2021-2022 REPORT

The Case for Fixing and Building Out National Parks Air Monitoring Networks

NATIONAL PARKS CONSERVATION ASSOCIATION

This report addresses the impacts of poor air quality, examines the legislative mandates for air monitoring, details the existing air monitoring networks, and makes recommendations to improve air quality monitoring for our national parks.

The Case for Fixing and Building Out National Parks Air Monitoring Networks



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Cover: Great Smoky Mountains National Park, Tennessee ©Nickolay Khoroshkov | Dreamstime **Opposite Page:** Washington Monument, Washington DC ©Lunamarina | Dreamstime **Top Left:** Mountain goat in Grand Canyon National Park, Arizona ©Vladislav Turchenko | Dreamstime **Top center:** Joshua tree, Joshua Tree National Park, California ©Daniel Schreurs | Dreamstime **Top right:** Petroglyphs, Arches National Park, Utah ©Delstudio | Dreamstime

Congress must allocate more funds for national park monitoring networks to ensure that robust science guides the enduring protection of our cultural and natural resources for their own sake and that of people's health.

Executive Summary

Our national parks are places of unparalleled natural wonder, historical significance, and cultural value, yet most are plagued by poor air quality that can threaten human health and detrimentally impact park ecosystems. Climate change is only making these problems worse—magnifying adverse impacts on air quality in and around our parks and disproportionately impacting vulnerable communities visiting, living or working nearby. At the same time, we may not know the extent of the harm because of inadequate air pollution monitoring which helps track pollution in and around these public lands. This report addresses the impacts of poor air quality, examines the legislative mandates for air monitoring, details the existing air monitoring networks, and makes recommendations to improve air quality monitoring for our national parks.

The National Park Service has a legal responsibility to protect air quality and natural resources from air pollution. Air quality monitoring is crucial to this effort. However, our existing monitoring networks need repair, expansion, and modernization for which increased funding is critical to provide the most useful, accurate, and complete data possible. Increased funding will also provide for the maintenance of existing networks and allow for more data analysis, which is essential to inform policies to improve the air in our national parks. This report concludes by calling on Congress to allocate a one time infrastructure investment of $3.3 million and $2.6 million annually for national park monitoring networks to ensure that robust science guides the enduring protection of our cultural and natural resources for their own sake and that of people's health.

Opposite Page: Inspiration Point, Channel Islands National Park, California

Introduction

Nearly every national park suffers from poor air quality and the effects of climate change. In fact, the National Parks Conservation Association (NPCA)[1] recently found that 401 parks (96%) are damaged by air pollution problems, including unhealthy air, harms to nature, hazy skies, and climate change.[2] For that reason, the National Park Service (NPS)—as well as Congress—must commit to policies that benefit our air, parks, and climate. But in order to improve the health and safety of park ecosystems, park-goers and dependent communities, we must better understand just how significant the air pollution problem is. Unfortunately, the air quality monitoring networks that are supposed to help us do just that are decades old and in dire need of maintenance, replacement, and upgrades.

Dangers to Air Monitors

All facets of the monitoring networks have been impacted by the following dangers, resulting in less rigorous quality control measures, a reduction in the number of station, measurement gaps and termination of measurement.

Wildfires

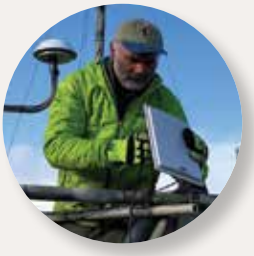
Due to more frequent and severe wildfires across the west, more and better smoke monitoring is needed.

Aging Infrastructure

Air monitors require upgrades and without consistent funding, equipment may become outdated or data may be inaccurate.

Storms

Severe storms, like hurricanes, put air monitors in danger in places like Big Bend National Park in Texas and the Everglades in Florida.



Lack of Staffing and Upkeep

Decreased monitoring fund puts NPS in a tough position where they can't keep up with the continued maintenance and staffing needs.

How Air Monitoring Aids Policy Makers

Air Monitors provide the most useful, accurate and complete data possible. They help decision makers identify emission sources for pollution prevention and control in and around the national parks.

Monitors Help Answer Some Essential Questions about Air Pollution

WHAT?

What are the levels of pollution in national parks? What types of pollutants are reaching the parks and from what sources?

HOW?

How does pollution affect park ecosystems, views and visitors?

WHERE?

Where is pollution traveling from?

WHEN?

When are the parks most impacted by pollution?

Air Quality Index - Particulate Matter

How Air Monitoring Aids Parks and Visitors

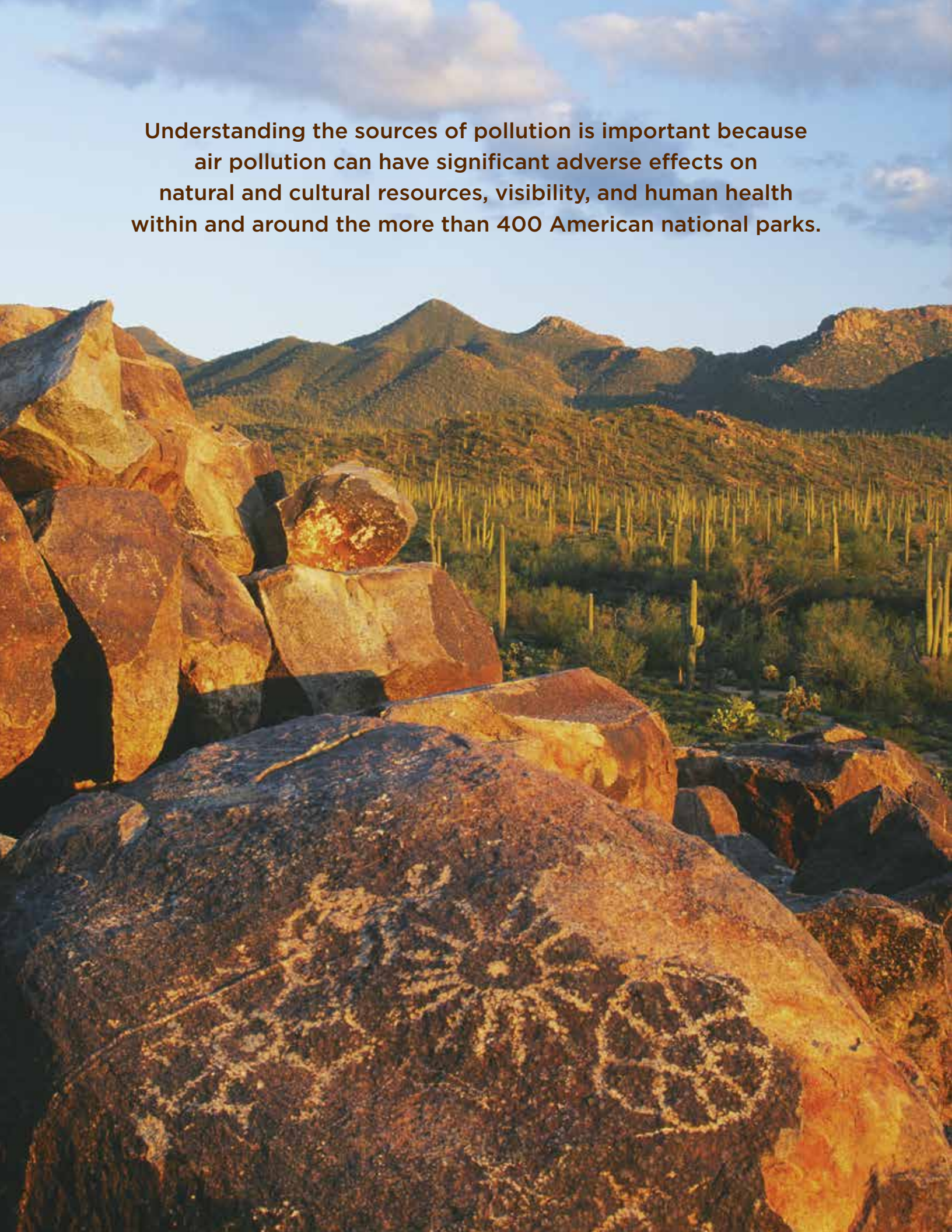
NPS monitors ozone at 102 parks hourly and issues alerts to the public when ozone reaches unhealthy levels. For people and wildlife, ozone makes it harder to breathe by inflaming and irritating our lungs. It can cause asthma attacks and is particularly dangerous when we breathe heavily—like when we're hiking in a park. Visitors can take precautions or postpone their visit once ozone levels have decreased.

The air pollution affecting our national parks negatively affects the health of people, the health of our natural environments (including wildlife, vegetation, lakes, streams, and soils), damages cultural resources, and can even impact how well we see. According to the NPS, the pollutants of concern are ground-level ozone, sulfur and nitrogen compounds, particulate matter (PM), toxic compounds (such as mercury and pesticides), and greenhouse gases.[3] This report mainly focuses on ground-level ozone,[4] sulfur and nitrogen compounds, and PM.

Most of the air pollution affecting national parks is created outside of park boundaries. That pollution is linked to four main types of sources: mobile sources,[5] stationary sources,[6] area sources,[7] and natural sources.[8] Mobile sources account for more than half of all the air pollution in the United States, with cars being the primary mobile source. Stationary sources, like power plants, emit large amounts of pollution from a single location and are sometimes called point sources. Together, mobile and stationary sources are the most significant cause of pollution in our national parks. And while the majority of these sources are not found within park boundaries, pollution from these sources travel with the wind and impact our most protected national park lands and cultural resources. Accordingly, air quality monitoring networks need to be robust and well-maintained to help us better understand and track our air pollution problems.

The NPS participates in a variety of monitoring networks to track visibility, gaseous pollutants, and atmospheric deposition in parks around the country. These networks monitor both the quantity and specific makeup of pollutants, visibility impacts caused by haze, PM, ozone concentrations, and airborne concentrations of sulfur and nitrogen. Monitoring data is then used to inform the public and to help environmental decision-makers identify emission sources for pollution prevention and control. However, recent data losses due to more frequent and extreme weather events, more frequent and destructive wildfires, the COVID-19 pandemic, and aging infrastructure threaten the completeness and continuity of monitoring data from these networks. Unfortunately, while Congress has given the power to both NPS and the Environmental Protection Agency (EPA) to monitor and address air quality, the NPS cannot meet its federally-mandated air quality obligations unless Congress also provides adequate funding to repair, expand, and upgrade our existing monitoring networks.

Understanding the sources of pollution is important because air pollution can have significant adverse effects on natural and cultural resources, visibility, and human health within and around the more than 400 American national parks.



Air Quality and National Parks

Air Quality Effects on National Parks

Per NPCA's 2019 Polluted Parks report, 96% of national parks in the United States suffer from significant problems related to and caused by air pollution. As there are over 400 national parks across the country, this indicates that there is a serious air quality problem throughout the country that has not been solved since Congress made air pollution control a national priority. Poor air quality makes air unhealthy to breathe, causes haze pollution, and detrimentally impacts sensitive species and habitats within national parks. And most of the same sources of pollution that contribute to these problems, are also driving the climate crisis—further exacerbating the degradation of our national parks.

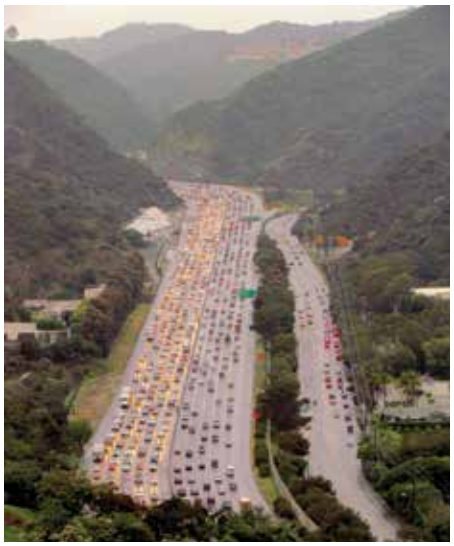
Most air pollution originates far beyond national parks, from mobile, stationary, area, and natural sources,[9] sometimes traveling hundreds of miles. Mobile and stationary sources are of the greatest concern as they are the largest sources of pollutants that ultimately end up in national parks. Mobile sources, such as automobiles, on- and off-road vehicles, and planes, emit NOx that reacts with VOCs in the presence of sunlight to create ground-level ozone. While mobile sources from roads, highways, and other high-traffic areas that lie outside of national parks create pollution that is blown by wind into the parks,[10] mobile sources also generate air pollutants within parks from park employees and visitor vehicles. Stationary sources, like power plants and oil refineries, emit tons of pollutants, including NOx, VOCs, SO2, PM, greenhouse gases, and hazardous air pollutants. Area sources are typically made up of smaller individual sources, which when aggregated can be significant. Historically these sources had not been a dominant contributor to national parks pollution but are becoming increasingly significant due to increased oil and gas development in rural areas (leading to higher levels of VOCs and methane).[11] Understanding these sources of pollution, including pollutant trajectories, is important because air pollution can have significant adverse effects on natural and cultural resources, visibility, and human health within and around the more than 400 American national parks.[12]

Ground-level ozone and PM can detrimentally impact human health for park visitors, employees, and nearby residents, including many disproportionately impacted communities such as Black, Indigenous, and People of Color (BIPOC) populations. Ground-level ozone is a significant danger because even short-term exposure to high levels of ozone can irritate respiratory systems and reduce lung function, especially in people who suffer from asthma or other respiratory issues. Children, people with asthma, older adults, active workers, and those who work outdoors are at the greatest risk from ozone exposure, although healthy people without any preexisting conditions can also suffer from the harmful effects of ozone.[13] These effects include difficulty breathing, shortness of breath, pain while breathing, sore throat, coughing, inflammation and damage to airways, aggravation of existing lung diseases, more frequent asthma attacks, and weakening the lung resistance to respiratory diseases.[14] In particular, park rangers and visitors at

Check it Out!

Nearly every national park is affected by air pollution and climate change in adverse ways. NPCA's *Polluted Parks* report evaluates damage from air pollution at 417 national parks based on harm to nature, hazy skies, unhealthy air and climate change.

Opposite Page: Signal Hill, Saguaro National Park, Arizona ©Dndavis | Dreamstime **Bottom Left:** Los Angeles highway, California ©Julien Viry | Dreamstime **Bottom Right:** Oil pump, front range of the Colorado Rocky Mountains ©Steve Keller | Dreamstime



national parks are at higher risk of health issues due to elevated ozone levels by working and recreating outdoors for extended periods of time. Due to the seriousness of these effects, the NPS actively monitors ozone at 102 national parks on an hourly basis and issues alerts to the public when ozone levels are at unhealthy levels.

Elevated PM levels can cause many of the same health effects in children, adults with heart or lung disease, and asthmatics, as well as causing temporary symptoms of irritation of the eyes, nose, and throat even in healthy visitors.[15] The two types of PM of concern are classified as "fine particulates", which are 2.5 micrometers or less and are typically found in smoke or haze, and "coarse particles," which are between 2.5 and 10 micrometers (both much smaller than human hair, which typically has a diameter of 50-70 micrometers). Fine particles are particularly dangerous because they can work their way into the lungs and bloodstream.

Impacts on Parks and Communities

Our national parks are places of unparalleled natural wonder, historical significance, and cultural value, yet most are plagued by poor air quality that can threaten human health and detrimentally impact park ecosystems.

Cultural Resources	**Air pollution can degrade building, artifacts and entire monuments through chemical corrosions and soiling caused by particles.**
Lakes and Streams	**Nitrogen and sulfur pollution that comes through rain, snow or fog can cause changes to water chemistry.**
Plants and Soil	**Ozone pollution stifles tree and crop growth and causes leaves of common tree species to blacken and wither.**
Wildlife	**Any changes to ecosystem's air, water and soil due to air pollution and climate change, directly impact wildlife's ability to adapt and survive.**
Lost Revenue and Lower Visitation	**When the air at a national park isn't clean, visitation drops by at least 8 % harming local economies and indicating that air quality directly affects national park public use.**
Park Views (Haze)	**Air pollution obscures scenic park views—in some cases obliterating more than 90 miles in visibility.**
Public Health	**While air pollution affects everyone, those exercising outdoors, children, the elderly and anyone with asthma or other respiratory illnesses are especially at risk.**

People with heart disease are at elevated risk when it comes to high PM levels as exposure can trigger heart attacks.

The sensitive plant and animal species protected within national parks are vulnerable to air pollution in several ways. Nitrogen and sulfur deposits can cause acidification of soil and water (e.g., acid rain). These effects are especially detrimental to the sensitive flora, bodies of water, and shrublands in deserts and high-elevation parks. Nitrogen-caused artificial fertilization can negatively affect biodiversity in protected flora and disrupt the ecosystem's nutrient cycling. These effects are especially prevalent in nutrient-poor ecosystems where small changes in soil composition can have significant ecosystem changes. Furthermore, acidification of water bodies is especially prevalent in the Eastern United States as a result of generations of poorly regulated pollution. Even today, many water bodies still register nitrogen pollution levels above the critical-load amount, meaning that there are harmful changes in the affected ecosystems. Algae bloom caused by this excessive fertilization can result in fish die-offs due to lack of oxygen, and some water ecosystems become uninhabitable for

Above: ©Wavebreakmedia Ltd | Dreamstime

certain species of fish altogether. Cultural sites and historic artifacts are also at risk as acid rain can accelerate the deterioration of stone, causing the premature loss of structures and artifacts with historic value located within national parks.

Ground-level ozone is also a significant harm to nature. Ozone enters plants through small openings in leaves and oxidizes the plant tissue during the respiratory cycle. High levels of ozone in plants can reduce photosynthesis, slow growth, and reduce natural resilience to environmental stressors such as disease, insect damage, severe weather, and other pollutants. Increased ground-level ozone can injure sensitive plants, essentially "burning" the plant during its respiratory cycle, and decrease their resiliency and survival. On days when ozone pollution is high, chances are that visibility is also impaired.

Air Pollution Has No Boundaries

On average, air pollution causes 50 miles of scenery to be lost to regional haze and also has far ranging impacts within park boundaries.

Visibility impairment, also known as haze, happens when sunlight encounters tiny particles in the air (more particles mean more impairment).[16] Some of the causes include natural haze from dust and some types of wildfires, but also air pollution (including SO2 and NOx) from industrial sources, power generation, transportation, and agriculture. While visibility has improved by an average of twenty to thirty miles over the past twenty years, the clarity of views at nearly all national parks are still impacted by air pollution. On average, air pollution causes fifty miles of scenery to be lost at national parks due to regional haze. When park visibility is bad, there is a robust and statistically significant decrease in park visitors as compared to the number of visitors when visibility is considered to be good according to a 2018 study conducted by Iowa State and Cornell University.[17] Furthermore, visibility tends to be worst during summer, when the number of visitors to national parks peaks. Where visitors shorten or cancel park travel due to poor air quality, local businesses pay the price.

Below: Bryce Canyon National Park, Utah
©Marysmn | Dreamstime

Air Quality Conditions and Trends in National Parks

In 2002, the NPS prepared a report that offers an in-depth summary of air quality based on 20 years of monitoring data conducted in national parks.[18] In that report, the NPS found that average annual visibility in Eastern parks was about 100 miles less than estimates for natural visibility conditions; Western parks, although significantly better when compared to their Eastern counterparts, fell short of natural visibility conditions by between sixty and ninety miles. Although average visibility across the country improved significantly in the ten years after the passage of the 1990 Clean Air Act (CAA) Amendments, not all national parks showed an improvement in visibility over the same period of time. Additionally, the 2002 Report indicates that despite improvement in visibility on the clearest days, many Western parks showed either degradation or significant degradation in visibility on the haziest days tracked between 1990 and 1999. The 2002 Report also found that despite improvements to urban area ground-level ozone levels, "ozone … levels in 29 parks have increased by 4 percent, with some parks showing increases of nearly 20 percent."[19] Accordingly, the "clear message that has emerged … is that good air quality in national parks cannot be taken for granted."[20]

Above: Sequoia National Park, California ©Haveseen | Dreamstime **Below:** Monument Valley Navajo Tribal Park, Utah (Left) ©Lunamarina | Dreamstime • (Right) ©Richard Van Der Woude | Dreamstime

Monitors by the Numbers

NPS collects and analyzes data from air monitors inside and outside national park boundaries, but many parks have no monitors in which to access data.

69

Number of parks with access to monitors **inside** park boundaries

230

Number of parks with access to monitors **outside** park boundaries

124

Number of parks with no access to monitors in or out of park boundaries

Although the NPS has not released any updates to its 2002 Report, the NPS has a website ("The Big Picture") with more recent information on conditions and trends. This information is based on monitoring data and NPS analysis methods.[21] While air quality has improved over the last 30 years, current conditions are still poor in hundreds of parks and recent 10-year trends for visibility, ozone, nitrogen and sulfur deposition, and PM are largely stagnant or deteriorating in numerous parks across the country. [22] Indeed, 93 national parks do not meet the EPA's 2015 ozone standard (set at 70 ppb),[23] and the 2018 study conducted by Cornell University and Iowa State University found that while "summer ozone concentrations decreased by more than 13% from 1990 to 2014 in metropolitan areas ... National parks saw less progress."[24] In fact, ozone exceedances occur regularly, especially in the Southwest, forcing the NPS to issue ozone safety alerts to protect visitors and sensitive populations. For example, Sequoia and Kings Canyon National Parks recorded no fewer than 67 ozone exceedance days between 2009 and 2018 (with one year recording 110 exceedance days).[25] Twenty-seven national parks and monuments, moreover, exceeded the ozone standard at least once between January and October 2020.[26] And because these alerts and exceedances are tied to the EPA's current 70 ppb ozone standard, there may be additional unaccounted for harms.[27]

The "bigger picture" found on the NPS's website, however, is that the vast majority of parks in the country have no trends information available. No data after 2018 is available for any national park. Air quality in national parks is a matter of great importance for NPS research and the agency has long demonstrated its commitment to fulfilling its duty to protect air quality and related values in some manner since the NPS was itself established. While air quality trends and conditions show some improvements, there is still work to be done and clean air "cannot be taken for granted." But to build on this progress, we need adequate air monitoring to determine what steps may be taken to improve the air in all of our national parks.

Top: Air quality technician checks equipment at Sequoia National Park monitoring site, California ©NPS **Above:** Harper's Ferry National Historical Park, Maryland ©Steveheap | Dreamstime

Monitoring provides information that allows people, including vulnerable populations, to either take precautions or change their plans to guarantee a safe, enjoyable trip to Joshua Tree, Acadia, or any one of the beautiful parks in the United States where and when air quality is an issue.

Legal Requirements for Air Quality Monitoring

As the NPS acknowledges, it has a responsibility under the NPS Organic Act and the CAA "to protect air quality and resources that might be adversely affected by air pollution."[28] "Monitoring," the NPS explains, "is critical to carrying out these statutory mandates."[29] In addition to these two laws, the NPS also has obligations under the Wilderness Act and the National Environmental Policy Act—both of which also rely on adequate monitoring to be effectively implemented.

NPS Organic Act

The NPS Organic Act was passed in 1916. It established the NPS within the Department of Interior (DOI). The NPS is required to manage National Parks monuments, and reservations with the purpose to "conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations." In the past, the National Park Service the court, in the case *Greater Yellowstone Coalition v. Kempthorne*, found that "impairment" means "an impact that 'would harm the integrity of park resources and values, including the opportunities that otherwise would be present for the enjoyment of those resources or values."[30] That impairment includes "impacts on air quality," which can "have impacts on human health and the quality of visitor experience."[31] It is clear that the National Park Service must work to improve air-quality to follow its statutory mandate.

While the EPA is the primary agency that regulates air pollution, the NPS helps inform better regulation through its understanding and analysis of air quality conditions and trends within national parks. At the very least, the NPS must consider how its actions may affect air quality (even if it does not itself regulate air pollution). To do so, however, the NPS requires a robust monitoring network. The data needed to understand

Statutory Mandates

Mandated by numerous legislation, NPS has a legal responsibility to protect air quality and resources that could be adversely affected by air pollution. And air monitors are a crucial tool in this effort.

- **1916** NPS Organic Act
- **1963** Clean Air Act
- **1964** Wilderness Act
- **1969** National Environmental Policy Act

air quality in national parks helps provide the Park Service with knowledge about the area, which can inform research on the best strategy to protect it. For example, in Joshua Tree National Park the staff posts health advisories when ozone reaches unhealthy levels. Without the underlying data, health advisories would not be possible. That could have a devastating effect on visitors because ground-level ozone can be harmful to children, the elderly, those with health problems and those who work or exercise outdoors causing lung damage, sinus inflammation and several other irritating respiratory issues. Monitoring will give those vulnerable populations information that allows them to either take precautions or change their plans to guarantee a safe, enjoyable trip to Joshua Tree, Acadia, or any one of the beautiful parks in the United States where and when air quality is at issue.

Improving air quality in national parks can make trips to parks safer and more enjoyable, but without first having the proper understanding of the problem, generated through air monitors and interpreted by the NPS, the agency cannot adequately manage parks the way the 1916 Organic Statute requires.

Opposite Page: Joshua Tree National Park, California ©Wirestock | Dreamstime **Above:** Bison, Yellowstone National Park, Wyoming ©Ace10462 | Dreamstime

Wilderness Act

The Wilderness Act was passed in 1964 and required that an area designated as wilderness be "protected and managed so as to preserve its natural conditions." Like in national parks, the requirement to protect and preserve natural conditions applies to air quality. These Wilderness areas include a national network of more than 400 federally-designated areas and are managed by the NPS, the Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (USFWS), and the U.S. Forest Service (USFS). In 2006, the NPS issued guidelines on what constitutes wilderness areas in national parks. The guidelines say that NPS lands that are at least 5,000 acres and have the following five characteristics: 1) The earth and its community of life are untrammeled by humans, where humans are visitors and do not remain; 2) The area is undeveloped and retains its primeval character and influence without permanent improvements or human habitation; 3) The area generally appears to have been affected primarily by the forces of nature, with the imprint of humans' work substantially unnoticeable; 4) The area is protected and managed so as to preserve its natural conditions; and 5) The area offers outstanding opportunities for solitude or a primitive and unconfined type of recreation.[32]

In order to adequately maintain wilderness areas, the NPS must intimately understand the resources and values of those areas and the effect of air quality on them. Similarly, the 2006 NPS Management Policies indicate that the NPS "has a responsibility to support appropriate scientific activities in wilderness" and "scientific activities are to be encouraged in wilderness."[33] It even mentions "those scientific activities (including inventory, monitoring, and research) that involve a potential impact to wilderness resources or values (including access, ground disturbance, use of equipment, and animal welfare) should be allowed when the benefits of what can be learned outweigh the impacts on the wilderness resources or values."[34]

Similarly, the management policy says that "in every park containing wilderness, the conditions and long-term trends of wilderness resources will be monitored to identify the need for effects of management actions."[35]

Not only do the 2006 NPS Management Policies allow for monitoring in Wilderness areas, it mandates it. Section 4.7.1 states "The National Park Service has a responsibility to protect air quality under both the 1916 Organic Act and the [CAA]. Accordingly, the Service will seek to perpetuate the best possible air quality to parks." It then says "because the current and future quality of park air resources depends heavily on the actions of others, the Service will acquire the information needed to effectively participate in decision-making that affects park air quality." This includes a call for the service to both "inventory the air quality-related values associated with each park" and "monitor and document the condition of air quality and related values."

Currently, 50 national park units have designated wilderness areas, totaling more than 44 million acres.[36] Many other parks have "other categories of wilderness" that are managed under the same wilderness policies. Together, over 80% of NPS lands are managed as wilderness. This stunning wilderness acreage is encouraged by the 2006 NPS Management Policies to be monitored for long term trends to best manage the area. In order to follow those guidelines, there must be sufficient funding to ensure that "every park containing wilderness" has monitoring that is adequate to enable the Park Service to "identify the need for effects of management actions."

Above Left: Park runner ©Mimagephotography | Dreamstime **Above Right:** Moro Rock, Sequoia National Park, California ©Filedimage | Dreamstime **Below:** Yellowstone National Park, Wyoming ©Brizardh | Dreamstime

The only way for the NPS to be certain it is adequately determining the environmental impacts of any decision it makes, it needs to understand the air quality baseline of the park where that decision is being made.

National Environmental Policy Act

In 1969, Congress passed the National Environmental Policy Act. NEPA is sweeping legislation that impacts every federal agency. It requires any federal agency to conduct an Environmental Impact Statement (EIS) any time it is undertaking a major action that may adversely impact the surrounding environment. As a Federal Agency, the NPS must adhere to NEPA whenever it commits to a major action. In 2011, the Director of the NPS issued an order to the NPS along with a handbook on following NEPA. Within the order, the Director highlighted that "it is essential that NPS management decision (1) be scientifically informed, and (2) insist on resource preservation as the highest of many worthy priorities."[37] The Director's Order continues to command park superintendents to carry out the "day-to-day implementation of conservation planning and impact analysis activities related to parks under their administration."[38] This includes both assuring the best science is being used and implemented within the park, but also that resource specialists have "knowledge of existing technical and scientific information on park resources and the quality of such information." Similarly, the corresponding NEPA Handbook (which was amended in 2015) explicitly expressed the need for park employees to consider air quality as a direct impact on any management decision and even as an indirect impact when a management strategy such as the creation of a parking lot, could foreseeably increase vehicles on the road and adversely impact air quality.

In order to comply with NEPA, the NPS must use the best science available. The best science includes data about the current air quality of parks. Without that data, the NPS will not be able to adequately determine whether the action it is considering will meet a "critical load"—the amount of pollution above which harmful changes in sensitive ecosystems occur.[39] The only way for the NPS to be certain it is adequately determining the environmental impacts of any decision it makes it needs to understand the air quality baseline of the park where that decision is being made. Without that knowledge, the NPS runs the risk that it may allow an action or management strategy to take place without actually considering the possibility of reaching the critical load of pollution that will certainly violate the duty NPS has to conserve areas from impairment.

Above: Winding road in Olympic National Park ©Jerryway | Dreamstime **Below:** Yosemite Village, Yosemite National Park, California ©Maryna Konoplytska | Dreamstime

Clean Air Act

The CAA was originally passed in 1963, but significantly amended in 1970. Since then, it has been substantially amended in 1977 and in 1990. Generally stated, the CAA includes programs for criteria pollutants, hazardous pollutants, acid deposition, and regional haze (among others). Under the National Ambient Air Quality Standards (NAAQS) program, the EPA has targeted six criteria pollutants for regulation: Carbon Monoxide, Lead, PM, Ozone, Nitrogen Dioxide and SO2. For these pollutants, the EPA sets national primary (public-health-based) and secondary (welfare-based)[40] standards. The EPA then designates areas of the country as meeting those standards ("in attainment") or failing those standards ("in nonattainment"). In order to maintain air quality that complies with NAAQS standards, pollution sources are required to implement certain measures identified by states and approved by EPA in State Implementation Plans (SIPs). Because national park pollution mainly happens outside of a park and then enters the park, adequate NAAQS standards and SIPs are critical to cleaning national park air.

In 1977, Congress amended the CAA to add—among other programs—visibility provisions to protect "areas of great scenic importance." In particular, CAA section 169A establishes a national visibility improvement objective that includes remedying existing impairment and preventing future impairment in 156 "Class I" areas, which include national parks larger than 6,000 acres and national wilderness areas larger than 5,000 acres what were in existence in 1977. The CAA's visibility provisions are implemented through SIPs and require coordination among the EPA, states, and Federal land managers (such as NPS).

Top: Pollution detection center in park ©Phuchit | Dreamstime **Above:** NPS employee changing a filter pack on an IMPROVE visibility monitoring station. Photo courtesy of Mackenzie Reed/NPS **Below:** South rim, Grand Canyon National Park, Arizona ©Twildlife | Dreamstime

The 1977 CAA Amendments also established the Prevention of Significant Deterioration (PSD) program, which was designed to provide protections from pollution in areas that have clean air already. The PSD program requires certain stationary sources to undergo preconstruction permitting review, which includes installation of Best Available Control Technology to reduce air pollution. The review procedures also authorize Federal land managers to review and comment on PSD permit applications and require a permit applicant to prove that they will not cause or contribute to an adverse impact to air quality related values in any Class I area (often by way of air quality modeling). It is imperative that national parks, and Class I areas in particular, have adequate air quality monitoring because air quality models are informed by monitoring data. Without critical monitoring data the EPA, permit applicants, and the Federal land managers cannot ensure that a newly permitted source will not cause or contribute to adverse impacts to air quality in our national parks.

In order for the NPS to comply with its statutory mandates under the NPS Organic Act, Wilderness Act, NEPA, and the CAA, it must rely on an adequate air monitoring program to better understand baseline air quality information, knowledge of trends, and speciation of pollutants.[41] While the NPS works with park resource managers and partners to operate an Air Quality Monitoring Program, limited and shrinking budgets are exacerbating the NPS' own monitoring efforts as well as those of other agencies. In the absence of increased funding, profound impacts are anticipated—preventing the NPS from addressing new and important emerging issues (including those related to climate change, such as more frequent and extreme wildfires) and may even restrict the ability of the NPS and park resource managers to carry out its core duty to conserve unimpaired the natural and cultural resources and values of the National Park System for the enjoyment, education, and inspiration of this and future generations.[42]

Above: Forest Fire, Lake Yellowstone, Yellowstone National Park, Wyoming ©James Mattil | Dreamstime **Below:** Air quality monitoring site near Long's Peak, Rocky Mountain National Park, Colorado. Photo courtesy of Mackenzie Reed/NPS **Bottom:** Mesa Verde National Park, Colorado ©Tang90246 | Dreamstime

Monitoring networks give the public and agencies a better, more complete understanding of air quality conditions and trends throughout the United States. This helps to inform policy making at the federal and local levels.

Air Quality Monitoring[43]

The NPS, EPA, and other federal, state, and local organizations implement a variety of air quality monitoring networks in response to the statutory requirements laid out by Congress. Together, these monitoring networks give the public and agencies a better, more complete understanding of air quality conditions and trends throughout the United States. This helps to inform policy making at the federal and local levels.

The NPS Air Resources Division (ARD) has three primary focuses for its Air Quality Monitoring Program: visibility, gaseous pollutants, and atmospheric deposition. Additionally, the program has three main objectives: documenting current conditions and tracking trends, understanding sources of pollution, and identifying risks to park air quality and resources impacted by airborne contaminants.[44] For these monitoring objectives to be met adequately, ARD requires continuity of measurements, high temporal and spatial resolution from monitoring sites, robust sample collection and analysis, and inclusion of additional data such as survey monitoring, special studies, and seasonal measurements.[45]

The networks detailed below provide critical monitoring data to identify and assess park-specific as well as national air quality conditions and trends. But according to a 2015 NPS report on air quality monitoring, some monitors have been in operation since the 1970s and the equipment may be decades old. Moreover, rising costs and decreased funding "have impacted all facets of the monitoring networks, resulting in less rigorous quality control measures, a reduction in the number of stations, measurement gaps, and termination of measurements."[46]

The Interagency Monitoring of Protected Visual Environments (IMPROVE) Network is the main visibility monitoring network across the country. It was established in 1985 and consisted of monitoring sites located mainly in national parks. However, with the implementation of the Regional Haze Rule (RHR), the number of monitoring sites was expanded to monitor federally-designated Class I areas. In addition to the main IMPROVE network, separately-sponsored protocol sites collect data outside of Class I areas using identical technology, giving a general overview of visibility, both within and beyond national parks across the country. IMPROVE is a collaborative network managed by a steering committee: the members of the committee consist of representatives from the EPA, NPS, USFS, FWS, BLM, National Oceanic and Atmospheric Administration (NOAA), state air quality organization representatives, the Arizona Department of Environmental Quality, Environment and Climate Change Canada, and the South Korea Ministry of Environment. The IMPROVE objectives are to provide current visibility conditions in Class I areas, identify sources of human-created visibility impairment, record long-term visibility trends, and participate in regional haze monitoring. Each IMPROVE site collects 24-hour samples every three days using four independent sampling modules designed to analyze different types of air pollutants; some monitors also include optical monitoring and record real-time scenic conditions.

Gaseous pollutant monitoring measures ozone and meteorological parameters. Most of the NPS's gaseous monitoring stations are part of the Clean Air Status and Trends Network (CASTNET), which assesses trends in pollutant concentrations, atmospheric deposition, and ecological effects attributed to changes in air pollutant emissions. While the NPS and the EPA are the main sponsors of the program, other organizations like the

Objectives of the Air Quality Monitoring System

1 **Documentation**
Documenting current conditions

2 **Tracking Trends**
Tracking trends and understanding sources of pollution

3 **Identification**
Identifying risks to park air quality and resources impacted by airborne contaminants

Opposite Page: Great Mountains National Park, Colorado ©Nickolay Khoroshkov | Dreamstime

BLM, Tribal leadership, universities, and other state and local agencies play a key role in sponsoring individual CASTNET sites and providing services that support the operation of the network. These organizations contribute by providing land, covering general operations and maintenance, and engaging in air monitoring analysis. While traditional CASTNET sites require shelter and significant energy, technological advances since 2012 have allowed new smaller footprint sites to be installed in the northeast which are cost-effective and require less infrastructure.

The National Atmospheric Deposition Program (NADP) is a monitoring program for precipitation chemistry and consists of aggregating data from many different groups and monitoring systems that has been in place since 1978. NADP is useful for tracking wet deposition (CASTNET, on the other hand, can provide estimates for dry deposition). The National Trends Network (NTN) collects and records long-term data regarding acids, nutrients, and base cations in precipitation across the United States. The NTN is of particular value for national parks because its sites are primarily located away from urban areas and sources of pollution, meaning that it collects data that is representative of the typical location of national parks away from industrial areas or major cities. The NTN collects data by collecting and analyzing precipitation samples weekly for pollutants.

Both the IMPROVE and CASTNET are predominantly rural networks (whereas EPA and State managed SLAMS and NCore monitors are predominantly urban). Accordingly, these networks are invaluable in understanding the nature and extent of pollution problems around the country.[47] This is particularly the case for disproportionately affected BIPOC communities who may reside outside of urban centers and not have locally-sited monitors.

The NPS Gaseous Pollutant Monitoring Program (GPMP) was implemented in 1980 as part of the monitoring response to Congress's Regional Haze Rule. The sites are located primarily around or in Class I areas, and as such are concentrated in the western United States. Data from this program is utilized to establish existing or baseline gaseous pollutant concentrations in national parks, assess air quality trends, and evaluate compliance with national air quality standards. Furthermore, this network helps to identify air pollutants with the potential to cause adverse effects to national park resources and compare measurable effects of pollution to existing pollutant levels.

Below: Air monitoring tower at Wind Cave National Park broken during a strong blizzard in December 2017 ©National Park Service

Visibility Air Monitoring Explained
Visibility monitoring data is one of the many types of data collected and analyzed at national parks. These monitors measure aerosol particles in the air that absorb light and create haze that impairs visibility.

And though NPS' "first priority is maintaining [its] current monitoring capabilities," increased smoke impacts in parks over the last several years revealed "real-time smoke monitoring as a high priority."

Currently, 74 parks have in-park monitoring of one or more air quality parameters and an additional 230 parks have nearby monitoring that the NPS considers "representative" of park air quality conditions.[49] In total, there are 240 monitors situated in national parks and 380 representative monitors. Nevertheless, not all monitors measure data for all parameters; for example, some PM monitors can only measure PM2.5 or PM10 (and no other pollutants).[50]

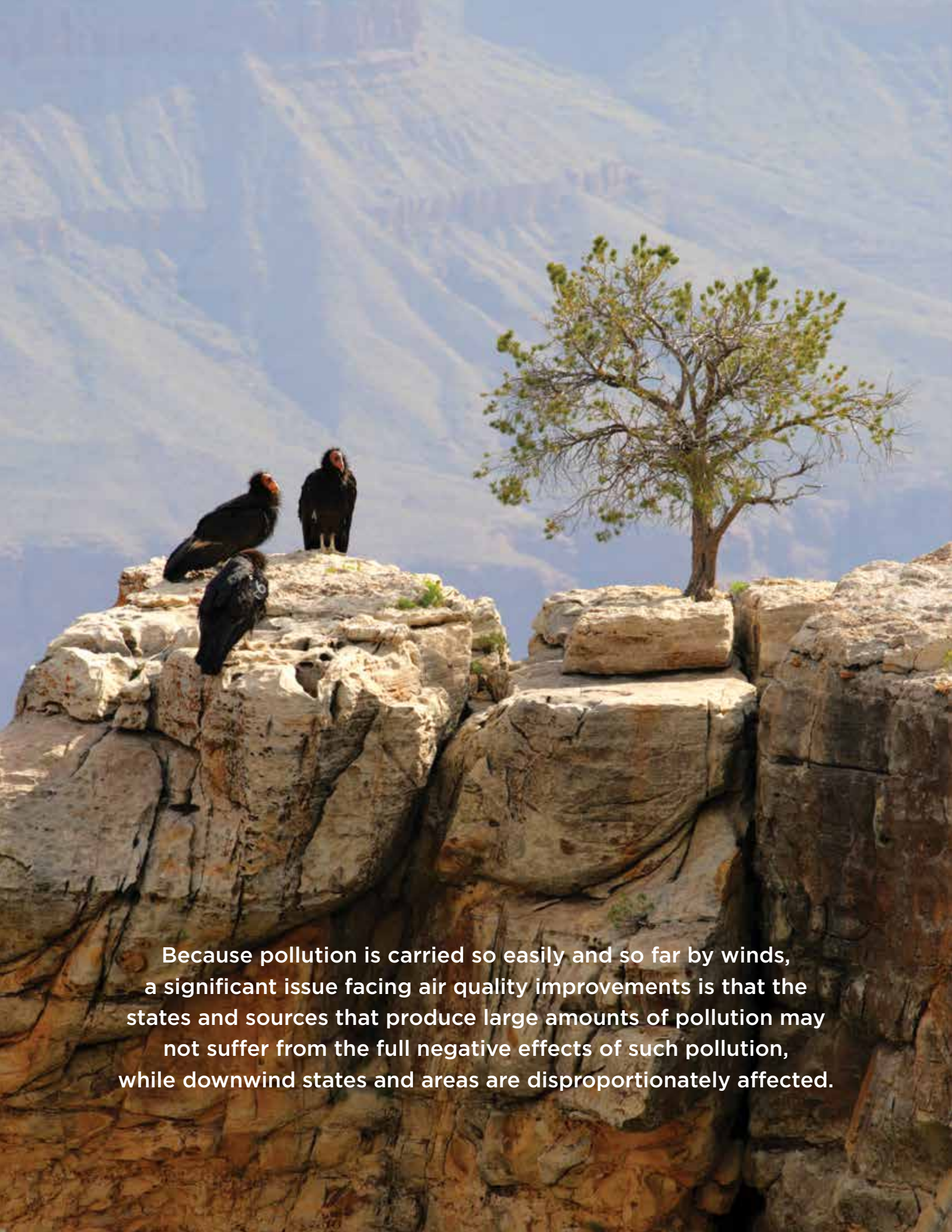
The biggest issue facing the different monitoring networks is shortfalls in funding. While cost-saving measures have been implemented in recent years, the 2015 NPS report makes clear that future cost-saving measures will necessitate reducing the number of pollutants measured, reducing participation in collaborative networks, and reducing the actual number of sampling sites in NPS-run networks. But in response to questions posed by NPCA in late 2020, the NPS explained that "stagnant or reduced budgets combined with increasing costs have made it necessary to reduce network sizes and capabilities, along with reduced analysis and reporting. These cuts have impacted spatial coverage, and data quality has suffered."[51]

These cost-saving measures are antithetical to the NPS's mission to monitor and improve air quality in national parks. Increased funding and support for the NPS is needed to maintain monitoring at even current levels and to allow for improved and expanded networks that will continue to provide valuable, comprehensive, and reliable data. Meanwhile, over the past 10 years, "25 IMPROVE sites have been removed … due to budget constraints," "CASTNET has lost 4 sites," and "20 GPMP sites have ozone instruments that will no longer have certifiable data beginning in the next 2 years."[52] Additionally, "[m] any tribal communities are underserved from a monitoring standpoint" and "hundreds of urban and suburban park units that have little to no air quality monitoring."[53]

Maintenance measures for active sites have also slowed. "The reduced maintenance visits have resulted in an increase in data loss due to instrument failures."[54] Reduced funding has also impaired NPS' ability to backfill positions lost to retirement or departure.[55] And though NPS' "first priority is maintaining [its] current monitoring capabilities," increased smoke impacts in parks over the last several years revealed "real-time smoke monitoring as a high priority."[56]

As noted above, these monitoring networks help identify sources of pollution and pollutant trajectories (i.e., where and how far pollution travels). With incomplete or scant data, federal and state decision-makers may not be able to spot pollution trends or secure necessary pollution controls. And while regulators often prioritize urban pollution, some of that pollution may be falling on rural communities and our national parks hundreds of miles away. Finally, due to rapid increases in oil and gas development and production operations near many national parks, there is an urgent "need to better characterize related emissions" in order to influence "future oil and gas emission control strategies.[57]

Above: Sulfur gas vents, Hawaii Volcanoes National Park, Hawaii ©George Burba | Dreamstime

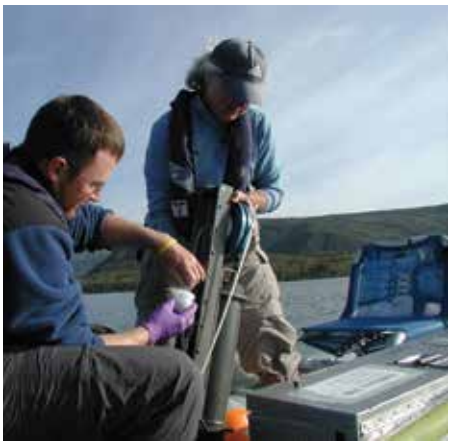


Because pollution is carried so easily and so far by winds, a significant issue facing air quality improvements is that the states and sources that produce large amounts of pollution may not suffer from the full negative effects of such pollution, while downwind states and areas are disproportionately affected.

AQ Analysis and Importance

While cities have seen large improvements in air quality over the last few decades, the same success has not been seen in national parks.[58] Air quality monitoring provides information about current conditions and how pollution may be moving from sources hundreds of miles away, providing guidance for what preventative measures may result in actual improvement in national parks and the areas where they are located, many of which are rural. As laid out in section III, the EPA sets NAAQS for certain air pollutants that define protective levels of air quality around the country. States must ensure that their areas meet those standards, or else the areas are designated as "nonattainment areas." These nonattainment areas tend to be concentrated in urban settings in California and the Northeast. However, sources within a nonattainment area (or even cleaner, "attainment" areas) can cause pollution problems downwind from even hundreds of miles away. Furthermore, nearly 110 national parks are located in nonattainment areas where the pollution does not have to travel nearly as far to negatively impact the parks, visitors, employees, and nearby communities.[59]

Because pollution is carried so easily and so far by winds, a significant issue facing air quality improvements is that the states and sources that produce large amounts of pollution may not suffer from the full negative effects of such pollution, while downwind states and areas are disproportionately affected. This phenomenon also helps explain why national parks, despite not much pollution occurring within their boundaries, experience such poor air quality. Air quality monitoring in national parks serves as an indicator that rural areas, along with national parks, can be disproportionately subjected to pollution even where they are not home to significant sources of pollution (notwithstanding pollution caused by wildfires).



Regional haze is another area of concern when it comes to air monitoring. In addition to obscuring scenic views, the same pollution that muddies the skies can also pose public health issues. Regional haze occurs most often when pollutant-laden air is trapped in low-lying areas and can stay in place for days at a time. Because of the aesthetic and health impacts of regional haze, Congress established the Regional Haze Program which requires the restoration of visibility in national parks to their natural conditions. While the response to regional haze is impressive and significant improvements have been made, there is still a long way to go to restoring park visibility to its full glory.

In addition to monitoring, the NPS is also tasked with aggregating and interpreting the data from air quality monitors and making it accessible. The agency also has an affirmative obligation to participate in and consult on environmental decision-making with state and local agencies as well as sister federal agencies. In so doing the NPS has an important role in SIPs, Regional Haze plans, and air permitting decisions connected to its duty to assess and protect air quality in national parks.

Opposite Page: California condors, Grand Canyon National Park, Arizona ©Chee-onn Leong | Dreamstime **Top Left:** IMPROVE air monitoring shelter blown over in 84 mph winds at Carlsbad Caverns National Park ©National Park Service **Top Right:** Sample collection from Denali National Park and Preserve, Alaska ©National Park Service **Bottom Left:** EPA air quality monitoring station ©Bidgee | Wikimedia Commons **Bottom Right:** Students observing ozone sensitive plants at an ozone garden in Great Smoky Mountains National Park ©National Park Service

Most of the work done on monitors—such as replacing filters and repairs after storms—can only be completed by someone manually. That means dollars that go to repairing and maintaining the National Park Air Quality Monitoring network also helps fuel American jobs, including in many rural or exurban areas where much national park land is located.

Recommendations | Future of Air Monitoring

Fortunately, most of the tools for the NPS are already in place, but adequate funding is needed to make these tools work as intended. Additional funding is needed to do three things. First, it will help repair or replace critical monitoring infrastructure that is broken down or severely damaged. Second, increased funding will help expand air monitoring networks (by restarting monitors and adding new ones). Lastly, increased funding can help develop new analytical and monitoring techniques to better detect air pollution problems. According to recent NPS estimates, an investment of $3.3 million is needed for infrastructure repair, replacement, or upgrades, and $2.608 million is needed annually for operation/maintenance and personnel.[60]

The first thing funding is needed for is to address the state of current disrepair in air quality monitoring. An increase in funding would ensure existing monitors can be repaired, brought back online and continuously maintained and monitored. Currently, air monitors are in national parks that are sometimes hard to reach. That means repairs can sometimes be costly or neglected. Similarly, filters need to be replaced occasionally and more routine maintenance is required. Funding can help ensure that these routine measures are consistently taking place, but sometimes routine measures are not enough. If air monitors are damaged in storms the NPS must be able to fix or replace those monitors. This is becoming especially important as climate change causes more frequent severe storms and more frequent wildfires. In 2019, the EPA along with the Office of the Inspector General pointed out that air quality monitoring is at risk of being inadequate when severe storms like hurricanes take place. In Texas and Florida, which are home to Big Bend National Park and the Everglades, respectively, are most in danger of serious storms and related issues. And, as the NPS recently stated, more significant smoke impacts have made "real-time smoke monitoring" a "high priority."[61] Without proper funding, air quality monitors are less resilient in dealing with an increasingly uncertain future. Similarly, without adequate funding, the NPS has not been able to adequately audit the data it is collecting.[62]

Increasing funding for routine maintenance and repair does not just help improve air quality monitoring, but it also represents an investment in American workers. Most of the work done on monitors—such as replacing filters and repairs after storms—can only be completed by someone manually. That means dollars that go to repairing and maintaining the National Park Air Quality Monitoring network also helps fuel American jobs, including in many rural or exurban areas where much national park land is located. Increasing funding is not just an investment in America's health, but also in its economy.

The next aspect funding will allow is an expansion of the existing networks. Both the IMPROVE and CASTNET networks are too small and made with aging infrastructure. However, an increase in funding could solve both of those issues. First, an increase in funding—especially funding directed by Congress to expand the monitoring—would allow NPS to begin expanding its network with new monitors. In addition to expanding the network, increased funding can also allow for innovation. Adding new monitors in places where there are no monitors or replacing older monitors with functional or more modern design will ensure that NPS is retrieving and using the most accurate data. This in turn will ensure better coverage of park sites with state of the art monitors, more comprehensive emissions information, and continuously reliable data capture. There are also newer, more

Opposite Page: Big Bend National Park, Texas ©Zrfphoto | Dreamstime **Above:** Tropical mangrove ©Andy Morgan | Dreamstime

Request for Air Monitor Funding

One-Time Infrastructure Investments: $3.3 Million

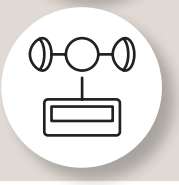
Repair

Repair broken monitors and infrastructure to bring equipment back online

Replace

Replace broken or outdated monitors to rebuild monitoring capacity and network.

Expand | Upgrade



Install monitors in necessary and high air pollution areas, and upgrade technology to meet present day air quality issues.

Annual Operating Cost: $2.6 Million

Maintenance

Regularly maintain air monitors and address routine upgrades and inspections of technology.

Personnel

Provide staff, universities and researchers with the funding necessary for maintenance, analysis and action.

BONUS: Economic Return-Jobs!

cutting-edge monitors that could be highly valuable if their efficacy were to be demonstrated. For example, low-cost, and more portable, monitors, known by the EPA as "air sensors" are becoming increasingly popular. With investment, field testing of these sensors could increase alongside greater data collection potentially establishing these monitors as reliable if the data verifies their accuracy. Expansion of existing networks is also needed to meet the urgent climate challenges we are facing today, including a need for smokie monitoring due to wildfire impacts that must be accounted for.

Lastly, there may be opportunities for next-generation "monitoring" through satellite-derived data. Launching in 2022, the Tropospheric Emissions: Monitoring of Pollution, or TEMPO, will monitor air quality during daylight hours in a geostationary orbit (meaning continuous information across the whole United States). Some of the anticipated benefits of TEMPO include: improved understanding of pollution sources and daily variations; better smoke monitoring (including how fire impacts the formation of ozone and PM); improved air quality warnings and alerts; better detection of stratospheric ozone intrusions (particularly in the mountainous western United States); and improved understanding of lightning-generated NOx, and associated formation of ozone.[63]

There are several reasons why TEMPO could revolutionize air quality in national parks. First, with satellite monitoring there could be an in-depth understanding of air quality as it exists now. TEMPO

may allow NASA in partnership with the EPA to get a complete monitoring picture of the entire United States without concern for storms or maintenance causing costly repairs. Second, TEMPO could reduce the need for ground monitors that may be difficult to maintain or access in national parks in the future. Lastly, with hourly monitoring of the entire United States, scientists in national parks may

have a better understanding of how air pollution travels from one place to another. With this kind of data, the NPS along with the EPA could better protect our most vulnerable places or identify areas that need an on-the-ground monitor. That clearer picture could pinpoint exactly what facilities cause the most pollution and where. That kind of data would give policymakers the tools to mitigate that pollution and ensure healthy, enjoyable visits to everyone's favorite natural, cultural and historic areas. But in order to take full advantage of TEMPO or other satellite "monitors," it is imperative that there be a comprehensive network of air quality monitors on the ground to validate the new data coming from such a novel technology. National park lands are the perfect place to expand this network because it will both fill the need for national park air quality monitoring, and simultaneously help scientists usher in a new era of air monitoring.

Above: North window, Arches National Park, Utah ID ©Andrey Tarantin | Dreamstime **Right:** Wrangell-St. Elias National Park and Preserve, Alaska ©Mariusz Jurgielewicz | Dreamstime

Conclusion

The NPS' mission is to preserve unimpaired the natural and cultural resources and values of the National Park System for the enjoyment, education, and inspiration of current and future generations. With improved air monitoring and better practices, the NPS can better address air quality within and around national parks and better protect our natural and cultural resources, as well as help protect the most vulnerable communities in and near our national parks.

Air quality in national parks needs significant improvement. The vast majority of the National Park System suffers from polluted air. This pollution puts natural and cultural resources as well as visitors of those parks at risk, not to mention neighboring communities. Accurate and comprehensive data is necessary for scientists and policymakers to adequately combat that problem. To repair and build out air quality monitoring sufficient to cover national park sites, Congress should provide additional funding at the level of $2.608 million a year and a one-time cost of $3.3 million,[64] the NPS and the EPA can improve current monitoring, expand the network, and use state-of-the-art air monitoring design. With better data in hand, regulators can better prioritize actions to mitigate emissions from sources affecting national parks and our communities. With less pollution, America's national parks will be better conserved for all to enjoy, including future generations.

Resources

1. For 100 years, the nonpartisan National Parks Conservation Association has been the leading voice in safeguarding our national parks. NPCA and its 1.3 million members and supporters work together to protect and preserve our nation's most iconic and inspirational places for future generations. For more information, visit **www.npca.org**.
2. See **https://www.npca.org/reports/air-climate-report**
3. **https://www.nps.gov/subjects/air/pollutants.htm**
4. Because ozone is not directly emitted into the air, ozone precursors—nitrogen oxides (NOx) and volatile organic compounds (VOCs)—are important pollutants to track because they react with sunlight to create ground-level ozone. Accordingly, this report addresses monitoring of NOx and VOCs as important contributors to ozone.
5. Mobile sources refer to the engine exhaust from cars, trucks, and other on- and off-road vehicles, which occurs inside and far beyond park boundaries.
6. Stationary sources include buildings with smokestacks (like power plants and oil refineries) as well as natural resource extraction (like mining and oil production/transportation), and other industrial emitting activities that take place in a defined area.
7. Area sources include agricultural areas, cities, and wood burning fireplaces.
8. Natural sources include wind-blown dust, volcanoes, and some wildfires.
9. While natural sources of pollution, such as some wildfires and wind-blown dust, can negatively impact air quality over short periods of time, they are not as easily-addressed through programs designed to reduce anthropogenic pollution. However, it is important to note that recent data has shown that the PM from wildfires may have an even more detrimental effect on human health than other PM in the atmosphere. See **https://www.nature.com/articles/s41467-021-21708-0#Sec2.**
10. Not only does ozone transport readily in the wind, VOCs and NOx can be blown hundreds of miles before reacting in sunlight to form ozone downwind.
11. See 2020 NPS Response to NPCA Monitoring Questions (on file with NPCA) (hereafter, 2020 NPS Q&A), 7 (confirming NPS' interest in monitoring oil and gas emissions (VOCs, methane, and air toxics)).
12. While the monitoring networks discussed below do not collect data on air toxics, toxic compounds such as heavy metals and persistent organic pollutants (POPs) can pose a significant health risk as well. The most common of these air toxics are mercury and pesticides. Unlike ozone and PM, these toxics are particularly harmful because they do not break down naturally in the environment and can bioaccumulate as they move up through the food chain.
13. See **https://www.stateoftheair.org/stateoftheair2020.pdf.**
14. See **https://link.springer.com/article/10.1007/s11356-017-9239-3.** See also **https://www.nps.gov/subjects/air/humanhealth-ozone.htm.**
15. See **https://www.nps.gov/subjects/air/humanhealth-pm.htm.**
16. See **https://www.nps.gov/subjects/air/visibility.htm.**
17. See **https://advances.sciencemag.org/lens/advances/4/7/eaat1613**
18. **http://npshistory.com/publications/air-quality/aqnps-2002.pdf**
19. Id. at 45.
20. Id. at 46.
21. **https://www.nps.gov/subjects/air/national-summary.htm.**
22. See **https://www.nps.gov/subjects/air/national-summary.htm**. For example, nearly 50 parks are "poor" for human health and vegetation health ozone conditions; nearly all parks are reported "poor" for wet nitrogen conditions; dozens of parks are reported "poor" for wet sulfur conditions; and only four parks are reported to have "good" visibility conditions.
23. See **https://irma.nps.gov/DataStore/Reference/Profile/2279061.** By contrast, in 1997, just nine parks did not meet the EPA's 80 ppb ozone standard: Joshua Tree, Sequoia, Great Smoky Mountains, Cape Cod, Shenandoah, Yosemite, Mammoth Cave, Cowpens, and Acadia.
24. See **https://advances.sciencemag.org/content/4/7/eaat1613**
25. See **https://www.nps.gov/subjects/air/park-conditions-trends.htm?tabName=exceedances&parkCode=SEKI&aramCode=Ozone&startYr=2009&endY=2018&monitoringSite=061070009%20(AQS)%20Ash%20Mountain&timePeriod=10-year.**
26. Sequoia & Kings Canyon, Joshua Tree, Mojave, Yosemite, Carlsbad Caverns, Guadalupe Mountains, Indiana Dunes, Rocky Mountain, Saguaro, Chamizal National Monument, Death Valley, Zion, Great Basin, Lassen Volcanic, Pinnacles, Yellowstone, Canyonlands, Mesa Verde, Chiricahua, Cape Cod National Seashore, Acadia, Petrified Forest, Dinosaur, Wind Cave, Craters of the Moon National Monument, and Mount Rainier. The NPS maintains an ozone map showing the frequency of ozone exceedances over the

Acknowledgements

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past five years, illustrating geographic and annual patterns. See **https://www.nps.gov/subjects/air/ozone-exceed.htm.**

27. For instance, NPCA has raised concerns with the EPA's ozone standard on the basis that it is insufficient to show the cumulative impact of ozone exposure that takes place over a period of months for trees, plants, ecosystems, that are exposed to high levels of ozone consistently. This metric, W126, is a seasonal index that reflects the exposures to plants and trees during the three-month growing season when daytime ozone concentrations are highest.
28. NPS Air Quality Monitoring Strategy, Natural Resources Report NPS/NRSS/ARD//NRR—2015/909, v, available at **http://npshistory.com/publications/nr-reports/nrr-2015-909.pdf** (2015 NPS Report).
29. Id.
30. 577 F.Supp. 23 183, 194 (D.D.C. 2008) (quoting NPS Management Policies, § 1.4.5).
31. Id. at 205.
32. NPS Management Policies, § 6.2.1.1.
33. Id. at § 6.3.6.1.
34. Id.
35. Id. at § 6.3.6.2.
36. See **https://www.nps.gov/subjects/wilderness/wilderness-parks.htm.**
37. Director's Order #12.
38. Id. at 6.
39. **https://www.nps.gov/articles/airprofiles-acad.htm**
40. The CAA defines effects on welfare as including "effects on soils, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility, and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being, whether caused by transformation, conversion, or combination with other air pollutants." 42 USC § 7602(h).
41. 2015 NPS Report, v.
42. See 2015 NPS Report, 3.
43. There are other monitoring networks that measure some or all of the same pollutants of concern (i.e., ozone, PM, NOx, VOCs, SO2) including NCore and SLAMs, which are run by federal, state/local, or tribal governments and may be located near stationary sources or major roadways. In this discussion, we focus specifically on those networks that the NPS participates in.
44. 2015 NPS Report, at 4.
45. Id. at 4-5.
46. Id. at 13.
47. For example, many of EPA's interstate air pollution transport rules rely on these monitors to determine whether pollution is crossing state lines and whether additional pollution controls may be necessary.
48. The NPS considers monitors that are sited within 10km of park boundaries to be "representative" of ozone and PM conditions. See NPS Air Quality Analysis Methods 2020, Appendix B, **https://www.nps.gov/articles/analysis-methods2020.htm.**
49. **https://www.nps.gov/subjects/air/air-monitoring.htm.**
50. **https://www.nps.gov/articles/analysis-methods2020.htm.**
51. See 2020 NPS Q&A.
52. Id. at 2.
53. Id. at 3.
54. Id.
55. Id. at 5.
56. Id. at 1. Other future priorities include: linking air chemistry and deposition to develop critical load thresholds for ecosystem impacts; agricultural emissions; mercury and toxics emissions and cycling; and greenhouse gases and climate. 2015 NPS Report, 9.
57. Id. Oil and gas production emissions are also an urgent environmental justice concern—as recent studies who BIPOC communities "were disproportionately exposed ...." Lara J. Cushing, et al., Up in smoke: characterizing the population exposed to flaring from unconventional oil and gas development in the contiguous US, Environ. Res. Lett. 16 (Feb. 2021), **https://iopscience.iop.org/article/10.1088/1748-9326/abd3d4/pdf.**
58. See **https://www.npca.org/reports/air-climate-report.**
59. In addition to the 93 national parks that are currently nonattainment for the 2015 ozone NAAQS, about a dozen more are nonattainment for the 2008 ozone NAAQS, the 2012 PM2.5 annual average, the 2006 PM2.5 24-hour average, and/or the 1987 PM10 24-hour average. See **https://irma.nps.gov/DataStore/Reference/Profile/2279061.**
60. 2020 NPS Q&A, 1.
61. Id.
62. Id. at 8.
63. **https://www.epa.gov/sciencematters/tempo-new-era-air-quality-monitoring-space.**
64. 2020 NPS Q&A, 8.


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