozone 8-hour Average	2012 $PM_{2.5}$ Annual Average	2006 $PM_{2.5}$ 24-hour Average	1987 PM_{10} 24-hour Average
African Burial Ground NM	X			X
Antietam NB	X			
Appalachian NST	X	X	X	
Arlington House, The Robert E. Lee Memorial N MEM	X			
Big Thicket N PRES	X			
Cabrillo NM	X			
Carter G. Woodson Home NHS	X			
Casa Grande Ruins NM				X
Castle Clinton NM	X			X
Castle Mountains NM				X
Catoctin Mountain Park	X			
César E. Chávez NM	X			X
Chamizal N MEM				X
Channel Islands NP	X			
Chattahoochee River NRA	X			
Chesapeake & Ohio Canal NHP	X			
Clara Barton NHS	X			
Constitution Gardens	X			
Cuyahoga Valley NP	X	X		
Death Valley NP				X
Delaware Water Gap NRA	X			
Devils Postpile NM	X	X	X	
Edgar Allan Poe NHS	X			
Eugene O'Neill NHS	X		X	
Federal Hall N MEM	X			X

Park Name	2008 Ozone 8-hour Average	2012 $PM_{2.5}$ Annual Average	2006 $PM_{2.5}$ 24-hour Average	1987 PM_{10} 24-hour Average
Fire Island NS	X			
First State NHP	X	X		
Ford's Theatre NHS	X			
Fort McHenry NM & Historic Shrine	X			
Fort Necessity NB	X			
Fort Point NHS	X		X	
Fort Washington Park	X			
Franklin Delano Roosevelt Memorial	X			
Frederick Douglass NHS	X			
Friendship Hill NHS	X			
Gateway NRA	X			
General Grant N MEM	X			X
George Washington Memorial PKWY	X			
Golden Gate NRA	X		X	
Governors Island NM	X			X
Great Smoky Mountains NP			X	
Greenbelt Park	X			
Hamilton Grange N MEM	X			X
Hampton NHS	X			
Harpers Ferry NHP	X			
Hopewell Furnace NHS	X			
Independence NHP	X			
Indiana Dunes NL	X			
James A Garfield NHS	X			
Jefferson National Expansion Memorial	X			
John Muir NHS	X		X	
Joshua Tree NP	X			X
Kennesaw Mountain NBP	X			
Korean War Veterans Memorial	X			
Lincoln Memorial	X			
Lyndon Baines Johnson Memorial Grove N MEM	X			
Manassas NBP	X			
Manhattan Project NHP			X	
Manzanar NHS				X
Martin Luther King Jr NHS	X			
Martin Luther King, Jr. Memorial	X			
Mary McLeod Bethune Council House NHS	X			
Mojave N PRES	X			X

Park Name	2008 Ozone 8-hour Average	2012 $PM_{2.5}$ Annual Average	2006 $PM_{2.5}$ 24-hour Average	1987 PM_{10} 24-hour Average
Monocacy NB	X			
Morristown NHP	X			
Muir Woods NM	X		X	
National Mall	X			
National Mall & Memorial Parks	X			
Paterson Great Falls NHP	X			
Pennsylvania Avenue NHS	X			
Piscataway Park	X			
Point Reyes NS	X		X	
Port Chicago Naval Magazine N MEM	X		X	
President's Park (White House)	X			
Presidio of San Francisco			X	
Prince William Forest Park	X			
Rock Creek Park	X			
Rocky Mountain NP	X			
Rosie the Riveter WWII Home Front NHP	X		X	
Sagamore Hill NHS	X			
Saguaro NP				X
Saint Paul's Church NHS	X			
San Francisco Maritime NHP	X		X	
Santa Monica Mountains NRA	X	X	X	
Sequoia & Kings Canyon NPs	X	X	X	X
Statue Of Liberty NM	X			X
Thaddeus Kosciuszko N MEM	X			
Theodore Roosevelt Birthplace NHS	X			X
Theodore Roosevelt Island Park	X			
Thomas Edison NHP	X			
Thomas Stone NHS	X			
Timpanogos Cave NM			X	X
Tumacácori NHP			X	X
Ulysses S Grant NHS	X			
Valley Forge NHP	X			
Vietnam Veterans Memorial	X			
Washington Monument	X			
Weir Farm NHS	X			
William Howard Taft NHS	X			
Wolf Trap NP for the Performing Arts	X			
Yosemite NP	X	X	X	X

Appendix E: Natural Visibility Conditions

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).

Natural visibility conditions for NPS Class I areas and parks outside the contiguous US are the estimated natural conditions on mid-range days (Group 50) from representative IMPROVE monitoring sites calculated based on methods in the in the *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule* (EPA 2003). The IDW estimation method was used to interpolate natural conditions for all other parks. The estimated natural condition on mid-range days for individual parks in the contiguous US, is the average value within park boundaries derived from this national analysis.

Table D. Estimated natural visibility conditions for NPS units.

Park Name	Estimated Natural Visibility Condition on Mid-range Days (deciviews)
Abraham Lincoln Birthplace NHP	7.5
Acadia NP	7.2
Adams NHP	7.7
African Burial Ground NM	8.4
Agate Fossil Beds NM	3.6
Alibates Flint Quarries NM	4.2
Allegheny Portage Railroad NHS	7.4
Amistad NRA	3.8
Andersonville NHS	7.5
Andrew Johnson NHS	7.2
Antietam NB	7.4
Appomattox Court House NHP	7.3
Apostle Islands NL	6.9
Arches NP	3.0
Arlington House, The Robert E. Lee N MEM	7.9
Arkansas Post N MEM	7.4
Assateague Island NS	7.6
Aztec Ruins NM	2.8
Badlands NP	4.7
Bandelier NM	3.0
Bent's Old Fort NHS	3.0
Big Bend NP	3.7
Bighorn Canyon NRA	3.1
Big Cypress N PRES	7.2
Big Hole NB	3.3

Park Name	Estimated Natural Visibility Condition on Mid-range Days (deciviews)
Biscayne NP	7.1
Big South Fork NRRA	7.4
Big Thicket N PRES	7.0
Black Canyon Of The Gunnison NP	2.9
Blue Ridge PKWY	7.2
Bluestone NSR	7.2
Boston African American NHS	7.6
Boston Harbor Islands NRA	7.7
Boston NHP	7.6
Booker T Washington NM	7.3
Bryce Canyon NP	2.8
Brices Cross Roads NBS	7.5
Brown V Board Of Education NHS	7.1
Buffalo NR	7.2
Cabrillo NM	4.6
Canyon De Chelly NM	3.0
Castle Clinton NM	8.4
Castle Mountains NM	3.8
Cape Cod NS	8.6
Casa Grande Ruins NM	4.2
Cape Hatteras NS	7.7
Cape Lookout NS	7.6
Canaveral NS	7.6
Canyonlands NP	3.0
Capitol Reef NP	3.1
Cane River Creole NHP	7.4
Carl Sandburg Home NHS	6.6
Castillo De San Marcos NM	7.7
Catoctin Mountain Park	7.4
Carlsbad Caverns NP	3.1
Capulin Volcano NM	2.7
Carter G. Woodson Home NHS	7.9
Cedar Creek & Belle Grove NHP	7.0
Cedar Breaks NM	3.3
César E. Chávez NM	4.2
Chamizal N MEM	3.3
Chattahoochee River NRA	7.4
Chickamauga & Chattanooga NMP	7.4
Chaco Culture NHP	2.7

Park Name	Estimated Natural Visibility Condition on Mid-range Days (deciviews)
Chickasaw NRA	6.1
Chiricahua NM	3.5
Channel Islands NP	4.5
Chesapeake & Ohio Canal NHP	7.4
Charles Pinckney NHS	8.3
Christiansted NHS	6.7
Little Rock Central High School NHS	7.2
Charles Young Buffalo Soldiers NM	7.4
City Of Rocks N RES	3.4
Clara Barton NHS	7.9
Constitution Gardens	7.9
Colorado NM	2.7
Colonial NHP	7.5
Congaree NP	7.7
Coronado N MEM	3.9
Cowpens NB	7.1
Crater Lake NP	2.7
Craters Of The Moon NM & PRES	3.8
Cumberland Gap NHP	7.3
Cumberland Island NS	7.7
Curecanti NRA	2.5
Cuyahoga Valley NP	7.5
Dayton Aviation Heritage NHP	7.4
Denali NP & PRES	3.2
Devils Postpile NM	3.5
De Soto N MEM	7.6
Devils Tower NM	3.9
Death Valley NP	4.2
Delaware Water Gap NRA	7.6
Dinosaur NM	2.5
Dry Tortugas NP	7.3
Ebey's Landing NH RES	5.2
Edgar Allan Poe NHS	7.8
Thomas Edison NHP	8.3
Effigy Mounds NM	7.1
Eisenhower NHS	7.4
El Malpais NM	3.0
El Morro NM	3.0
Eleanor Roosevelt NHS	6.9

Park Name	Estimated Natural Visibility Condition on Mid-range Days (deciviews)
Eugene O'Neill NHS	6.6
Everglades NP	7.1
Federal Hall N MEM	8.4
Fire Island NS	7.8
First Ladies NHS	7.5
Florissant Fossil Beds NM	2.5
Flight 93 N MEM	7.4
Fort Bowie NHS	3.5
Fossil Butte NM	2.7
Fort Caroline N MEM	7.7
Fort Davis NHS	3.4
Fort Donelson NB	7.5
Fort Frederica NM	7.7
Fort Laramie NHS	3.2
Fort Larned NHS	5.4
Fort Matanzas NM	7.7
Fort McHenry NM & Historic Shrine	7.6
Fort Monroe NM	7.5
Fort Necessity NB	7.3
Fort Point NHS	8.2
Fort Pulaski NM	7.8
Fort Raleigh NHS	7.6
Fort Scott NHS	7.2
Fort Smith NHS	7.1
Fort Stanwix NM	6.9
Fort Sumter NM	8.3
Ford's Theatre NHS	7.9
Fort Union NM	2.6
Fort Union Trading Post NHS	4.6
Fort Vancouver NHS	5.6
Fort Washington Park	7.8
Franklin Delano Roosevelt Memorial	7.9
Frederick Douglass NHS	7.9
Friendship Hill NHS	7.2
Frederick Law Olmsted NHS	7.6
Fredericksburg & Spotsylvania NMP	7.1
First State NHP	7.7
Gates Of The Arctic NP & PRES	4.1
Gauley River NRA	7.2

Park Name	Estimated Natural Visibility Condition on Mid-range Days (deciviews)
Gateway NRA	8.3
General Grant N MEM	8.4
George Rogers Clark NHP	7.5
Gettysburg NMP	7.4
George Washington Birthplace NM	7.5
Gila Cliff Dwellings NM	2.6
Glacier NP	4.5
Glen Canyon NRA	3.1
Golden Gate NRA	8.2
Governors Island NM	8.4
Golden Spike NHS	3.2
Great Basin NP	2.9
Grand Canyon NP	2.9
Grand Canyon-Parashant NM	3.6
Greenbelt Park	7.8
Grant-Kohrs Ranch NHS	3.2
Grand Portage NM	6.8
Great Sand Dunes NP & PRES	3.0
Great Smoky Mountains NP	7.5
Great Smoky Mountains NP	7.5
Grand Teton NP	2.5
Guilford Courthouse NMP	7.3
Gulf Islands NS	7.5
Guadalupe Mountains NP	3.1
George Washington Carver NM	7.2
George Washington Memorial PKWY	7.8
Harpers Ferry NHP	7.4
Hagerman Fossil Beds NM	3.5
Hamilton Grange N MEM	8.4
Haleakala NP	1.8
Hampton NHS	7.6
Hawaii Volcanoes NP	4.5
Herbert Hoover NHS	7.5
Horseshoe Bend NMP	7.6
Hopewell Culture NHP	7.4
Home Of Franklin D Roosevelt NHS	6.9
Hopewell Furnace NHS	7.6
Homestead NM of America	7.0
Hot Springs NP	7.2

Park Name	Estimated Natural Visibility Condition on Mid-range Days (deciviews)
Hovenweep NM	2.9
Harry S Truman NHS	7.2
Hubbell Trading Post NHS	3.0
Independence NHP	7.8
Indiana Dunes NL	7.4
Isle Royale NP	6.6
James A Garfield NHS	7.5
Jewel Cave NM	3.7
Jefferson National Expansion Memorial	7.5
Jean Lafitte NHP & PRES	7.5
Jimmy Carter NHS	7.5
John Day Fossil Beds NM	4.6
John D Rockefeller Jr Memorial PKWY	2.7
John F Kennedy NHS	7.5
Johnstown Flood N MEM	7.4
John Muir NHS	7.2
Joshua Tree NP	4.0
Katmai NP & PRES	5.5
Kenai Fjords NP	5.5
Kennesaw Mountain NBP	7.4
Keweenaw NHP	6.7
Kings Mountain NMP	7.2
Klondike Gold Rush NHP	5.1
Knife River Indian Villages NHS	4.6
Korean War Veterans Memorial	7.9
Lava Beds NM	3.8
Lake Chelan NRA	4.1
Lake Clark NP & PRES	5.5
Lake Mead NRA	3.7
Lake Meredith NRA	4.2
Lake Roosevelt NRA	4.8
Lassen Volcanic NP	3.5
Lewis and Clark NHP	5.0
Little Bighorn Battlefield NM	3.4
Lincoln Boyhood N MEM	7.5
Lincoln Home NHS	7.5
Lincoln Memorial	7.9
Little River Canyon N PRES	7.5
Longfellow NHS	7.5

Park Name	Estimated Natural Visibility Condition on Mid-range Days (deciviews)
Lowell NHP	7.2
Lyndon Baines Johnson Memorial Grove N MEM	7.9
Lyndon B Johnson NHP	5.1
Manhattan Project NHP	7.4
Marsh - Billings - Rockefeller NHP	6.5
Mammoth Cave NP	7.5
Martin Luther King Jr NHS	7.4
Mary McLeod Bethune Council House NHS	7.9
Manassas NBP	7.6
Manzanar NHS	4.3
Martin Van Buren NHS	6.7
Maggie L Walker NHS	7.3
Mesa Verde NP	2.8
Minidoka NHS	3.5
Minute Man NHP	7.3
Minuteman Missile NHS	4.7
Mississippi NRRA	7.0
Martin Luther King, Jr. Memorial	7.9
Missouri NRR	6.5
Montezuma Castle NM	3.6
Moores Creek NB	7.6
Mojave N PRES	4.0
Monocacy NB	7.5
Mount Rainier NP	5.3
Morristown NHP	8.1
Mount Rushmore N MEM	3.8
Muir Woods NM	8.8
Natural Bridges NM	3.0
National Mall & Memorial Parks	7.9
National Mall	7.9
Natchez NHP	7.4
Natchez Trace PKWY	7.5
Navajo NM	3.2
New Bedford Whaling NHP	8.5
Nez Perce NHP	4.1
New River Gorge NR	7.2
Nicodemus NHS	5.2
Niobrara NSR	5.0
Ninety Six NHS	7.3

Park Name	Estimated Natural Visibility Condition on Mid-range Days (deciviews)
North Cascades NP	4.1
National World War II Memorial	7.9
Obed WSR	7.4
Ocmulgee NM	7.5
Olympic NP	5.1
Oregon Caves NM & PRES	5.6
Organ Pipe Cactus NM	4.5
Ozark NSRs	7.4
Palo Alto Battlefield NHP	5.2
Pennsylvania Avenue NHS	7.9
Padre Island NS	5.2
Paterson Great Falls NHP	8.3
Pecos NHP	2.8
Petrified Forest NP	2.9
Pea Ridge NMP	7.2
Petersburg NB	7.4
Petroglyph NM	2.8
Perry's Victory & International Peace Memorial	7.4
Hohokam Pima NM	4.3
Pinnacles NP	5.4
Pipestone NM	7.1
Pictured Rocks NL	6.6
Piscataway Park	7.8
Pipe Spring NM	3.5
Port Chicago Naval Magazine N MEM	6.8
Poverty Point NM	7.5
Point Reyes NS	9.7
Prince William Forest Park	7.6
Pullman NM	7.4
Rainbow Bridge NM	3.2
Redwood NSP	7.6
Richmond NBP	7.3
Rio Grande WSR	3.6
River Raisin NB	7.4
Rock Creek Park	7.9
Ross Lake NRA	4.1
Rocky Mountain NP	2.9
Rosie the Riveter WWII Home Front NHP	8.0
Roger Williams N MEM	7.8

Park Name	Estimated Natural Visibility Condition on Mid-range Days (deciviews)
Russell Cave NM	7.5
San Antonio Missions NHP	5.1
Saint Croix NSR	6.9
Saint Croix Island IHS	7.6
San Francisco Maritime NHP	8.0
Saint-Gaudens NHS	6.5
Saguaro NP	3.8
Sagamore Hill NHS	8.1
Saugus Iron Works NHS	7.5
San Juan Island NHP	5.1
Salem Maritime NHS	7.6
Santa Monica Mountains NRA	4.0
Sand Creek Massacre NHS	3.4
Saint Paul's Church NHS	8.4
Salinas Pueblo Missions NM	3.3
Saratoga NHP	6.1
Salt River Bay NHP & Ecological PRES	6.7
Scotts Bluff NM	3.6
Sequoia & Kings Canyon NPs	5.1
Shenandoah NP	6.5
Shiloh NMP	7.5
Sleeping Bear Dunes NL	6.8
Springfield Armory NHS	6.7
Steamtown NHS	7.3
Statue Of Liberty NM	8.4
Stones River NB	7.5
Sunset Crater Volcano NM	3.3
Tallgrass Prairie N PRES	6.9
Theodore Roosevelt Island Park	7.9
Thomas Jefferson Memorial	7.9
Thaddeus Kosciuszko N MEM	7.8
Theodore Roosevelt Birthplace NHS	8.4
Theodore Roosevelt Inaugural NHS	7.4
Theodore Roosevelt NP	4.7
Thomas Stone NHS	7.7
Timpanogos Cave NM	3.0
Timucuan Ecological & Historic PRES	7.7
Tonto NM	3.7
Tuskegee Airmen NHS	7.6

Park Name	Estimated Natural Visibility Condition on Mid-range Days (deciviews)
Tuskegee Institute NHS	7.6
Tumacácori NHP	3.9
Tupelo NB	7.5
Tule Springs Fossil Beds NM	3.9
Tuzigoot NM	3.4
Ulysses S Grant NHS	7.4
Upper Delaware SRR	7.3
Valley Forge NHP	7.6
Valles Caldera N PRES	2.6
World War II Valor in the Pacific NM	3.8
Vanderbilt Mansion NHS	6.9
Vicksburg NMP	7.5
Virgin Islands NP	6.7
Vietnam Veterans Memorial	7.9
Voyageurs NP	7.1
Waco Mammoth NM	6.0
Washita Battlefield NHS	5.1
Walnut Canyon NM	3.3
Washington Monument	7.9
Weir Farm NHS	7.5
President's Park (White House)	7.9
Whiskeytown NRA	3.8
Whitman Mission NHS	4.5
White Sands NM	3.2
Wind Cave NP	3.7
President William Jefferson Clinton Birthplace Home NHS	7.2
Wilson's Creek NB	7.2
William Howard Taft NHS	7.5
Women's Rights NHP	7.1
Wolf Trap NP for the Performing Arts	7.8
Wright Brothers N MEM	7.6
Wupatki NM	3.3
Yellowstone NP	2.5
Yosemite NP	3.9
Yucca House NM	2.8
Zion NP	3.8

Appendix F: Nitrogen and Sulfur Deposition Status Adjustments

Park nitrogen or sulfur status may be adjusted based on results from national assessment reports that identified ecosystems and resources at risk to acidification and excess nitrogen enrichment in national parks. These reports provide a relative risk assessment of acidification and nutrient enrichment impacts from atmospheric nitrogen and sulfur deposition for parks with identified natural resources in 32 inventory & monitoring networks.

Ecosystem sensitivity 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 ratings to nutrient enrichment effects were based on percent sensitive vegetation types and number of high-elevation lakes within the park (Sullivan et al. 2011b).

If park ecosystems are ranked *Very High* in sensitivity to acidification or nutrient enrichment effects from atmospheric deposition relative to all inventory & monitoring parks, the condition category is adjusted to the next most conservative condition category. This adjustment does not apply to parks that already have a *Warrants Significant Concern* status based on wet deposition levels.

Table E. NPS units with "very high" ecosystem sensitivity ranking for acidification or nutrient enrichment impacts.

Park Name	Acidification	Nutrient Enrichment
Acadia NP	X	
Agate Fossil Beds NM		X
Allegheny Portage Railroad NHS	X	
Antietam NB	X	
Apostle Islands NL	X	
Arches NP		X
Big Bend NP		X
Big Cypress N PRES		X
Big South Fork NRRA	X	
Blue Ridge PKWY	X	
Bluestone NSR	X	
Buffalo NR	X	
Cabrillo NM		X
Canyonlands NP		X
Carl Sandburg Home NHS	X	
Carlsbad Caverns NP	X	X
Casa Grande Ruins NM		X
Catoctin Mountain Park	X	
Chaco Culture NHP		X

Park Name	Acidification	Nutrient Enrichment
Chesapeake & Ohio Canal NHP	X	
Chickamauga & Chattanooga NMP	X	
Congaree NP		X
Coronado N MEM		X
Crater Lake NP	X	
Cumberland Gap NHP	X	
Curecanti NRA	X	X
Death Valley NP	X	X
Delaware Water Gap NRA	X	
Denali NP & PRES	X	
Dinosaur NM		X
Fort Davis NHS		X
Fort Necessity NB	X	
Fort Pulaski NM		X
Fort Union NM		X
Fossil Butte NM		X
Gates Of The Arctic NP & PRES	X	
Gauley River NRA	X	
Gila Cliff Dwellings NM		X
Glacier NP	X	
Golden Spike NHS		X
Grand Canyon NP	X	X
Grand Teton NP	X	X
Great Basin NP	X	
Great Sand Dunes NP & PRES	X	X
Great Smoky Mountains NP	X	
Guadalupe Mountains NP		X
Hagerman Fossil Beds NM		X
Haleakala NP	X	
Harpers Ferry NHP	X	
Hovenweep NM		X
John Day Fossil Beds NM		X
Johnstown Flood N MEM	X	
Joshua Tree NP		X
Katmai NP & PRES	X	
Lake Clark NP & PRES	X	
Lake Mead NRA		X
Lassen Volcanic NP	X	
Lava Beds NM		X
Little Bighorn Battlefield NM		X

Park Name	Acidification	Nutrient Enrichment
Little River Canyon N PRES	X	
Manzanar NHS		X
Marsh - Billings - Rockefeller NHP	X	
Mojave N PRES		X
Montezuma Castle NM		X
Morristown NHP	X	
Mount Rainier NP	X	X
New River Gorge NR	X	
North Cascades NP	X	X
Obed WSR	X	
Olympic NP	X	X
Organ Pipe Cactus NM		X
Pecos NHP		X
Petrified Forest NP		X
Petroglyph NM		X
Pictured Rocks NL	X	
Rocky Mountain NP	X	X
Saguaro NP		X
Saint Croix NSR	X	X
Saint-Gaudens NHS	X	
Salinas Pueblo Missions NM		X
Scotts Bluff NM		X
Sequoia & Kings Canyon NPs	X	X
Shenandoah NP	X	
Tallgrass Prairie N PRES		X
Tonto NM		X
Upper Delaware SRR	X	
Voyageurs NP	X	
Washita Battlefield NHS		X
Wind Cave NP	X	X
Yellowstone NP	X	X
Yosemite NP	X	X

Appendix G: Mercury Deposition Status Adjustments

Mercury status and confidence are adjusted based on measured mercury concentrations in park wildlife as compared with established thresholds and fish consumption guidelines. Data on biota must be credible and available in at least three biotic compartments (e.g., fish, dragonfly larvae), preferably with a sample size N≥15 per compartment and N>3 sampling sites per 1,000 miles^2).

Table F: NPS units with status and/or confidence adjustments for mercury deposition.

Park Name	Condition Status Adjustment	Confidence Adjustment
Acadia NP	moderate to significant concern	low to high
Apostle Islands NL	–	low to high
Big Bend NP	n/a to moderate concern	n/a to medium
Big Cypress N PRES	–	low to high
Cape Cod NS	–	low to high
Chickasaw NRA	n/a to moderate concern	n/a to medium
Channel Islands NP	n/a to moderate concern	n/a to medium
Congaree NP	–	low to high
Denali NP & PRES	n/a to moderate concern	–
Everglades NP	–	low to high
Gates Of The Arctic NP & PRES	good to moderate concern	low to medium
Glacier Bay NP & PRES	n/a to moderate concern	n/a to medium
Grand Portage NM	n/a to significant concern	n/a to high
Guadalupe Mountains NP	significant to moderate concern	low to medium
Isle Royale NP	–	low to high
Katmai NP & PRES	n/a to moderate concern	n/a to medium
Knife River Indian Villages NHS	–	low to medium
Lake Clark NP & PRES	n/a to moderate concern	n/a to medium
Marsh - Billings - Rockefeller NHP	n/a to moderate concern	n/a to medium
Mammoth Cave NP	–	low to high
Mesa Verde NP	n/a to moderate concern	n/a to high
Mississippi NRRA	–	low to high
Mount Rainier NP	–	low to high
Noatak N PRES	n/a to moderate concern	n/a to medium
Olympic NP	–	low to high
Pictured Rocks NL	–	low to high
Saint Croix NSR	–	low to high
Saint-Gaudens NHS	–	low to moderate
Sleeping Bear Dunes NL	significant to moderate concern	low to high
Voyageurs NP	–	low to high
Wrangell - St Elias NP & PRES	n/a to moderate concern	n/a to medium
Yellowstone NP	–	low to high

The Department of the Interior protects and manages the nation’s natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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