# AIR QUALITY MONITORING CONSIDERATIONS FOR THE APPALACHIAN HIGHLANDS NETWORK

December 2001 (revised March 2004)

## Introduction

The NPS Air Resources Division (ARD) contracted with the University of Denver (DU) to produce GIS-based maps and an associated look-up table that provide baseline values for a set of air quality parameters for all Inventory and Monitoring parks in the U.S. These maps and table will serve as the Air Inventory for the parks. Air Quality Inventory products are available on the Internet at http://www2.nature.nps.gov/ard/gas/ (see section called *Air Atlas*). ARD used preliminary DU products to help develop an implementation strategy for expanding NPS air quality monitoring under the Natural Resources Challenge. Based on the implementation strategy, ARD funded installation of a wet mercury deposition monitor at Great Smoky Mountains National Park (NP) in FY 2002. The air monitoring implementation strategy will be revisited in FY 2004 if additional funding becomes available.

Data from the Air Quality Inventory, national air monitoring programs described below, and other air quality sources, were used in conjunction with park-specific resource information to evaluate the following needs relative to the Appalachian Highlands Network: 1) the need for additional ambient air quality monitoring at any Network park, e.g., wet deposition, dry deposition, visibility, and/or ozone monitoring, and 2) the need for air quality effects-related monitoring at any Network park. The assessment includes the four original parks that comprise the Appalachian Highlands Network plus a section of the Appalachian National Scenic Trail (NST). The results of the evaluation, as well as a brief summary of results of past air quality monitoring at relevant sites, are discussed below.

## Wet Deposition

The National Atmospheric Deposition Network/National Trends Network (NADP/NTN) is a nationwide network of precipitation monitoring sites. The network is a cooperative effort between many different groups, including the U.S. Environmental Protection Agency (EPA), U.S. Geological Survey, U.S. Department of Agriculture, and private entities. The NPS is a major participant in NADP/NTN, and the ARD recommends that any new wet deposition site installed in a park meet NADP/NTN siting criteria and follow NADP/NTN protocols. There are currently more than 200 NADP/NTN sites spanning the continental U.S., Alaska, Puerto Rico, and the Virgin Islands.

The purpose of NADP/NTN is to collect data on the chemistry of precipitation to monitor geographical and temporal long-term trends. The precipitation at each station is collected weekly according to strict clean-handling procedures. It is then sent to the Central Analytical Laboratory in Illinois where it is analyzed for hydrogen (acidity as pH), sulfate, nitrate, ammonium, chloride, and base cations (such as calcium, magnesium, potassium and sodium). NADP/NTN's excellent quality assurance programs ensure that the data remain accurate and precise.

The National Atmospheric Deposition Program has also expanded its sampling to include the Mercury Deposition Network (MDN), which currently has over 80 sites. The MDN was formed in 1995 to collect weekly samples of precipitation, which are analyzed for total mercury. The objective of the MDN is to monitor the amount of mercury in precipitation on a regional basis. MDN monitors in the area are located at Great Smoky Mountains NP (site #TN11), Mammoth Cave NP (site #KY10) and Shenandoah NP (site #VA28).

Only one of the five NPS units in the Appalachian Highlands Network has a NADP/NTN monitor on-site (i.e., Great Smoky Mountains NP), but the other four units have a monitor within 60 km (about 35 miles). NADP/NTN collects data on both pollutant deposition (in kilograms per hectare per year) and pollutant concentration (in microequivalents per liter). Deposition varies with the amount of annual on-site precipitation, and is useful because it gives an indication of the total annual pollutant loading at the site. Concentration is independent of precipitation amount, therefore, it provides a better indication of whether ambient pollutant levels are increasing or decreasing over the years. In general, wet deposition and concentration of sulfate is higher in the eastern than in the western U.S., and in 2000, as in previous years, there were "hot spots" in eastern Tennessee. In 2000, wet concentration of nitrate was moderate in eastern Tennessee and western North Carolina, while wet deposition of nitrate was high. The same year, wet concentration of ammonium was low to moderate in the Appalachian Highlands area, while wet deposition of ammonium was moderate. (see U.S. wet deposition isopleth maps at http://nadp.sws.uiuc.edu). Data from the NADP/NTN sites in the Appalachian Highlands region are summarized below.

Mount Mitchell, NC

Mount Mitchell, North Carolina, has had a NADP/NTN site (site #NC45) since 1985. To date, site data have not met the completeness criteria required for NADP/NTN to perform trend analyses.

Otto, NC

The NADP/NTN monitor in Otto, North Carolina, (site #NC25 (Coweeta Hydrologic Laboratory)) has been operating since 1978. Data show a decrease in wet nitrate, sulfate, and ammonium deposition; a decrease in wet sulfate concentration; and no trends in wet nitrate and ammonium concentration.

Great Smoky Mountains NP

The NADP/NTN site at Great Smoky Mountains NP, Tennessee, (site #TN11) has been operating since 1980. While concentration and deposition of wet sulfate have decreased, there have been no apparent trends in concentration or deposition of wet nitrate or ammonium.

Oak Ridge National Laboratory, TN

The Oak Ridge National Laboratory, Tennessee, NADP/NTN site (site #TN00) has been in operation since 1980. The site data show a decrease in concentration of wet sulfate, but no apparent trend in deposition of wet sulfate. There has been an increase in wet ammonium concentration, wet ammonium deposition, and wet nitrate deposition, but no apparent trend in wet nitrate concentration.

Speedwell, TN
The NADP/NTN site was installed at Speedwell, Tennessee, (site #TN04) in 1999. Sufficient data are not yet available to characterize pollutant trends at the site.

Charlottesville, VA
Charlottesville, Virginia, has had an NADP/NTN site (site #VA00) since 1984. Site data show wet concentration and deposition of sulfate, wet concentration and deposition of nitrate, and wet concentration and deposition of ammonium have decreased since 1990.

Eggleston, VA
An NADP/NTN site has been operating at Eggleston, Virginia, (site #VA13 (Horton's Station)) since 1978. Wet sulfate concentration, wet sulfate deposition, and wet nitrate concentration have decreased at the site since 1987. There have been no apparent trends in wet nitrate deposition, wet ammonium deposition or wet ammonium concentration.

Natural Bridge, VA
An NADP/NTN monitor was installed at Natural Bridge, Virginia, (site #VA99) in 2002. Data are not yet available from the site.

Shenandoah NP
The NADP/NTN site at Shenandoah NP (site #VA28) has been operating since 1981. A review of site data shows concentration and deposition of wet sulfate have decreased, as has deposition of wet nitrate. There has been no apparent trend in concentration of wet nitrate, concentration of wet ammonium, or deposition of wet ammonium.

Data from all Appalachian Highlands Network region NADP/NTN sites show a decrease in wet sulfate concentration and deposition, which is consistent with a nationwide reduction in sulfur dioxide emissions. While trends in wet deposition and concentration of nitrate and ammonium are not consistent among sites, at all sites except Oak Ridge National Laboratory, they are either stable or decreasing.

Existing NADP/NTN sites may provide adequate coverage for the Appalachian Highlands Network. Cost information is provided in case the Network is interested in installing a new site. A NADP/NTN wet deposition site costs $13,000 for equipment purchase and installation, and operating costs (including site operation, chemical analysis, and reporting) are about $7,000 per year.

**Dry Deposition**
The Clean Air Status and Trends Network (CASTNet) is considered the nation's primary source for atmospheric data to estimate dry acidic deposition. Established in 1987, CASTNet now comprises over 70 monitoring stations across the U.S. The majority of the monitoring stations are operated by EPA; however, approximately 20 stations are operated by the NPS in cooperation with EPA. Each CASTNet dry deposition station measures:

weekly average atmospheric concentrations of sulfate, nitrate, ammonium, sulfur dioxide, and nitric acid; hourly concentrations of ambient ozone; and meteorological conditions required for calculating dry deposition rates. Dry deposition rates are calculated using atmospheric concentrations, meteorological data, and information on land use, vegetation, and surface conditions. CASTNet complements the database compiled by NADP/NTN. Because of the interdependence of wet and dry deposition, NADP/NTN wet deposition data are collected at or near all CASTNet sites. Together, these two long-term databases provide the necessary data to estimate trends and spatial patterns in total atmospheric deposition. The ARD recommends that all new dry deposition sites installed in parks use CASTNet siting criteria and follow CASTNet protocols.

Great Smoky Mountains NP has a CASTNet monitor on-site, and the other four units in the Appalachian Highlands Network have a monitor within 70 km (about 40 miles). CASTNet uses different monitoring and reporting techniques than NADP/NTN, so the dry deposition amounts are reported here as nitrogen and sulfur, rather than nitrate, ammonium, and sulfate. In addition, because CASTNet calculates dry deposition based on measured ambient concentrations and estimated deposition velocities, there is greater uncertainty in the reported values. Due to the small number of CASTNet sites nationwide, use of dry deposition isopleth maps is not advised at this time. CASTNet data collected at the sites in the Appalachian Highlands Network region are summarized below.

Cranberry, NC

Cranberry, North Carolina, has had a CASTNet site (site # PNF126) since 1988. Site data indicate no trends in dry nitrogen or sulfur deposition. CASTNet estimates total nitrogen deposition at the site is composed of 12 percent dry deposition and 88 percent wet deposition, while total sulfur deposition is 13 percent dry and 87 percent wet.

Otto, NC

The CASTNet monitor in Otto, North Carolina, (site #COW137 (Coweeta Hydrologic Laboratory)) has been operating since 1990. Site data show no trend in dry nitrogen or sulfur deposition. Total nitrogen deposition at the site is 21 percent dry and 79 percent wet, while total sulfur deposition is 15 percent dry and 85 percent wet.

Edger Evins Park, TN

A CASTNet site has been operating at Edger Evins State Park, Tennessee, (site #ESP127) since 1988. Site data show a decrease in dry sulfur deposition, but no trend in dry nitrogen deposition. CASTNet estimates total nitrogen deposition at the site consists of 25 percent dry deposition and 75 percent wet deposition, while total sulfur deposition is 24 percent dry and 76 percent wet.

Great Smoky Mountains NP

A CASTNet site was installed at Great Smoky Mountains NP, Tennessee, (site #GRS420) in 1998. Sufficient data are not yet available to characterize dry deposition at this site.

Speedwell, TN
The Speedwell, Tennessee, CASTNet site (site #SPD111) has been operating since 1989. A review of the site data shows no apparent trend in dry nitrogen or sulfur deposition. CASTNet estimates total nitrogen deposition at Speedwell consists of 28 percent dry deposition and 72 percent wet deposition, while total sulfur deposition is 39 percent dry and 61 percent wet.

Eggleston, VA
A CASTNet site has been operating at Eggleston, Virginia, (site #VPI120) since 1988. Site data indicate no trends in dry nitrogen or sulfur deposition. CASTNet estimates total nitrogen deposition at the site is composed of 50 percent dry deposition and 50 percent wet deposition, while total sulfur deposition is 49 percent dry and 51 percent wet.

Shenandoah NP
The CASTNet site at Shenandoah NP (site #SHN418) has been operating since 1988. The site data show a decrease in dry sulfur deposition but no apparent trend in dry nitrogen deposition. CASTNet estimates total sulfur deposition at Shenandoah NP is 60 percent wet and 40 percent dry, while total nitrogen deposition is 56 percent wet and 44 percent dry.

Existing CASTNet sites may provide adequate coverage for the Appalachian Highlands Network. Installation and annual operating costs for a CASTNet site are about $83,000 and $55,000, respectively.

**Air Toxics**
Air toxics, e.g., mercury, dioxins, and benzene, may be a concern for Network parks, particularly those that are located near urban areas. Some states conduct air toxics monitoring. In most cases, the monitoring is focused primarily on urban areas and/or industrial sites. The air agencies in states with Appalachian Highlands Network parks were contacted regarding current and planned air toxics monitoring. The results are summarized below.

Georgia
Contact: Susan Zimmer-Dauphinee, 404-363-7079
Georgia has a long history of air toxics monitoring, and monitoring has taken place in a number of locations around the state, but none near the Appalachian NST. The state appears amenable to monitoring at other locations in the future.

Kentucky
Contact: Larry Garrison, 502-573-3382
The state does not conduct air toxics monitoring near any Appalachian Highlands Network park. There are no plans to install additional sites in the near future.

North Carolina
Contact: Julie Kinlaw, 919-733-3843
The state conducts air toxics monitoring in a number of locations, but the only site near Appalachian Highlands Network parks is Asheville (Blue Ridge Parkway and Great

Smoky Mountains NP). There are no plans to add additional sites to the state's toxics monitoring program in the near future.

Tennessee
Contact: Jackie Waynick, 615-532-0554
An air toxics monitor was scheduled to be installed in Kingsport (Blue Ridge Parkway and Great Smoky Mountains NP) in the summer of 2002.

Virginia
Website: http://www.deq.state.va.us/airmon
Monitoring sites and data are listed on the Virginia Department of Environmental Quality website. No air toxics monitoring is conducted near Appalachian Highlands Network parks.

**Surface Water Chemistry**
The Water Resources Division's (WRD) *Baseline Water Quality Data Inventory and Analysis* reports were reviewed for Big South Fork National River and Recreation Area (NRRA), Blue Ridge Parkway, and Obed Wild and Scenic River (WSR). Other water quality summary information was reviewed for Great Smoky Mountains NP. No data were available for the Appalachian NST. Air pollution concerns relative to surface water chemistry include acidification due to sulfur and nitrogen deposition in fresh water, eutrophication from excess nitrogen deposition in fresh or saline water, and deposition of toxic air pollutants such as mercury, other metals, and organics. Acid-sensitive surface waters typically have a pH below 6.0 and an acid neutralizing capacity (ANC) below 100 microequivalents per liter (μeq/l). Water quality data for Appalachian Highlands Network parks are summarized below.

Big South Fork NRRA
A review of the 1994 *Baseline Water Quality Data Inventory and Analysis* report for Big South Fork NRRA indicated park surface waters consist of the Cumberland River and some creeks. Data collected on the Cumberland River between 1960 and 1992 had an average pH of 7.2 and an average ANC of 152 μeq/l. Data collected on Black, North Whiteoak, and Pine Creeks between 1974 and 1986 had pH values of 7.4 to 7.8 and ANC values of 160 to 513 μeq/l. These data indicate park surface waters are not sensitive to acidification from atmospheric deposition.

Blue Ridge Parkway
A review of the 1996 *Baseline Water Quality Data Inventory and Analysis* report for Blue Ridge Parkway indicated few water quality data have been collected in the park and none have been collected since 1986. Large rivers such as the James, Roanoke, Linville, and Swannanoa would not typically be sensitive to acidification from atmospheric deposition. Data collected between 1974 and 1979 at various locations on Spring Creek had average pH values ranging from 5.2 to 6.8 and ANC values ranging from 40 to 192 μeq/l. These data indicate some surface waters in the park could be sensitive to acidification from atmospheric deposition. The Network may want to collect additional

water chemistry data to assess the current condition, and sensitivity, of surface waters in the park.

Great Smoky Mountains NP

As a prototype monitoring park, Great Smoky Mountains has an intensive, weekly, water quality monitoring program at the Nolan Divide watershed. In addition, the park conducts synoptic, quarterly, water quality sampling at 90 locations throughout the park. Monitoring data indicate some streams in the park are susceptible to acidification from atmospheric deposition. In fact, some streams are currently experiencing either episodic or chronic acidification. In general, the sensitive streams tend to be at higher elevations.

Obed WSR

A review of the 1999 *Baseline Water Quality Data Inventory and Analysis* report for Obed WSR indicated park surface waters consist of the Obed and Emory Rivers, and numerous creeks, reservoirs, and springs. Data collected on the Obed River between 1965 and 1979 had an average pH of 6.8. Samples collected on the Emory River between 1967 and 1997 had average pH values of 6.3 to 7.0 and average ANC values of 120 to 304 μeq/l. Data collected on Clear Creek, Ramsey Creek, and White Creek between 1979 and 1998 had average pH values of 6.2 to 7.1 and average ANC values of 36 to 184 μeq/l. Samples collected at Rock Creek had low pH and ANC values, however, this creek is influenced by acid mine drainage. The data indicate surface waters in the park are not sensitive to acidification from atmosphericdeposition.

**Particulate Matter**

Small or "fine" particles in the air, typically those less than 2.5 micrometers in diameter, $PM_{2.5}$, are a leading cause of human respiratory illness. Particles are present everywhere, but high concentrations and/or specific types have been found to present a serious danger to human health. Fine particles in the air are the main contributor to human-caused visibility impairment. The particles not only decrease the distance one can see; they also reduce the colors and clarity of scenic vistas. Moisture in the air enhances the impact, so areas in the Eastern U.S., with higher relative humidity, have worse visibility than areas in the arid West (see attached Air Inventory map). In 1997, EPA finalized new stricter, human-health based, National Ambient Air Quality Standards (NAAQS) for particulate matter. Original NAAQS for particulate matter were for those particles 10 microns or less ($PM_{10}$). The new national standards now regulate $PM_{2.5}$.

Great Smoky Mountains NP has $PM_{10}$ and $PM_{2.5}$ monitoring on-site through the IMPROVE program. Big South Fork NRRA and Obed WSR have $PM_{10}$ monitors within 35 km; site information and data are not available for Tennessee's $PM_{2.5}$ monitors. There are both $PM_{10}$ and $PM_{2.5}$ monitors within 35 km of the Appalachian NST and Blue Ridge Parkway in Virginia and North Carolina. No monitors are located near the Appalachian NST in Georgia. None of the states with Appalachian Highlands Network parks have areas currently designated nonattainment for $PM_{10}$. Nationwide $PM_{2.5}$ monitoring was initiated in 1999; nonattainment areas will not be designated until 2004. Preliminary data indicate some counties in Virginia and North Carolina will not meet the $PM_{2.5}$ annual NAAQS.

**Visibility**
In 1985, in response to the mandates of the Clean Air Act, Federal and regional/state organizations established the Interagency Monitoring of Protected Visual Environments (IMPROVE) program to protect visibility in Class I air quality areas. Class I areas are national parks greater than 5,000 acres and wilderness areas greater than 6,000 acres, that were established prior to August 7, 1977. All other NPS areas are designated Class II. The objectives of the IMPROVE program are: to establish current visibility conditions in all Class I areas; to identify pollutants (particles and gases) and emission sources responsible for existing man-made visibility impairment; and to document long-term trends in visibility. In 1999, there were 30 official IMPROVE sites and 40 protocol sites. Because of recently enacted regulations that require improving visibility in Class I areas, the number of visibility monitors is increasing. Protocol sites are being upgraded to full IMPROVE sites and 80 new sites are being added to the IMPROVE network.

While the IMPROVE program has focused on Class I air quality areas, a great deal of visibility monitoring has been conducted in Class II areas. The ARD recommends that new visibility monitoring in NPS areas be conducted in coordination with the IMPROVE program (the IMPROVE program is managed out of the NPS ARD office in Fort Collins, Colorado). Some I&M Networks are considering monitoring visibility at scenic vistas with digital cameras. While this type of monitoring would not be adequate for regulatory purposes, it is useful for documenting visibility conditions and trends and provides an excellent means of sharing that information with the public. The cost of installing an automated digital camera site with web access is $10,000 to $15,000, with annual costs of about $6,000.

Great Smoky Mountains NP has had an IMPROVE monitor on-site in Tennessee (site #GRSM) since 1988, and the other units in the Appalachian Highlands Network have an IMPROVE monitor within 140 km (about 85 miles). Other IMPROVE monitors in the Appalachian Highlands Network region are located in Cohutta Wilderness Area, Georgia (site #COHU; operating since 2000), Mammoth Cave NP, Kentucky (site #MACA; operating since 1991), Linville Gorge Wilderness Area, North Carolina (site #LIGO; operating since 2000), Shining Rock Wilderness Area, North Carolina (site #SHRO; operating since 1994), James River Face Wilderness Area, Virginia (site #JARI; operating since 1994), and Shenandoah NP (site # SHEN; operating since 1988).

Visibility trend data are available for Great Smoky Mountains NP, Mammoth Cave NP, and Shenandoah NP. Data show no trends in good, bad, or average visibility at either Great Smoky Mountains NP or Mammoth Cave NP. Good, bad, and average visibility is improving at Shenandoah NP. As for the sources of visibility impairment, 1996-1998 aerosol data from the three parks and Shining Rock Wilderness Area show that, on an annual basis, visibility impairment is primarily due to sulfates (sources include coal combustion and oil refineries), then organics (sources include automobiles and chemical manufacturing), then soil (from windblown dust), then light absorbing carbon (sources include wood burning), and then nitrates (sources include coal and natural gas combustion and automobiles). At all sites, visibility was best in the winter and worst in the summer.

Existing IMPROVE sites may provide adequate coverage for the Appalachian Highlands Network. Installation and annual operating costs for an IMPROVE site are about $58,000 and $39,000, respectively.

**Ozone**

Both Great Smoky Mountains NP and Blue Ridge Parkway have a number of ozone monitors on-site or nearby. The rest of the Network parks have a monitor within 30 km (20 miles). Existing ozone monitors may provide adequate coverage for the Appalachian Highlands Network. Installation and annual operating costs for an ozone monitoring site are about $71,000 and $44,000, respectively. According to a map generated by DU for the Air Inventory, all five Appalachian Highland Network parks are likely to have exceedances of the human health-based 8-hour National Ambient Air Quality Standard.

**Vegetation**

For vegetation, the focus is on ozone sensitivity because 1) ozone is a regional pollutant and is, therefore, more likely to affect park resources than either sulfur dioxide or nitrogen oxide which quickly convert to other compounds, and 2) the literature on ozone sensitivity is more recent and more reliable than that for other pollutants. Park vascular plant lists contained in a May 2001 version of NPSpecies were compared to the general ozone-sensitive plant species lists maintained by the ARD (see attached species lists). The ARD lists were developed by an expert in the field of ozone effects on vegetation. Note that the ARD lists are general guides to ozone sensitivity. Differences in plant genetics, weather conditions, water availability, and ozone concentrations will affect whether or not a species exhibits injury in a particular park. In particular, studies have shown that plants will not take up ozone unless there is sufficient soil moisture. Ozone sensitive species of natural vegetation were identified for all five units in the Appalachian Highlands Network (see attached tables of sensitive species for Network parks).

It is generally agreed that plant foliar injury occurs after a cumulative exposure to ozone. One ozone statistic that is used to evaluate the risk of plant injury is the SUM06. SUM06 is the sum of all hourly average ozone concentrations greater than or equal to 0.06 parts per million (ppm). In 1997, a group of ozone effects experts recommended 3-month, 8:00 a.m. to 8:00 p.m., SUM06 effects endpoints for natural vegetation, i.e., 8 to12 ppm-hrs for foliar injury to natural ecosystems and 10 to 15 ppm-hrs for growth effects on tree seedlings in natural forest stands. According to a SUM06 map generated by DU, all five Appalachian Highlands Network parks are likely to have ozone concentrations, during some years, that are high enough to harm native vegetation. The ARD has contracted with a plant physiologist to evaluate historic ozone concentration and precipitation data to assess the likelihood of finding ozone-induced foliar injury in I&M parks and to develop standardized protocols for ozone injury surveys. The risk assessment should be completed for the Appalachian Highlands Network by June 1, 2003, and the protocols should be available in early 2004. If a high potential for injury is indicated, Network staff may want to conduct foliar injury surveys on sensitive species. Good survey species are black cherry (*Prunus serotina*) and common milkweed (*Asclepias syriaca*). Surveys have been conducted in Great Smoky Mountains NP for a number of years. The park has experienced both high ozone levels and substantial injury of vegetation.

**Conclusions**

The NPS is concerned about the ambient concentrations and potential effects of a number of air pollutants in units of the National Park System. The pollutants and effects of primary emphasis are: 1) fine particles and their effects on human health and visibility, 2) ozone and its effects on human health and vegetation, and 3) sulfur and nitrogen deposition and their effects on soils, surface waters, and biota.

It is always desirable to collect ambient air quality data on-site, particularly if air pollution sensitive resources have been documented in a park. However, the high cost of monitoring precludes the NPS from monitoring ambient air quality in every park. Ideally, off-site data can be used to indicate pollutant concentrations at a park. A number of factors, e.g., differences in elevation and meteorology, location of pollution sources, and urban versus rural settings, influence how well an off-site monitor represents pollutant concentrations in a park. Lacking a detailed evaluation of these factors for off-site monitors near Appalachian Highlands Network parks, ambient air quality monitoring needs discussed below are based solely on the distance between monitors and parks. Park-specific resource information was used to evaluate the need for air pollution effects monitoring. Effects monitoring needs discussed below are limited to two techniques that can be incorporated into a Vital Signs monitoring program relatively easily—ozone-induced foliar injury surveys and surface water chemistry monitoring.

All of the NPS units in the Appalachian Highlands Network have a NADP/NTN wet deposition monitor within 60 km.

All of the NPS units in the Appalachian Highlands Network have a CASTNet dry deposition monitor within 70 km.

There are no indications that surface waters in Big South Fork NRRA or Obed WSR are susceptible to acidification from atmospheric deposition. Data indicate some creeks in Blue Ridge Parkway may be acid-sensitive. Additional water chemistry monitoring is recommended in this park. The sensitivity of surface waters on the Appalachian NST is not known; synoptic surveys could help determine if sensitive surface waters occur in the park. Great Smoky Mountains NP's long-term stream chemistry-monitoring program should continue. Given the high levels of nitrogen and sulfur deposition monitored in the region and the sensitivity of park surface waters, atmospheric deposition and surface water acidification are a concern for the Appalachian Highlands Network.

All of the Appalachian Highlands Network parks have a $PM_{10}$ monitor within 35 km.

All of the NPS units in the Appalachian Highlands Network have an IMPROVE visibility monitor within 140 km. IMPROVE monitoring documents regional visibility impairment and trends; it does not capture localized "hot spots" of visibility impairment.

Ozone is a significant air pollution threat for Network parks, both in terms of human health and vegetation. All Network parks have an ozone monitor on-site or within 30 km. Nevertheless, because ozone concentrations are heavily influenced by elevation and location of pollution sources, it is desirable to confirm the adequacy of nearby off-site monitoring for the Appalachian NST, Big South Fork NRRA and sections of the Blue Ridge Parkway. It is also desirable to document any spatial differences in ozone concentrations at Big South Fork NRRA and Obed WSR.

Ozone sensitive species have been identified for all five NPS units in the Appalachian Highlands Network. Vegetation surveys to document ozone-induced foliar injury are warranted at all Network parks.

**Relevant Websites**
**NADP -** http://nadp.sws.uiuc.edu/
**CASTNet** - http://www.epa.gov/castnet/
**Ozone** - http://www.epa.gov/air/data/sources.html
**IMPROVE** - http://vista.cira.colostate.edu/improve/
**Ozone-specific sources and data** - http://www.epa.gov/ttn/rto/areas/
**Air toxics -** http://www2.nature.nps.gov/ard/aqmon/air_toxics/