Catoctin Mountain Park

Top 10 Resources and Values Impacted by Air

1 Spectacular views
Scenic vistas from Chimney Rock, Hog Rock, Thurmont Vista, and the Blue Ridge Summit Overlook are key to visitor enjoyment. Poor air quality can make these vistas hazy, and land-use changes could drastically alter them.

2 Visitor experience & recreation
The park offers many outdoor activities, including hiking, rock climbing, and fishing. Ozone and particulate matter can make breathing difficult for sensitive groups, especially when they are active outdoors.

3 Trees, shrubs, & flowers
Plant health and diversity are affected by air quality. For example, ozone can damage sensitive plants including: cut-leaf coneflower and tulip poplar. Sugar maple trees are particularly sensitive to acid deposition.

4 Surface Water
Sensitive surface waters in the park are susceptible to the impacts of acid deposition. Acidification can affect the reproduction and survival of fish, amphibians, and aquatic insects.

5 Wetland vegetation
Wetlands can be sensitive to air pollution. Atmospheric nitrogen deposition, along with runoff, can potentially alter the community composition of wetland plants, at the expense of native plants.

6 Wildlife
Airborne toxics including mercury can deposit with rain and snow and accumulate in organisms. These toxins can impair reproductive and neurological systems.

7 Fishing
Mercury/toxics can build up in food webs leading to fish consumption advisories. Mercury and other toxics related fish consumption advisories exist for fish caught in Maryland waters.

8 Native species
Excess nitrogen from atmospheric deposition can cause weedy, non-native plant species to grow faster and out-compete native vegetation adapted to low nitrogen conditions.

9 Climate change adaptation
Air pollution can decrease ecosystem resilience to climate change. Reducing emissions can mitigate both climate change and poor air quality.

10 Dark night skies
Nocturnal animals and insects rely on darkness to hunt or hide. At night, pollution can make stargazing more difficult because it scatters artificial light — increasing the impact of light pollution.

The National Park Service makes a difference protecting air quality by working with an array of partners and studying air pollution impacts in parks.

Laws and Policies

Clean Air in National Parks – It's the Law!

In the Clean Air Act (CAA), Congress set a national goal "to preserve, protect, and enhance the air quality in national parks, national wilderness areas, national monuments, national seashores, and other areas of special national or regional natural, recreational, scenic or historic value" (42 U.S.C. §7470(2)). This goal applies to all units of the National Park System.

The act includes special provisions for 48 park units, called "Class I" areas under the CAA, all other NPS areas are designated as Class II, including Catoctin Mountain Park. While the most stringent protections are provided to Class I areas, the legislation also aims to limit the level of additional pollution allowed in Class II areas, and potential impacts to these areas are to be considered.

Air quality may be important for many Class II parks, such as Catoctin Mountain Park, that contain air quality-sensitive natural resources, or where maintenance of air quality standards is important for protecting visitor and employee health. Additional authority to consider and protect air quality related values (AQRVs) in Class II parks is provided by the NPS Organic Act and the Wilderness Act.

Cooperative Conservation—Key to Park Protection

The NPS has successfully influenced initiatives aimed at reducing air pollution from sources that threaten park resources. However, success requires active NPS participation, and the agency engages in extensive consultation with air regulatory agencies, stakeholders and other federal land managers to address air resource issues. The time and energy the NPS invests toward this end is not trivial and can be supported by including air and scenic resource protection in internal agency planning documents.

Parks are encouraged to consider NPS responsibilities to protect air quality, air quality related values (AQRVs), and scenic views when discussing park significance and identifying fundamental and important resources. The emphasis that a park places on air resources can influence the NPS's ability to effectively engage in external decision making.

Air Quality Benchmark Conditions and Current Trends

The 2006 NPS Management Policies clarify that the Service will seek to "perpetuate the best possible air quality in parks" (Section 4.7.1). This means establishing benchmark conditions for air quality that are consistent with the CAA and other policy goals. Currently, the NPS Air Resources Division (ARD) focuses on four primary measures and associated benchmark conditions to evaluate air quality conditions in national parks:

Visibility

Unfortunately, vistas at Catoctin Mountain Park are sometimes obscured by pollution-caused haze. Currently, visibility condition at the park is a significant concern, falling far from the ARD recommended benchmark for good condition..

Visibility is a measure of how far and how well we can see a distant and varied scene. 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 scenic views. The deciview (dv) metric measures visibility changes as perceived by the human eye (analogous to the decibel scale), and is used by the air regulatory community to track visibility conditions and trends.

The CAA established a national goal to return visibility to "natural conditions" in Class I areas. 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). The ARD recommends that average visibility days should be < 2 dv above natural conditions as a benchmark for good visibility condition (NPS 2013), which is consistent with this CAA goal.

Based on 2008−2012 estimated visibility data, average visibility at Catoctin Mountain Park was 11.1 dv above estimated natural conditions,[1] and falls within the significant concern category (NPS *In Prep*). The degree of confidence in the visibility condition at Catoctin Mountain Park is medium because estimates are based on interpolated data from more distant visibility monitors.

Ozone

Ground-level ozone at Catoctin Mountain Park warrants significant concern. Ground-level ozone is formed when nitrogen oxides from vehicles, power plants, and other combustion sources combine with volatile organic compounds from gasoline, solvents, and vegetation in the presence of sunlight.

The National Ambient Air Quality Standard (NAAQS) for ozone is set by the EPA, and is based on human health effects. Frederick county Maryland, home to Catoctin Mountain Park, does not meet the NAAQS ozone standard of an 8-hour average concentration of 75 parts per billion (ppb). For this reason, the county is an EPA-designated "non-attainment" area for ozone.

Some plant species are more sensitive to ozone than humans. Accordingly, the NPS ARD recommends a benchmark for good ozone condition of 60 ppb or less, which is 80% of the human health-based NAAQS (NPS 2013).

[1] Estimated annual average natural condition is 7.4 deciviews (dv) at Catoctin Mountain Park.

The significant concern for Catoctin Mountain Park ozone levels is based on NPS Air Resources Division benchmarks and the 2008–2012 estimated ozone concentration (4th highest 8-hour average) of 72.8 parts per billion (ppb). This ozone level would normally warrant moderate concern, however, the condition has been elevated because the park is within a county designated by the EPA as nonattainment (not meeting) for the ground-level ozone standard for human health of 75 ppb (4th highest 8-hour average). Confidence in the ozone condition at Catoctin Mountain Park is medium because estimates are based on interpolated data from more distant ozone monitors.

W126 is a biologically relevant measure that focuses on plant response to ozone exposure and is a better predictor of vegetation response than the metric used for the human health standard. The W126 metric measures cumulative ozone exposure over the growing season in "parts per million-hours" (ppm-hrs). The NPS ARD recommends a W126 of < 7 ppm-hrs to protect sensitive vegetation. At Catoctin Mountain Park, the W126 metric during 2008−2012 was 11.6 ppm-hrs, and is above the recommended levels. This ARD-recommended level for the W126 metric is unrelated to the ARD recommended benchmark for ozone condition (which already includes a vegetative component; see above).

A risk assessment that considered ozone exposure, soil moisture, and sensitive plant species concluded that plants in Catoctin Mountain Park were at high risk of foliar ozone injury (Kohut 2007; Kohut 2004). The park has several ozone-sensitive plants including *Liriodendron tulipifera* (tulip poplar) and *Rudbeckia laciniata* (cut-leaf coneflower).

Catoctin conducted a few ozone monitoring studies in the 1980s, which indicated some moderate to high ozone damage to plants including basswood, milkweed, and clematis (NPCA 2006; NPS 1988). However, more recent monitoring has shown little damage.

Sulfur and Nitrogen Deposition

Wet sulfur and nitrogen deposition conditions both warrant significant concern at Catoctin Mountain Park in accordance with ARD benchmarks. In addition, estimated levels of total nitrogen deposition are well above the critical load for to protecting lichen and forest vegetation in the Eastern Temperate Forests.

Sulfur and nitrogen compounds in air pollution (e.g., industry, 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. NPS ARD recommends a nitrogen or sulfur wet deposition of less than 1 kg/ha/yr as condition to protect sensitive ecosystems (NPS 2013).

Nitrogen, together with sulfur, can also acidify soils and surface waters the park. Ecosystems at Catoctin Mountain Park park were rated as having very high sensitivity to acidification effects relative to all Inventory & Monitoring parks (Sullivan et al. 2011a; Sullivan et al. 2011b). Acidification of soils, lakes and streams can result in changes in community structure, biodiversity, reproduction, and decomposition. Plants sensitive to the effects of acidification in the park include *Acer saccharum* (sugar maple) trees.

Wet sulfur deposition at the park warrants significant concern. This condition is based on NPS Air Resource Division benchmarks and the 2008–2012 estimated wet sulfur deposition of 3.6 kg/ha/yr. For 2003–2012, the trend in wet sulfur concentrations in rain and snow at Catoctin Mountain Park improved. Confidence in the wet sulfur deposition condition and trend at Catoctin Mountain Park is high because there was an on-site deposition monitor during the most recent validated data period.

Although nitrogen is an essential plant nutrient, surplus levels of atmospheric nitrogen deposition can stress ecosystems. Excess nitrogen can cause weedy, non-native plant species to grow faster and out-compete native vegetation adapted to low nitrogen conditions; decreasing biodiversity and contributing to loss of ecosystem health and function (Blett & Eckert 2013; Bobbink et al. 2010). Exotic grasses can increase fire risk (Rao et al. 2010).

Ecosystems at Catoctin Mountain Park are not typical of nitrogen-sensitive systems and were rated as having very low sensitivity to nutrient-enrichment effects relative to all Inventory & Monitoring parks (Sullivan et al. 2011c; Sullivan et al. 2011d). However, wet nitrogen deposition at the park warrants significant concern. This condition is based on NPS Air Resources Division benchmarks and the 2008–2012 estimated wet nitrogen deposition of 4.5 kilograms per hectare per year (kg/ha/yr), well above the benchmark level for good condition. For 2003–2012, the trend in total wet nitrogen concentrations in rain and snow at Catoctin Mountain Park remained relatively unchanged (no statistically significant trend). The degree of confidence in the wet nitrogen deposition condition and trend at Catoctin Mountain Park is high because there was an on-site deposition monitor during the most recent validated data period.

A critical load, defined as the level of deposition below which harmful effects to the ecosystem are not expected, is also a useful tool in determining the extent of deposition impacts (i.e., nutrient enrichment) to park resources. It can also serve to communicate these impacts to managers, regulators, and the public.

Pardo et al. (2011) suggested a critical load of 3−8 kilograms nitrogen per hectare per year (kg N/ha/yr) to protect lichen and forest vegetation in the Eastern Temperate Forests, which includes Catoctin Mountain Park. This study estimated that current total nitrogen deposition (wet plus dry) in this park is approximately 14.2 kg/ha/yr, suggesting that current levels of nitrogen deposition are above ecosystem health thresholds and are known to affect diversity of plants and lichens (Pardo et al. 2011). Total deposition levels that are above a critical load value for a particular ecosystem are a major concern to the NPS.

Mercury/Toxics Deposition

Mercury/toxics are rated by ARD as a significant concern at Catoctin Mountain Park.

Mercury and other toxic pollutants (e.g., pesticides, dioxins, PCBs) accumulate in the food chain and can affect both wildlife and human health. Sources of atmospheric mercury include by-products of coal-fire combustion, municipal and medical incineration, mining operations, volcanoes, and geothermal vents. Exposure to high levels of mercury in humans may cause damage to the brain, kidneys, and the developing fetus. High mercury concentrations in birds, mammals, and fish can result in reduced foraging efficiency, survival, and reproductive success.

Other toxic air contaminants of concern include pesticides (e.g., DDT), industrial by-products like PCBs and PFCs, and emerging chemicals such as flame retardants for fabrics (PBDEs). Some of these contaminants are carcinogenic. These pollutants enter the environment from historically contaminated soils, current day industrial practices, and air pollution.

While there are direct mercury inputs to surface waters from industrial processes, another contributor of mercury to inland water bodies is atmospheric deposition. Wet deposition transfers atmospheric constituents to the Earth's surface in precipitation. This pathway can lead to mercury loadings in water bodies, where mercury may be converted to a bioavailable toxic form of mercury, methylmercury, and bioaccumulate through the food chain. Wetlands, especially those rich in organic matter, are important sites for methlymercury production. The predicted concentrations of methylmercury in surface waters at the park are low to moderate as compared to other NPS units (Krabbenhoft *In Press*).

The hazard of contaminants to terrestrial vertebrates at Catoctin Mountain NP appears to be minimal, but little if any terrestrial vertebrate ecotoxicological data are available (Rattner and Ackerson 2006).

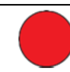
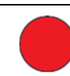
Maryland Department of Health lists statewide fish consumption advisories for mercury, PCBs, and pesticides present in various freshwater and marine species of different lengths (EPA NLFA 2014). Given the consumption guidelines, mercury/toxics is rated as a moderate concern at the park. The confidence level in this condition is medium because Catoctin Mountain Park does not have park-specific studies examining mercury/toxics levels in park ecosystems.

Climate Change Adaptation

Air pollution, and specifically the emission of greenhouse gases, is the primary cause of climate change. Air pollution also directly impacts park resources, as stated above, further decreasing resilience to the effects of climate change. The majority of air pollutants are emitted from sources outside of the parks. However, air pollution is also emitted directly inside parks, for example, by automobiles, generators, wildfires, and construction. With respect to air pollution and climate change, there are several strategies Catoctin Mountain Park can undertake:

- Continue in-park emission reduction activities (e.g. alternative fuel vehicle fleet and energy efficiency).
- Continue working toward Climate Friendly Parks goals.
- Identify ecosystems and plant communities most vulnerable to climate change and air quality impacts, and devise management strategies accordingly.
- Reduce ecosystem vulnerability to climate change by mitigating air pollution stressors and increasing ecosystem resilience.
- Use interpretative and educational tools to highlight the connections between air pollution and climate change.

Table 1. Air Quality at Catoctin Mountain Park

Indicators of Condition	Condition / Trend
Visibility	
Ozone	
Nitrogen Wet Deposition	
Sulfur Wet Deposition	
Toxics/Mercury Deposition	

Resource Threats and Opportunities

- Air quality and scenic resources are impacted by regional and local sources of air pollution such as power plants, industry, agriculture, and urban sprawl.
- Park air quality can benefit from collaboration with the local community, as well as, state and federal agencies.
- Planning can emphasize efforts to protect air quality, scenic views, and resources sensitive to air pollution.
- Incorporate air quality into interpretive themes.
- Monitoring of air quality parameters (e.g., visibility, ozone) can help the park understand potential threats.
- Special studies to examine pollution dose-response relationships in sensitive park ecosystems.
- Continue monitoring toxic contaminants in park biota and support assessment of resource impairment.

Studies and References

Blett, T. and Eckert, G. 2013. Restoration of nitrogen-impacted park systems through removal of invasive plant species: general guidelines for NPS plants and projects.

Bobbink et al. 2010. Global assessment of nitrogen deposition effects on terrestrial plant diversity: a synthesis. Ecological Applications 20(1):30-59.

Kohut, R.J. 2007. Ozone risk assessment for Vital Signs Monitoring Networks, Appalachian National Scenic Trail, and Natchez Trace National Scenic Trail. NPS/NRPC/ARD/NRTR—2007/001. National Park Service, Fort Collins, Colorado. Available at: https://irma.nps.gov/App/Reference/DownloadDigitalFile?code=152846&file=OzoneRiskAssessment_NRTR2007_001.pdf.

Kohut R.J. 2004. Ozone risk assessment for National Capital Region Network. National Park Service. Fort Collins, Colorado. Available at: https://irma.nps.gov/App/Reference/DownloadDigitalFile?code=442206&file=ncrnO3RiskOct04.pdf.

Krabbenhoft, D. P. *In Review*. Modeling Surface-Water Methylmercury in National Parks. U.S. Geological Survey Wisconsin Water Science Center, Middleton, Wisconsin.

[EPA NLFA] U.S. Environmental Protection Agency National List of Fish Advisories. “Advisories Where You Live” accessed from http://fishadvisoryonline.epa.gov/General.aspx on September 4, 2014.

National Parks Conservation Association. 2006. State of the parks: Catoctin Mountain Park. National Parks Conservation Association, Washington, DC. Available at: http://www.npca.org/about-us/center-for-park-research/stateoftheparks/catoctin/catoctin.pdf.

National Park Service, Air Resources Division. *In Preparation*. Air quality in national parks: trends (2003–2012) and conditions (2008–2012). Natural Resource Report NPS/NRSS/ARD/NRR—2014/XXX. National Park Service, Denver, Colorado.

National Park Service, Air Quality Division. 1988. Air quality in the national parks. Natural Resources Report 88-1. National Park Service, Denver, Colorado.

Pardo, L.D., M.J. Robin-Abbott, C.T. Driscoll, eds. 2011. Assessment of nitrogen deposition effects and empirical critical loads of nitrogen for ecoregions of the United States. Gen. Tech. Rep. NRS-80. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. Available at: http://www.nrs.fs.fed.us/pubs/38109.

Rao L.E., Allen E.B., Meixner T. 2010. Risk-based determination of critical nitrogen deposition loads for fire spread in southern California deserts. *Ecological Applications* 20 (5): 1320–1335.

Rattner, B.A. and Ackerson, B.K. 2006.Contaminant exposure and potential effects on terrestrial vertebrates residing in the National Capital Region Network and Mid-Atlantic Network. Available at: http://nature.nps.gov/air/pubs/pdf/toxics/RattnerReport2006.pdf.

Sullivan, T.J., G.T. McPherson, T.C. McDonnell, S.D. Mackey, D. Moore. 2011a. Evaluation of the sensitivity of inventory and monitoring national parks to acidification effects from atmospheric sulfur and nitrogen deposition: main report. Natural Resource Report NPS/NRPC/ARD/NRR—2011/349. National Park Service, Denver, Colorado. Available at https://irma.nps.gov/App/Reference/DownloadDigitalFile?code=428429&file=main_acidification-eval_2011-05.pdf.

Sullivan, T.J., G.T. McPherson, T.C. McDonnell, S.D. Mackey, D. Moore. 2011b. Evaluation of the sensitivity of inventory and monitoring national parks to acidification effects from atmospheric sulfur and nitrogen deposition: National Capital Region Network (NCRN). Natural Resource Report NPS/NRPC/ARD/NRR—2011/367. National Park Service, Denver, Colorado. Available at https://irma.nps.gov/App/Reference/DownloadDigitalFile?code=428447&file=ncrn_acidification-eval_2011-05.pdf.

Sullivan, T. J., McDonnell, T. C., McPherson, G. T., Mackey, S. D., Moore, D. 2011c. Evaluation of the sensitivity of inventory and monitoring national parks to nutrient enrichment effects from atmospheric nitrogen deposition: main report. Natural Resource Report NPS/NRPC/ARD/NRR—2011/313. National Park Service, Denver, Colorado. Available at https://irma.nps.gov/App/Reference/DownloadDigitalFile?code=427566&file=main_n_sensitivity_2011-02_updated.pdf.

Sullivan, T. J., McDonnell, T. C., McPherson, G. T., Mackey, S. D., Moore, D. 2011d. Evaluation of the sensitivity of inventory and monitoring national parks to nutrient enrichment effects from atmospheric nitrogen deposition: National Capital Region Network (NCRN). Natural Resource Report NPS/NRPC/ARD/NRR—2011/317. National Park Service, Denver, Colorado. Available at https://irma.nps.gov/App/Reference/DownloadDigitalFile?code=425449&file=ncrn_n_sensitivity_2011-02.pdf.

Appendix A: Trends and Conditions Methods

Condition Assessment Derivation

In the status and trend symbols used in the air quality summary Table 1 above, the background color represents the current condition status, the direction of the arrow summarizes the trend in condition, and the thickness of the outside line represents the degree of confidence in the assessment.

Condition Status		Trend in Condition		Confidence in Assessment	
	Warrants Significant Concern		Condition is Improving		High
	Warrants Moderate Concern		Condition is Unchanging		Medium
	Resource is in Good Condition		Condition is Deteriorating		Low

Condition Assessment Derivation

Air quality condition is represented by the color of the circle. The Air Resources Division (ARD) uses all available monitoring data over a five-year period to generate interpolations for ozone, nitrogen and sulfur wet deposition, and visibility indicators in the contiguous United States. Monitors used include NPS, Environmental Protection Agency (EPA), state, tribal, and local monitors. These interpolations produce estimates of air quality parameters at all NPS units located within the contiguous United States, including many without on-site monitoring. Estimates for ozone, wet deposition, and visibility are assigned to one of three condition categories: *Warrants Significant Concern*, *Warrants Moderate Concern*, or *Resources is in Good Condition*. The mercury/toxics deposition condition is determined based on a risk assessment, an evaluation of fish consumption advisories, and in-park or representative data and studies.

Trend Derivation

Unlike the condition estimates, which are derived from interpolated data, trends are computed from data collected over a ten-year period at on-site or nearby representative monitors (within 10 kilometers of the park for ozone, 16 kilometers of the park for wet deposition, and 100 kilometers of the park for visibility). Trends are calculated for sites that have at least 6 years of annual data and an annual value for the final year of the 10 year period. On the air quality summary Table 1, trends are represented by arrows. All *improving* (up arrows) and *deteriorating* (down arrows) trends have at least 95% probability of being correct (those with p-values ≤ 0.05). Statistically significant (p-value ≤ 0.05) trends with zero slope are represented by flat arrows. Parameters with no statistically significant trend (p-value ≥ 0.05) are also represented by flat arrows.

Confidence

The degree of confidence is represented by the thickness of the outside line of the condition/trend symbol and is the confidence in the condition only. Degree of confidence for ozone, nitrogen and sulfur wet deposition, and visibility is based on how well the nearest monitoring site(s) represent air quality reported 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 date from more distant monitors.

Degree of confidence for mercury/toxics is based on validity of in-park or representative data and studies examining levels of mercury/toxics in park ecosystems.