United States General Accounting Office

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Briefing Report to Congressional Committees

May 2001

AIR POLLUTION

Air Quality and Respiratory Problems in and Near the Great Smoky Mountains

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Contents

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United States General Accounting Office
Washington, DC 20548

May 25, 2001

The Honorable Charles H. Taylor
Chairman
The Honorable James P. Moran
Ranking Minority Member
Subcommittee on Legislative
Committee on Appropriations
House of Representatives

The Honorable Robert F. Bennett
Chairman
The Honorable Richard J. Durbin
Ranking Member
Subcommittee on Legislative Branch
Committee on Appropriations
United States Senate

Although air quality has generally been improving throughout much of the United States in the past 20 years, there is growing concern about visibility, air quality, and certain respiratory illnesses in and near Great Smoky Mountains National Park, which straddles the border between North Carolina and Tennessee. In light of these concerns about the park and adjacent areas, we were directed to analyze recent trends in and contributing factors to (1) visibility impairments, (2) ground-level ozone,[1] and (3) respiratory illnesses. In addition, we were directed to examine the Tennessee Valley Authority's (TVA) plans to reduce its emissions of regulated pollutants from generating electricity. We generally focused our review on the period from 1990 to 1999 or 2000, depending on data availability. (See H. Rept. 106-1033, Conference Report to Accompany H.R. 4577, Making Omnibus Consolidated and Emergency Supplemental Appropriations for Fiscal Year 2001.)

The results of our work are summarized in this letter. Briefing Sections I through V contain the charts that we used to brief Chairman Taylor and his staff on March 1 and 22, 2001, along with explanatory notes.

[1]Ozone is a colorless gas that occurs both in the earth's upper atmosphere and at ground level. In this report, we use the term ozone to refer to ground-level ozone.

Results in Brief

Reduced visibility, high ozone levels, and respiratory illnesses in and near Great Smoky Mountains National Park are continuing concerns. Visibility remained poor throughout the 1990s. The number of days when ozone levels exceeded a health-based standard generally rose during the decade but fell in 2000. Visibility impairment and ozone are largely attributable to three types of emissions.

- Sulfur dioxide, which is generated primarily from coal-fired power plants north and west of the park, can be transformed into sulfate particles, which are the main contributor to reduced visibility.
- Nitrogen oxides, which are generated largely from motor vehicles, as well as coal-fired power plants, participate in ozone formation.
- Volatile organic compounds, which result from both natural sources (such as isoprene from trees) and human actions (including a wide range of compounds resulting from such activities as the incomplete combustion of gasoline), also participate in ozone formation.

The sulfate particles and ozone gas formed from these emissions are associated with respiratory illnesses. Relative to the entire states of North Carolina and Tennessee, the counties that border the park generally have slightly higher death rates from two types of respiratory illness, even though they have substantially lower death rates from all causes. Research is continuing on why and how air pollution leads to adverse health effects.

In response to federal laws and other factors, the Tennessee Valley Authority is making substantial environment-related investments and expects to reduce its annual emissions of sulfur dioxide by 36 percent and its “ozone-season” (primarily summer time) emissions of nitrogen oxides by 68 percent between 1999 and 2005.

Background

Great Smoky Mountains National Park encompasses 800 square miles in North Carolina and Tennessee. Designated a national park in 1934, it is 95 percent forested and is renowned for the diversity of its plant and animal resources and the beauty of its ancient mountains. Elevations in the park range from 800 feet to 6,643 feet.

Areas adjacent to the park are growing in population and economic activity. For example, between 1990 and 2000, while the U.S. population grew 13 percent, the population of North Carolina and Tennessee grew 21 percent and 17 percent, respectively, and the population grew 18 percent in Buncombe County, the most populous county in western North Carolina. Recreational visits to the park increased from 8.2 million in 1990 to 10.2 million in 2000, and non-recreational visits to the Park increased from 9.4 million to 10.9 million during the same period.

The burning of coal, gasoline, and other fossil fuels—by electric utilities, motor vehicles, manufacturing facilities, and other sources—generates sulfur dioxide and nitrogen oxide gases. When emitted into the air, these gases, and the substances, into which they can be transformed, may be transported hundreds of miles away. In the atmosphere, these gases may be transformed into tiny particles or may react with other chemicals. Visibility is impaired when light encounters these tiny airborne particles and is absorbed or scattered before reaching the observer. Humidity magnifies the problem because the particles may attract water and grow in size, thereby scattering more light. In addition to reducing visibility, these tiny particles, which can be inhaled deeply into the lungs, have been consistently associated in epidemiological studies with hospital admissions and premature deaths.

Ozone is not emitted; it forms when nitrogen oxides react with volatile organic compounds in the presence of sunlight. Repeated exposure to ozone may permanently damage lungs or trigger symptoms, such as chest pains or coughing. It may also interfere with plants' ability to produce and store food, making them more susceptible to pathogens, pests, and other pollutants. (By contrast, in the upper atmosphere, ozone forms a protective layer that shields the earth from harmful ultraviolet rays.)

The Clean Air Act[2] requires the Environmental Protection Agency (EPA), in concert with state and local air pollution agencies, to regulate mobile and stationary source emissions of certain air pollutants. In addition, for pollutants it determines to be harmful to human health, EPA is responsible for setting standards for concentrations of those pollutants in the air that people breathe. It has designated six such principal pollutants, including sulfur dioxide, nitrogen dioxide, particulate matter, and ozone. Finally, certain provisions of the act specifically address visibility impairments.

Although the 1977 amendments to the Clean Air Act established tougher requirements for new power plants and certain other facilities, existing facilities—including those operated by TVA and many other electric utilities—were exempted from these requirements, so long as they did not

[2]It was enacted in its present statutory format in 1970 and has been amended since then, most recently in 1990.

make physical changes to the plants that resulted in increased emissions. EPA alleged in 1999 that TVA and several privately owned utilities had violated the Clean Air Act provisions by making physical changes to their units that had resulted in emissions increases. EPA's lawsuit against TVA is pending.

Despite the progress over the past 20 years in reducing the emissions of most principal pollutants and improving air quality, ozone concentrations in many counties in the United States exceed national standards, and visibility in many otherwise pristine areas remains a problem. Over the same time period, the prevalence of asthma—the most common chronic disease of children in the United States and other developed countries—has increased by more than half.

Visibility

Visibility in Great Smoky Mountains National Park remained poor throughout the 1990s. On the worst days (those ranked in the bottom one-fifth of all days in terms of visibility—usually hot and humid summer days), visibility ranged between 12 and 15 miles from 1989 through 1999, according to the latest available data from the National Park Service. On average days (the middle one-fifth of all days), visibility stayed at about 27 miles during the decade and, on the best days (those ranked in the top one-fifth of all days), it stayed at about 51 miles.

Reduced visibility is primarily caused by airborne particles that either scatter or absorb light. In the eastern states generally, and in the park specifically, during the summer, these particles are predominantly fine sulfate particles formed from sulfur dioxide gas, a product of burning coal and other fossil fuels. The electric utility sector accounted for 67 percent of the nation's sulfur dioxide emissions in 1999 (latest available data); the transportation sector, 7 percent; and other sources, the remaining 26 percent.

Because sulfur dioxide gas and the sulfate particles, into which it can be transformed, can travel hundreds of miles on wind currents, the particles that degrade visibility in the park may originate from emissions released over a large area. According to a recent National Park Service analysis of the air masses that reached the park on low-visibility days (that is, days with high levels of particulates), the majority started, or spent considerable time, over the industrial Midwest, which allowed them to accumulate substantial quantities of sulfur dioxide. Air masses arrived from the west on a lesser, but still significant, portion of the low-visibility days, while few air masses arrived from the east and south on such days.

In 1994, the year before the provisions of the Clean Air Act Amendments of 1990 limiting sulfur dioxide emissions took effect, the nation's electric utilities emitted 14.9 million tons of sulfur dioxide. In 1999, the level fell to 12.7 million tons, and it is projected to decrease to just under 9 million tons in 2010.

Ozone

The number of days when ozone levels in the park exceeded a health-based threshold set by EPA, called "exceedances," generally increased during the 1990s, according to data from EPA and the National Park Service. However, the number fell sharply in 2000. It is believed that the decline is related to the cooler summer temperatures in 2000.

Because sunlight is necessary to the formation of ozone and heat accelerates chemical reactions, ozone levels tend to peak in the summer months. The two principal precursors of ozone—nitrogen oxides and volatile organic compounds—have diverse sources. Motor vehicles and other transportation sources produced 55.5 percent of the nation's nitrogen oxide emissions in 1999 (latest available data); electric utilities produced 22.5 percent; and other sources produced the remaining 22 percent. Volatile organic compounds include isoprene, which trees produce, and various hydrocarbons, such as those emitted when gasoline evaporates or is burned incompletely. In North Carolina, Tennessee, and other southeastern states, trees and other natural sources produce relatively high levels of isoprene. Thus, there is an abundance of naturally occurring volatile organic compounds in these areas to react with nitrogen oxides to form ozone.

According to a recent National Park Service analysis, on high-ozone days, most of the air masses reaching the park arrived from the north and northwest—generally after passing through the industrial Midwest. Fewer air masses arrived from the west and south and very few arrived from the east.

The Clean Air Act Amendments of 1990 are expected to reduce national nitrogen oxide emissions by 2 million tons a year by 2010, relative to the level without these provisions. Other EPA policy initiatives are intended to make further cuts in emissions.

Respiratory Illnesses

Throughout the 1990s, death rates from two respiratory illnesses—(1) chronic lung disease[3] and (2) pneumonia/influenza—in North Carolina and Tennessee were consistently higher than the comparable national rates. Moreover, death rates from these illnesses in the North Carolina and Tennessee counties adjacent to the park were generally higher than the comparable rates for these states as a whole throughout the 1990s, even though these counties had substantially lower death rates from all causes. (These rates are age-adjusted to allow comparability between states and over time; however they were not adjusted for other influences, such as rates of smoking and socioeconomic levels.)

In the past 50 years, studies conducted in the United States and abroad have consistently shown that people who breathe polluted air are more likely to suffer adverse health effects. These effects may be reflected in increases in breathing problems, hospital admissions, and premature mortality from lung and heart conditions. People over the age of 65 and those with pre-existing chronic heart and lung conditions, such as heart disease and asthma, are more likely than others to experience adverse health effects from exposure to air pollutants. However, scientists do not clearly understand why and how air pollution leads to adverse health effects, and many other factors, notably cigarette smoking, also affect the development and severity of lung and heart diseases.

TVA's Plans to Reduce Emissions

TVA's decision on how to meet its customers' demands for electricity is constrained by federal environmental laws and regulations, as well as internal policies. In recent years, TVA relied on coal to generate 62 percent of its electricity and on nuclear power, hydropower, and other sources, in that order, to generate the remaining 38 percent. In 2000, TVA's peak capacity to generate electricity was 29.5 gigawatts (a gigawatt is a million kilowatts). TVA estimates that its peak demand for electricity will grow about 1.7 percent each year between 2001 and 2010. To meet this level, TVA will have to plan for an additional one-half a gigawatt increase each year—the equivalent of building an average-sized power plant every year. TVA can do so by purchasing power, constructing new plants, and providing incentives to its customers to reduce their peak demand.

[3] In this report we use the term "chronic lung disease" to refer to chronic obstructive pulmonary disease, an umbrella term that includes asthma, bronchitis, emphysema, and other chronic lung diseases.

Although TVA's coal consumption increased from 34 million tons in 1990 to 40 million tons in 1999, its emissions of sulfur dioxide (which can be transformed into visibility-reducing sulfate particles) declined 30 percent. To achieve this reduction, TVA, among other actions, switched to coals with lower sulfur contents and installed equipment called "scrubbers" to remove sulfur dioxide from exhaust gases. TVA estimates that such emissions will decline 36 percent between 1999 and 2005. TVA's emissions of nitrogen oxide (an ozone precursor) were relatively stable during the 1990s; however, it estimates that its emissions of nitrogen oxides—during the warm-weather months when ozone levels peak—will decline 70 percent between 1999 and 2005. To achieve this reduction, TVA is, among other actions, spending about $1 billion to install "selective catalytic reduction" devices—which remove nitrogen oxides from the exhaust gases—at some of its coal units.

Agency Comments

We provided a draft of this report for review and comment to the Departments of Agriculture, Health and Human Services, and the Interior; EPA; and TVA. We received letters from the Department of the Interior, EPA, and TVA, which are reprinted, along with our comments, as appendixes I through III, respectively. Those three agencies, as well as the Department of Agriculture and the Centers for Disease Control and Prevention (part of the Department of Health and Human Services) provided technical and clarifying comments, which we incorporated where appropriate. We did not receive comments from the National Institutes of Health (another part of the Department of Health and Human Services).

The agencies generally agreed with the facts and analysis we presented. The Department of the Interior said that our narrative description of visibility conditions is accurate. However, it also said that the methodology it uses to calculate visibility conditions is currently under review and that some of the data we presented may be affected by this review. EPA also told us about this review.

Similarly, EPA provided additional data on changes in the amount of airborne sulfate particles, an indicator of visibility. EPA said that a 12 percent decrease in sulfate particles was measured at a site about 100 miles northeast of Great Smoky Mountains National Park between the periods of 1990 through 1992 and 1998 through 2000. EPA did not provide comparable data for Great Smoky Mountains National Park.

EPA noted the overall appropriateness of how we presented the current understanding of the health risks from the pollutants that we examined. EPA and TVA commented that our location-specific analysis of death rates should be viewed with caution because of the many factors that influence the development and severity of respiratory illness. We agree.

Scope and Methodology

To analyze trends in visibility and ozone, we interviewed officials from, and reviewed studies and other documents prepared by, the Department of the Interior's National Park Service, the Department of Agriculture's Forest Service, EPA, and TVA, as well as recent scientific literature. We also interviewed representatives of, and reviewed studies and other documents prepared by, state officials in North Carolina and Tennessee and the Southern Appalachian Mountains Initiative—a voluntary partnership of federal and state agencies, industry, academia, environmental groups, and interested public participants.

To analyze trends in respiratory illnesses, we reviewed recent scientific literature and contacted the Centers for Disease Control and Prevention, a unit within the Department of Health and Human Services, and EPA health researchers to ascertain the availability of data on health outcomes associated with exposure to air pollution. We focused our analysis on mortality data because they were available for the nation as a whole and for the counties in North Carolina and Tennessee—the two states that border the park. We also focused on death from all causes and on death from pneumonia/influenza and chronic lung disease, two sets of illnesses that many studies associate with exposure to air pollution. We obtained national data from the Department's National Center for Health Statistics and state and county data from the North Carolina and Tennessee health agencies.

To describe trends in areas near the park, we divided counties in each state into regions used by the state agencies responsible for air quality monitoring and selected the region in each state that borders the park. To analyze the data for deaths from all causes and from selected respiratory illnesses, we used the same statistical procedures and significance tests that the National Center for Health Statistics uses to develop national death rates. To calculate death rates for comparison between the two states and the nation we used the 1940 standard population, the current practice of the National Center for Health Statistics. For the comparison between county clusters and the states, we used the 2000 standard population, the current practice of the North Carolina State Center for Health Statistics.

Although we did not independently verify the data obtained from the federal agencies and other sources, we used the same emissions and mortality data that federal and state agencies and other analysts generally use. We performed our work from October 2000 through May 2001 in accordance with generally accepted government auditing standards.

We are sending copies of this report to the Chairman and Ranking Member, Committee on Appropriations, United States Senate; the Chairman and Ranking Minority Member, Committee on Appropriations, House of Representatives; the Chairman and Ranking Member, Committee on Governmental Affairs, United States Senate; the Chairman and Ranking Minority Member, Committee on Government Reform, House of Representatives; Representative Zach Wamp and other interested Members of Congress; the Honorable Ann M. Veneman, Secretary of Agriculture; the Honorable Tommy G. Thompson, Secretary of Health and Human Services; the Honorable Gale A. Norton, Secretary of the Interior; the Honorable Christine Todd Whitman, Administrator, EPA; the Honorable Skila Harris and the Honorable Glenn L. McCullough, Jr., Members of the Board, TVA; and other interested parties. We will also make copies available to others upon request.

Questions about this report should be directed to me or David Marwick at (202) 512-3841. Key contributors to this report were Gene M. Barnes, Richard A. Frankel, and Cheryl A. Williams.

John B. Stephenson
Director, Natural Resources and Environment

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Air Pollution and Respiratory Illnesses in and Near the Great Smoky Mountains National Park

Briefings for
Chairman Charles H. Taylor
Subcommittee on Legislative
House of Representatives
March 1 and 22, 2001

As directed by House Report 106-1033 and as discussed with Chairman Charles H. Taylor, we focused on four issues:

- visibility, which is important to people who live near the park, visitors from other areas who travel to enjoy the park's vistas, and others;
- ozone, which can harm people, animals, and plants;
- respiratory illnesses, a manifestation of the harm from ozone and other causes; and
- Tennessee Valley Authority's (TVA) plans to reduce its emissions of sulfur dioxide and nitrogen oxides.

To do this work we interviewed officials from, and reviewed studies and other documents prepared by, the following five federal agencies:

- the Department of Agriculture's Forest Service,
- the Department of Health and Human Services' Centers for Disease Control and Prevention and National Institutes of Health,
- the Department of the Interior's National Park Service,
- the Environmental Protection Agency (EPA), and
- TVA.

We also collected information from North Carolina and Tennessee state agencies, non-profit groups, and others.

Visibility

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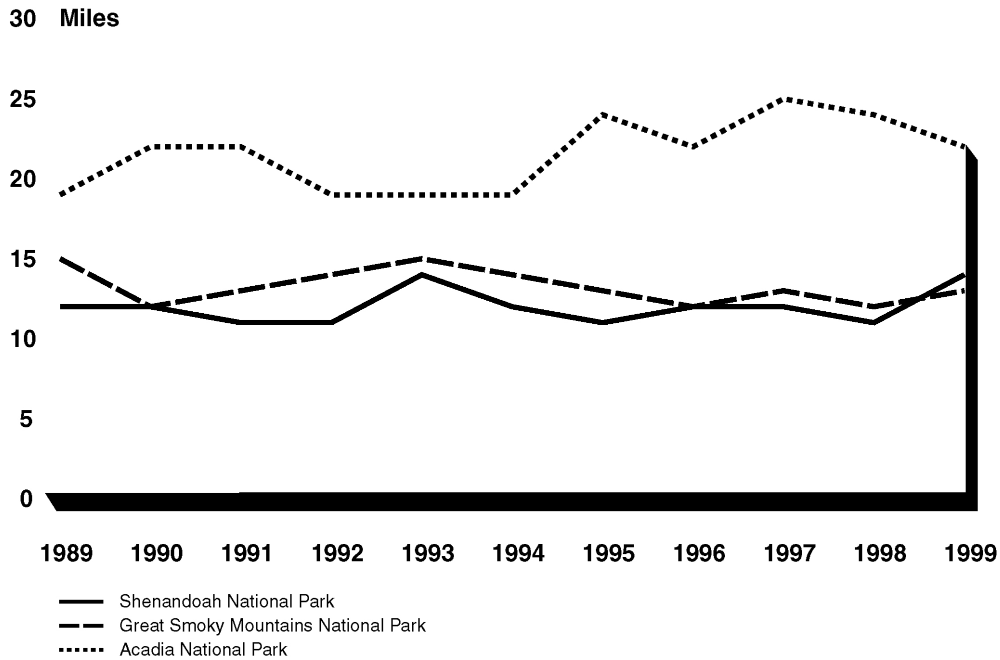
Visibility in the Park on the Worst Days Remained Poor During the 1990s



Source: National Park Service

Reduced visibility is caused by small particles in the air. In the east generally, and in the park specifically, most of these particles are sulfates, which are formed in the air from sulfur dioxide gas.

In analyzing visibility, we focused on the worst days, typically summer days, because it is then that reduced visibility is the most detrimental to enjoyment of the park. We obtained data for visibility on the worst days in Great Smoky Mountains National Park and two others parks selected for comparison. The other parks are Shenandoah in Virginia and Acadia in Maine.

On the worst-visibility days (those ranked in the lowest one-fifth of all days for each year), visibility in the park remained poor between 1989 and 1999, ranging between 12 and 15 miles, according to data from the National Park Service. Visibility remained essentially unchanged on average days and on the best-visibility days. Between 1989 and 1999, visibility on the worst days in Shenandoah generally stayed at about 12 miles, while it improved in Acadia to 22 miles.

Visibility

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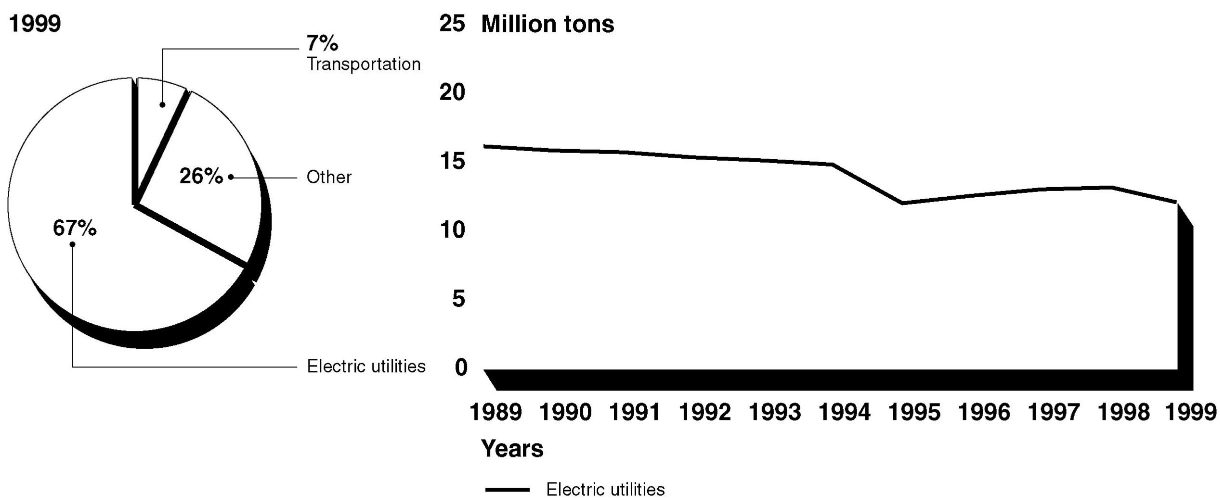
Electric Utilities Produce Two-Thirds of National Sulfur Dioxide Emissions



Source: EPA

Sulfate particles, in turn, are formed primarily from sulfur dioxide gas.

For the nation, the largest source of sulfur dioxide gas emissions in 1999 was the electric utility industry, which accounted for about 67 percent of the total, according to EPA's estimates. The transportation sector accounted for 7 percent and other sources accounted for the remaining 26 percent.

The 1990 amendments to the Clean Air Act require that sulfur dioxide emissions by electric utilities be reduced between 1995 and 2010. Electric utility emissions of sulfur dioxide declined substantially during the 1990s—from 16.2 million tons in 1989 to 12.7 million tons in 1999.

Under these amendments, these emissions are scheduled to decline to just under 9 million tons a year in 2010.

Visibility

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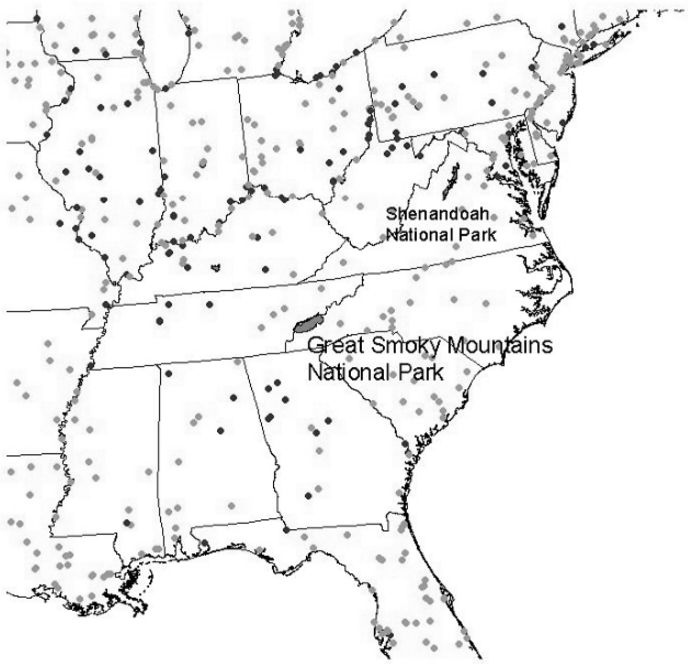
Many Power Plants Are Close to the Park



Note: Color differences denote different times at which plants must meet requirements under the Clean Air Act Amendments of 1990
Source: EPA

Atmospheric studies have found that sulfate produced from power plant emissions can travel many hundreds of miles. Therefore, the visibility-reducing sulfates that reach the park can come from sources near and far. Dozens of power plants are located in the eastern states.

National Park Service analysts recently traced the paths of the air masses that delivered sulfate particles to the park for the 3 days before reaching the park; they did this for both high- and low-visibility days, between May and September in the years 1995 through 1999. They found that on high-visibility days (that is, days with low levels of particulates), the air masses arrived from nearly all directions of the compass, although very few air masses arrived from the northeast. The air masses had often traveled many hundreds of miles, with some of them starting their 3-day journey as far away as Canada, the Gulf of Mexico, or the Atlantic Ocean. Because they traveled so quickly, they spent little time over any particular area, including the industrial Midwest and other areas with high levels of sulfur dioxide emissions.

Conversely, they found that on low-visibility days (that is, days with high levels of particulates), the air masses generally had traveled shorter distances, with most of them starting their 3-day journey just a few hundred miles away from the park and often following more roundabout trajectories, which kept them over particular areas for longer times. The predominant majority of the air masses started over the industrial Midwest, or spent considerable time there, which allowed them to accumulate substantial quantities of sulfur dioxide. A lesser, but still significant, portion of the air masses on these low-visibility days arrived from the region west of the park, while few air masses arrived from the east and south on such days.

Research continues on the sources of the air pollution that affects the park. The authors of a 1990 study told us that they are updating their study and hope to publish their results next year. Also, the Southern Appalachian Mountains Initiative—a voluntary partnership of federal and state agencies, industry, academia, environmental groups, and interested public participants—is analyzing the issue and also hopes to publish its results next year.

Ozone

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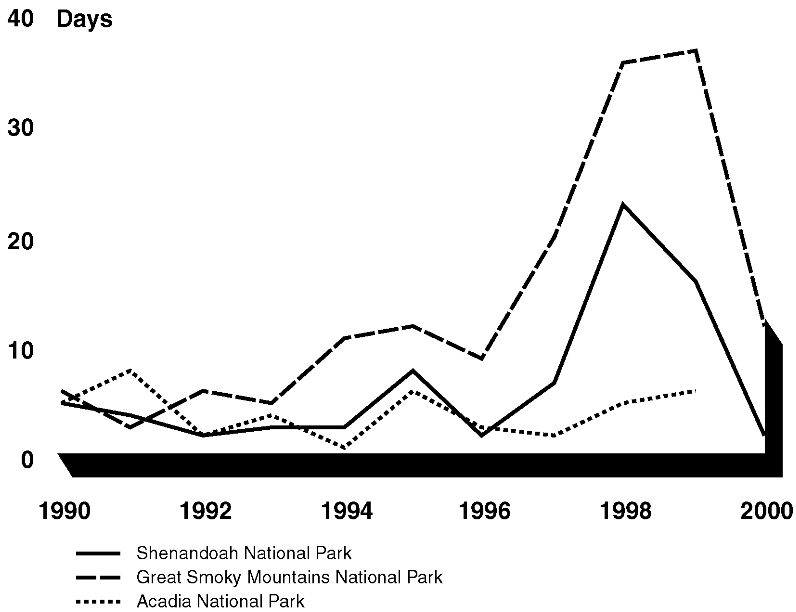
Exceedances of the Proposed Ozone Standard in the Park Increased in the 1990s, but Fell Sharply in 2000



Note: Data for Great Smoky Mountains National Park are for Look Rock
Source: National Park Service for Great Smoky Mountains and Shenandoah for 1999 and 2000; otherwise, EPA

Ground-level ozone is not emitted. It is produced from nitrogen oxides and volatile organic compounds in the presence of sunlight. Heat accelerates the chemical processes through which ground-level ozone is formed.

Pursuant to the Clean Air Act, EPA establishes public health standards for various air pollutants. For ozone, EPA has established a threshold of 0.08 parts per million, measured over an 8-hour period. An “exceedance” is recorded on any day when a monitor measures ozone levels that exceed this threshold. (The state of North Carolina has adopted the federal standard.)

We analyzed the number of exceedances during 1990 through 2000 for the Great Smoky Mountains and Shenandoah national parks and through 1999 for Acadia National Park. (Data for Acadia for 2000 were not available at the time of our review.).

- In the early and mid-1990s, the number of exceedances rose moderately in the park and was generally stable for the other two locations.
- In 1997-99, the number of exceedances was much higher for the Great Smoky Mountains and Shenandoah but remained level for Acadia.
- In 2000, the number of exceedances for the Great Smoky Mountains and Shenandoah fell sharply to about the 1996 level.

It is believed that this decline in the number of exceedances is related to the cooler summer temperatures in 2000.

Ozone

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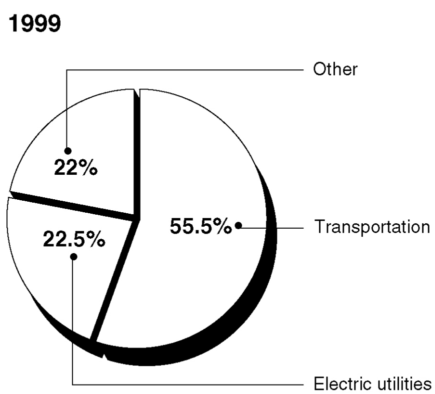
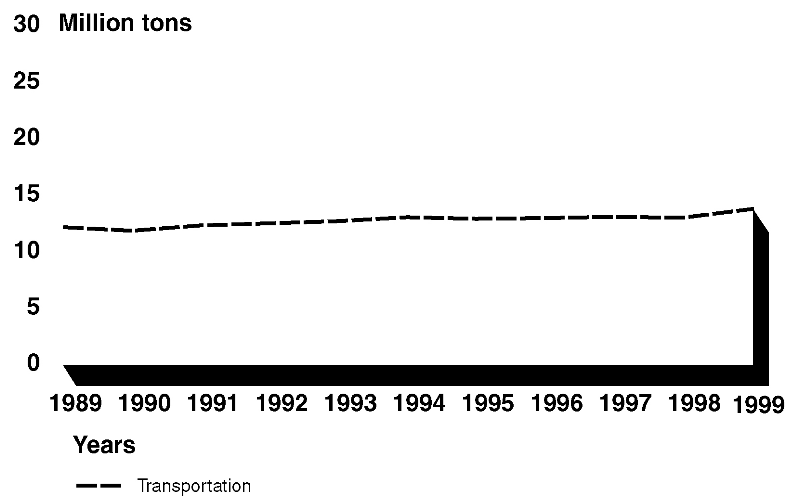
The Transportation Sector Produces Over Half of National Nitrogen Oxide Emissions





Source: EPA

In 1999, the transportation sector emitted 55.5 percent of nitrogen oxides nationwide, according to EPA's estimates. This includes cars and trucks (called on-road vehicles), as well as farm equipment and other engines (called non-road sources). Electric utilities accounted for 22.5 percent and other sources, the remaining 22 percent.

The transportation sector's emissions of nitrogen oxides increased from 12.2 million tons in 1989 to 14.1 million tons in 1999—a rise of 16 percent. This increase is less than the 28-percent increase during that same period in the number of miles traveled by cars, trucks, and other vehicles, according to the Federal Highway Administration.

Within the transportation sector, cars, trucks, and other on-road vehicles emitted 8.6 million tons in 1999, according to EPA. Farm equipment, lawn and garden equipment, and other non-road sources emitted the remaining 5.5 million tons.

National Park Service analysts recently traced the paths of the air masses that arrived at the park on the lowest and highest ozone days from 1995 through 1999; specifically, they traced the masses for the 3 days before they reached the park. On the low-ozone days (those ranked among the
15 percent with the lowest concentrations during the 5-year period), the air masses arrived from all directions, with a slight preponderance from the south and relatively few traveling over the northeast (New England to Pennsylvania). A substantial proportion of the air masses traveled long distances within 3 days; many traveled from the Atlantic Ocean and Gulf of Mexico, and a few traveled from the west (the Plains states) and the north (Canada).

On the high-ozone days (every day when an exceedance of the 8-hour standard was recorded in the park), the air masses traveled substantially shorter distances within 3 days. Virtually none of the paths extended back to the Atlantic Ocean or Gulf of Mexico. Even on land, the air masses traveled substantially shorter distances within 3 days than on low-ozone days, but they still traveled hundreds of miles, and a much smaller proportion arrived from south of the park. Thus, on high-ozone days, most air masses arrived in the park from the north and northwest—generally the industrial Midwest—with fewer air masses arriving from the west and south and very few arriving from the east.

Ozone

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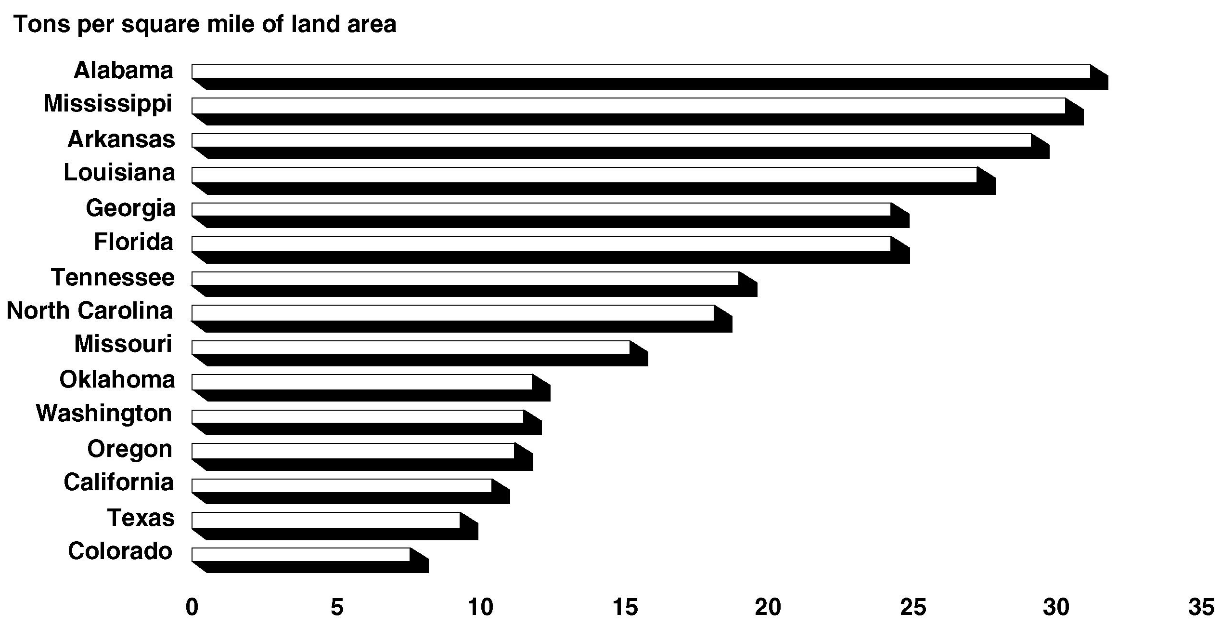
Southeastern States Produced Abundant Natural Volatile Organic Compounds per Square Mile, 1997



Note: Data presented for the 15 states with the largest volume of natural Volatile Organic Compounds
Source: GAO analysis of EPA data

Volatile organic compounds, which are another ozone precursor, originate from:

- human activities, such as various hydrocarbons that are emitted when gasoline and other fuels evaporate or are burned incompletely, and
- natural sources, such as isoprene from trees.

In 1997, the amount of naturally emitted volatile organic compounds (28 million tons) nationwide was greater than the amount released through human activities (19 million tons), according to EPA.

The Southeast, because of its forests, is particularly rich in the naturally produced compounds. Of the 15 states with the largest total amount of these compounds, the 8 states with the greatest concentrations—pounds per square mile of land area—are all located in the Southeast. Thus, there is an abundance of naturally occurring volatile organic compounds in these areas to react with whatever nitrogen oxides are produced to form ozone. Because the formation of ozone in such a geographic area is constrained by the available amount of nitrogen oxides (called NOx), such an area is described as being "NOx limited."

Respiratory Illnesses

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50 Years of Research Associates Health Problems With Air Pollution

- Increasing evidence associates air particles and ozone with respiratory problems.
- Small particles seem to be particularly harmful to human health.
- Air quality is one of many factors that influence the development and severity of disease.
- Research continues to try to better understand the causal link.

Over the past 50 years, epidemiological and other studies both here and abroad have consistently found that exposure to fine air particles and ozone is associated with respiratory and other health problems. Specifically, health effects—such as hospital admissions and premature mortality—increase as concentrations of ozone or airborne particles increase. These effects are seen most strongly in people with existing heart and lung conditions. Small particles seem to be particularly harmful to human health, in part because they can be inhaled deeply into the lungs and may carry other pollutants on their surfaces.

A range of factors influences the development and severity of lung and heart conditions, including exposure to allergens or pollutants, genetics, and behavior. For example, cigarette smoking is a primary cause of chronic lung disease, other than asthma, and lung cancer.

Epidemiological studies alone are limited in their ability to prove causality. However, they can suggest relationships for further scientific research, as in the case of cigarette smoking and heart disease. The exact causal link between exposure to air pollution and adverse health effects is not completely understood and research continues to try to learn the mechanisms by which pollutants harm human health and which kinds of airborne particles are the most harmful.

Respiratory Illnesses

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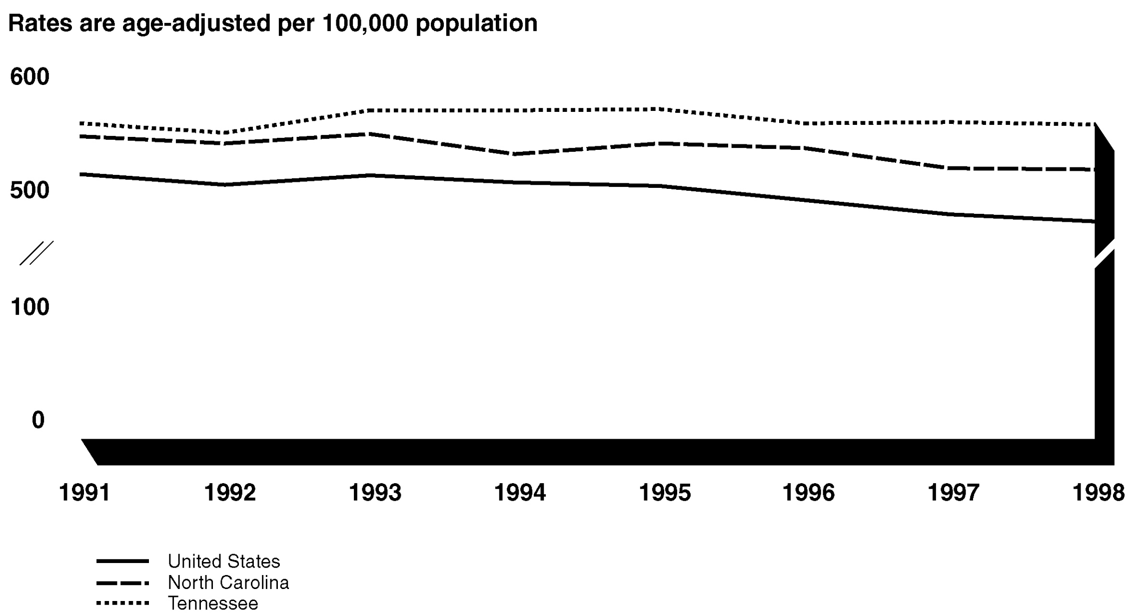
Death Rates for All Causes Were Higher in North Carolina and Tennessee Than in the United States



Note: Differences in death rates are statistically significant
Source: National Center for Health Statistics, and GAO analysis of unpublished data

To analyze trends in health, we used data on mortality—deaths—because comparable state-specific and national data on other health outcomes, such as hospitalizations, were not available. We adjusted all death rates for age to control for differences in the age distribution of the different populations. Age adjustment allows comparisons of rates over time and between groups; however, the rates are not adjusted for other influences, such as rates of smoking and socioeconomic levels.

We made three sets of comparisons for death rates from all causes and for deaths from chronic lung disease from 1991 through 1998:

1. We compared the nation as a whole to the states of North Carolina and Tennessee.
2. We compared the entire state of North Carolina with the 19 counties that constitute western North Carolina, as categorized by the state's Department of Environment and Natural Resources.
3. We compared the entire state of Tennessee with the 16 counties in eastern Tennessee, as categorized by the state's Department of Environment and Conservation.

In the first set of comparisons, we found that from 1991 through 1998

- overall death rates were consistently higher in North Carolina than in the United States as a whole, and higher in Tennessee than in North Carolina.
- overall deaths rates declined by 8 percent for the United States as a whole and by 5 percent for North Carolina, and essentially stayed the same for Tennessee.

Respiratory Illnesses

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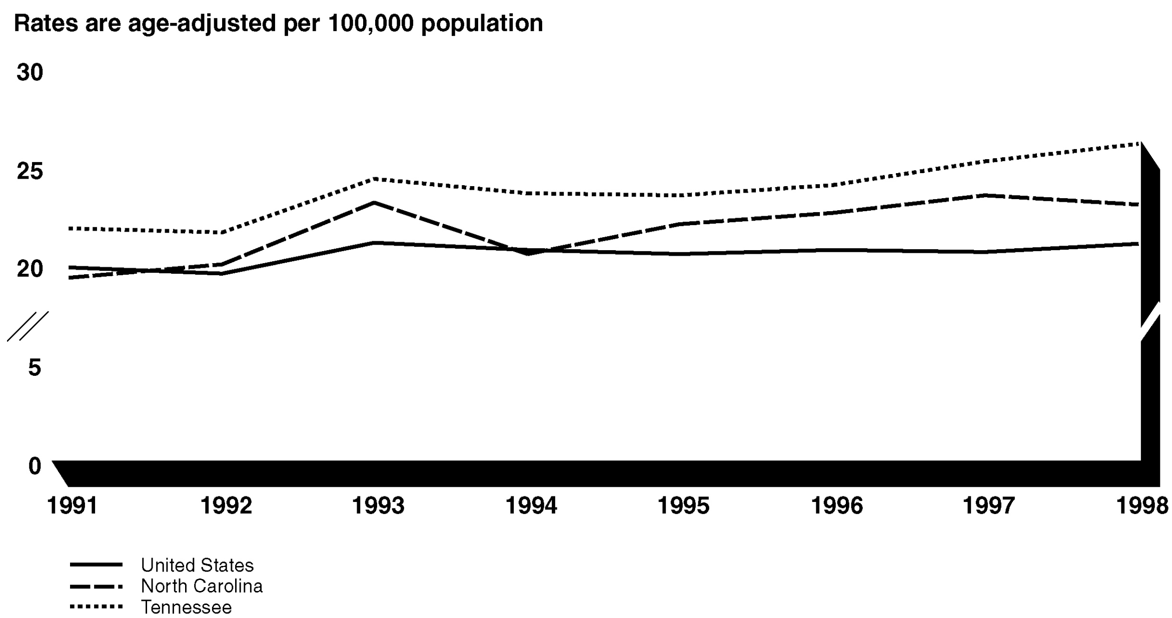
Death Rates for Chronic Lung Disease Were Higher in North Carolina and Tennessee Than in the United States



Note: Differences in death rates are statistically significant
Source: National Center for Health Statistics, and GAO analysis of unpublished data

Two sets of respiratory illnesses—chronic lung disease (a term applied to several related conditions including asthma, chronic bronchitis, and emphysema) and pneumonia/influenza—have consistently been associated with exposure to ozone and airborne particles. In the United States, these two sets of respiratory illnesses have been the fourth and sixth leading causes of death since 1991. Each year they together account for about 9 percent of all deaths.

For chronic lung disease, we found that between 1991 and 1998

- the rates for North Carolina were usually higher than the rate for the United States as a whole, and the rates for Tennessee were always higher than the rates for North Carolina;
- during the time period, these rates generally increased, which is counter to the general decline in death rates; and
- the increases in rates varied—6 percent for the United States but about 19 percent for North Carolina and 20 percent for Tennessee.

The trends for pneumonia/influenza followed similar patterns. Death rates in North Carolina and Tennessee were higher than the national rates, and the rates in Tennessee were usually higher than the rates in North Carolina. Moreover, death rates increased in each state by about 10 percent, but decreased slightly for the nation.

Respiratory Illnesses

GAO
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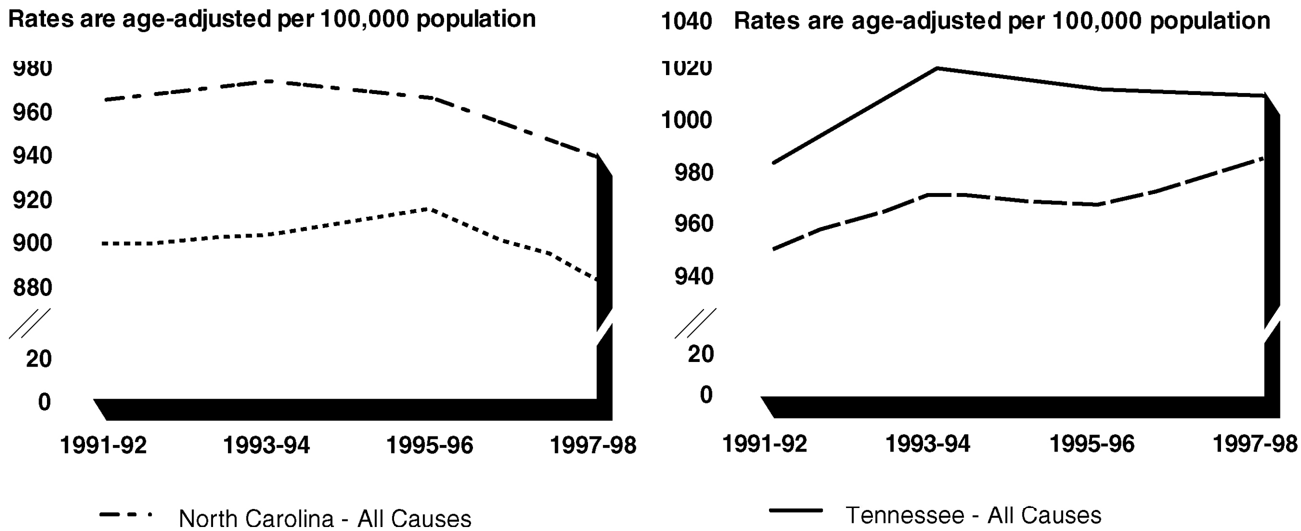
Death Rates for All Causes Were Lower in Areas Adjacent to the Park Than in Those States as a Whole



Note: Differences in death rates are statistically significant
Source: GAO analysis of unpublished North Carolina and Tennessee data

To analyze trends in health problems within each state, we compared age-adjusted death rates for the states of North Carolina and Tennessee with death rates for clusters of counties that border the park. In analyzing death rates for the entire state of North Carolina versus the 19 counties in western North Carolina, we found that

- overall death rates were consistently higher for the state than for western North Carolina
- during the period, death rates dropped by 3 percent for the state and 2 percent for western North Carolina.

Results for the entire state of Tennessee versus the 16 counties in eastern Tennessee were similar, except that death rates rose slightly from 1991 through 1998. We found that

- overall death rates were consistently higher for the state than for eastern Tennessee and
- during the period, death rates increased by 3 percent for the state and 4 percent for eastern Tennessee.

To enhance the soundness of our analysis, we compared deaths occurring over 2-year periods, rather than single years.

Respiratory Illnesses

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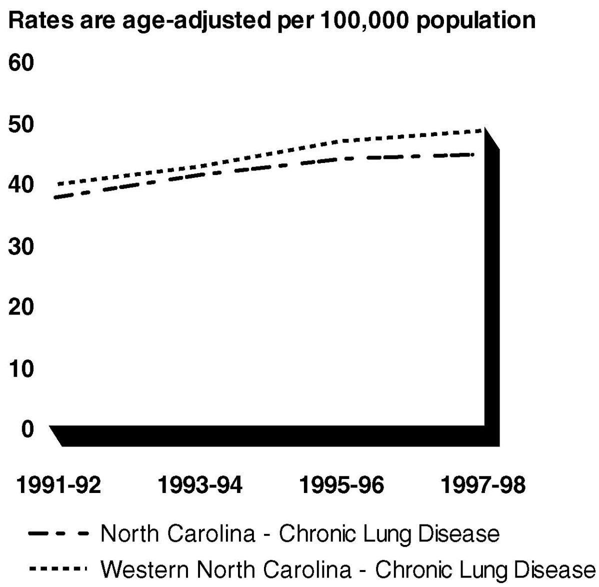
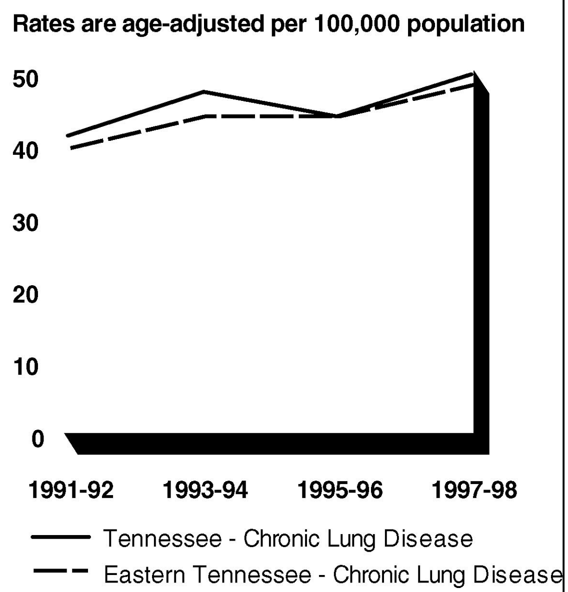
Death Rates for Chronic Lung Disease Increased in North Carolina and Tennessee Between 1991 and 1998





Note: Differences in death rates are statistically significant
Source: GAO analysis of unpublished North Carolina and Tennessee data

Finally, we focused on the two respiratory illnesses—chronic lung disease and pneumonia/influenza—in the states and county clusters. For chronic lung disease:

- there were increases in age-adjusted mortality during this period in both states—about 19 percent in North Carolina and about 20 percent in Tennessee,
- the rate per 100,000 deaths increased slightly faster in western North Carolina than in the state as whole, and
- the rate in eastern Tennessee increased more slowly than did the rate for the entire state.

The death rates for pneumonia/influenza (not shown here) were lower than the rates for chronic lung disease but increased in both states about 10 percent. The rate in western North Carolina increased more slowly than did the state rate and the rate in eastern Tennessee increased somewhat more rapidly.

Research is ongoing, in this country and abroad, to address the scientific uncertainties of the causal links between exposure to air pollution and harm to human health.

TVA's Emissions

GAO
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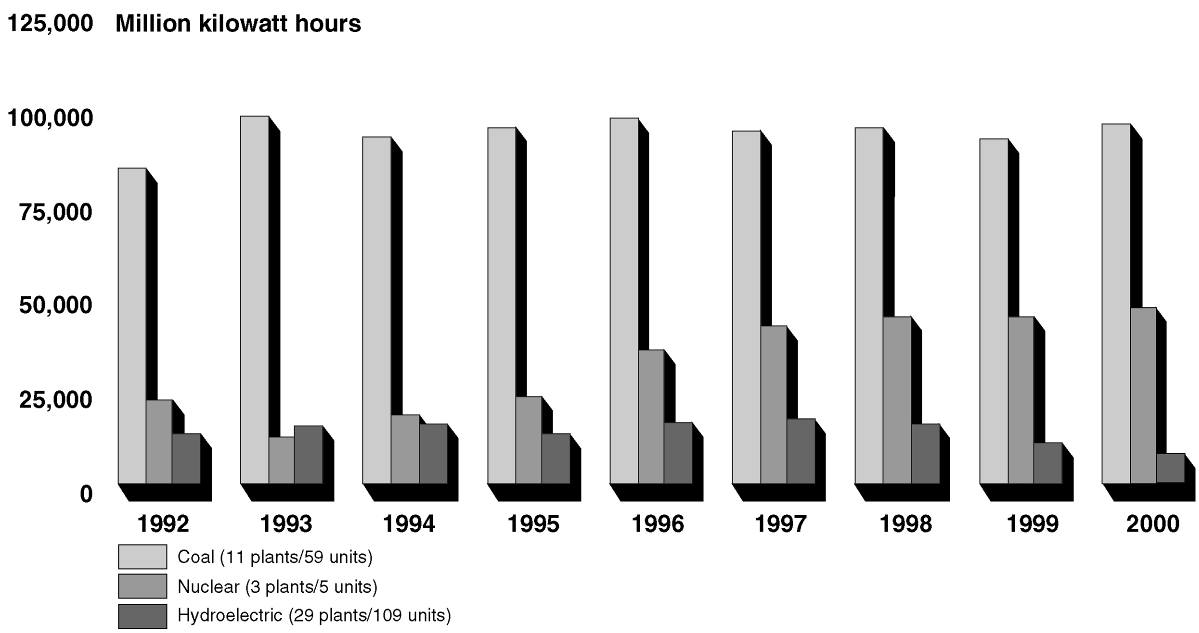
TVA Relied on Coal to Generate 62 Percent of Its Electricity, 1996-2000



Source: TVA

TVA's choices in generating power are constrained by laws, regulations, and internal policies. For example,

- The Clean Air Act limits certain emissions from coal-fired power plants.
- The TVA Act provides that the generation of power from hydroelectric units is a lower priority than navigation and flood control.
- An internal TVA policy limits the time period when TVA can draw down the lakes (reservoirs) that it manages for flood control and in the process generate hydropower.

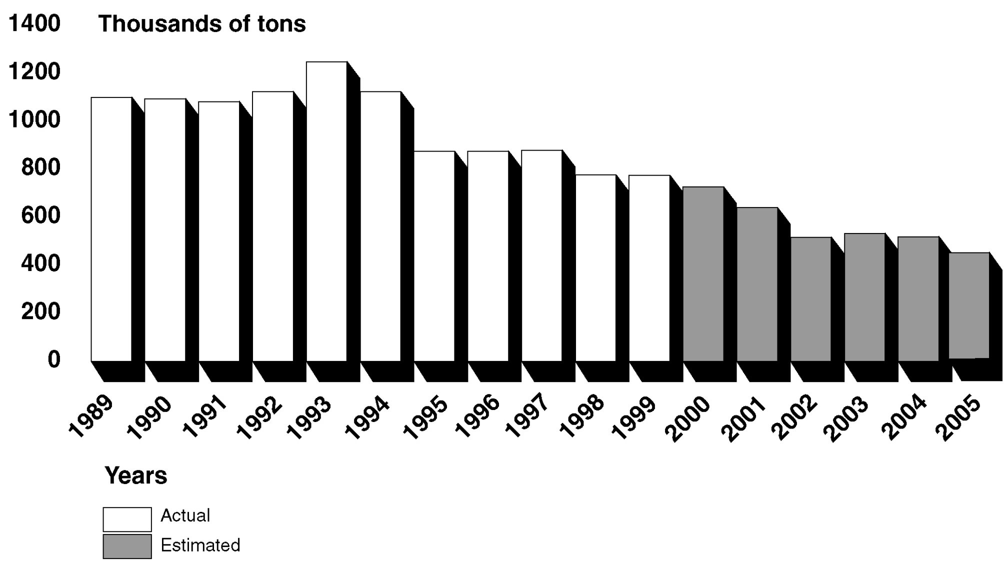
The longer the time frame, the more TVA must and can do to comply with laws, regulations, and policies. Because of the multiple purposes in the TVA Act and elsewhere, and because of other laws, regulations, and policies, TVA faces a difficult balancing act between its operating priorities and the often conflicting or competing user needs.

To generate electricity TVA relies primarily on coal. Between 1990 and 1999 TVA's coal consumption increased 18 percent. In the most recent 5-year period from 1996 through2000, coal accounted for 62 percent, nuclear power accounted for 28 percent, hydroelectric power accounted for 9 percent, and other sources accounted for the remaining 1 percent.

During that 5-year period, the amount of nuclear power increased from 35.4 to 46.9 million kilowatt-hours, and its share of the total increased from 24 percent in 1996 to 31 percent in 2000. In the same period, the amount of hydroelectric power fluctuated, largely because of changes in water levels; it generally declined from 16.1 to 8.8 million kilowatt-hours, and its share of the total declined from 11 percent in 1996 to 6 percent in 2000.

TVA's Emissions

TVA Cut Its Sulfur Dioxide Emissions During the 1990s and Expects to Cut More by 2005



Source: TVA

TVA's emissions of sulfur dioxide declined 30 percent from 1989-99. It estimates that, as a result of additional steps under way and planned for the next decade, its sulfur dioxide emissions will decline an additional 36 percent between 1999 and 2005. (The percentage reduction reflects TVA's most recent estimate of 2005 emissions, which is not reflected in the figure.)

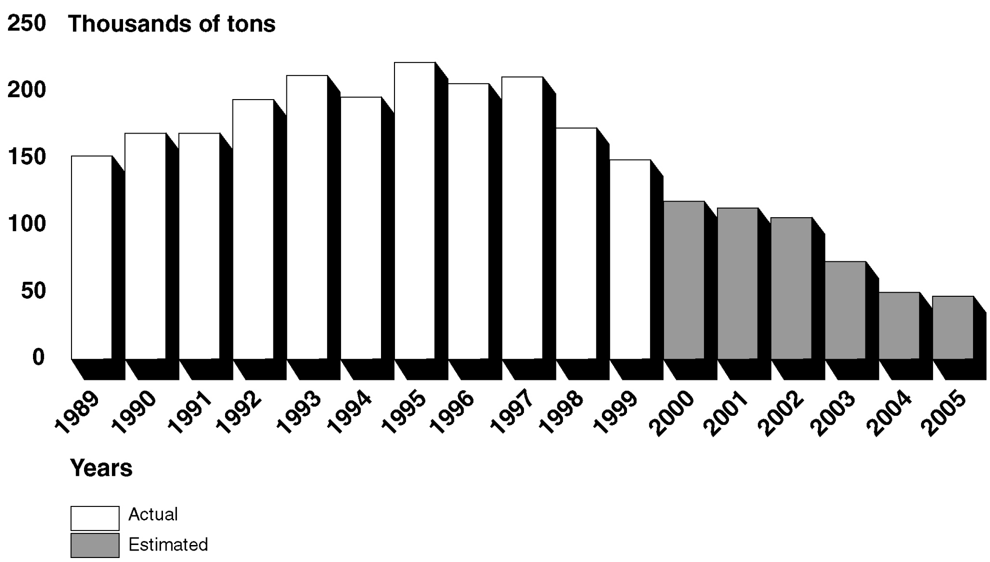
Among the steps TVA has taken and plans to take to reduce these emissions are:

- burning coals with lower sulfur contents at 51 of its 59 units and
- installing equipment called "scrubbers" in two units each at the Cumberland, Paradise, and Widows Creek plants. Scrubbers can remove more than 90 percent of the sulfur dioxide from a plant's emissions and are considered the best currently available technology for reducing such emissions.

TVA's Emissions

GAO
Accountability * Integrity * Reliability

TVA Expects to Cut Its "Ozone-Season" Emissions of Nitrogen Oxides Sharply by 2005



Note: The ozone season is May 1 to September 30
Source: TVA

In looking at emissions of nitrogen oxides, we focused on the 5-month "ozone season" (May 1 through Sept. 30) when ozone levels tend to be relatively high.

TVA's emissions of nitrogen oxide in 1999 were about the same as in 1989. In 1998, TVA announced plans to invest nearly $1 billion in pollution-control equipment. It projects that its ozone-season nitrogen oxide emissions will decline about 68 percent between 1999 and 2005. (The percentage reduction reflects TVA's most recent estimate of 2005 emissions, which is not reflected in the figure.)

The planned equipment includes selective catalytic reduction devices for 25 of its 59 coal-fired units. These devices transform nitrogen oxide emissions into harmless nitrogen and water vapor.

Appendix I: Comments From the Department of the Interior

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, D.C. 20240

MAY 2 3 2001

Mr. John B. Stephenson
Director, Natural Resources and Environment
U. S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Stephenson:

The Department of the Interior has reviewed the General Accounting Office's (GAO) draft report entitled "Air Quality and Respiratory Problems in and Near Great Smoky Mountains" (GAO-01-658) (GAO code 360077).

Overall, we found that the draft report is generally accurate on information related to Great Smoky Mountains National Park's air quality, specifically ozone and visibility levels during the 1990's. The enclosed comments are being made to ensure accuracy of the final report. Please be advised that the methodology we have been using for calculating visibility conditions is currently under review, and some of the data points presented in your report may be affected by this review. Nonetheless, the narrative description of visibility conditions is accurate.

Thank you for the opportunity to review and comment on this draft report.

Sincerely,

Joseph E. Doddridge

Acting Assistant Secretary for
Fish and Wildlife and Parks

Enclosure

Appendix II: Comments From the Environmental Protection Agency

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

MAY 21 2001

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

Mr. John B. Stephenson, Director
Natural Resources and Environment
General Accounting Office
441 G Street, Northwest
Washington, D.C. 20548

Dear Mr. Stephenson:

Thank you for the opportunity to review your draft report titled "Air Quality and Respiratory Problems in and Near Great Smoky Mountains." We appreciate the insights that this report provides into the importance of continuing to make progress toward cleaner air. What follows are highlights of the Environmental Protection Agency's (EPA's) Office of Air Quality Planning and Standards comments on the report. The EPA's Office of Research and Development will send additional technical comments under separate cover.

Revised Data for Visibility

As your staff is aware, the National Park Service (NPS) is currently recalculating estimated aerosol extinction derived from Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring network measurements. This monitoring network is the main source of visibility data. The NPS recomputations will result in a statistically significant improvement in visual air quality for the worst 20 percent of days through 1999 at the Shenandoah National Park (which matches the regional change in SO2 emissions), and no visibility change at the Great Smoky site.

The revised summary statistics will account for biases in the initial sulfur and nitrate measurements that resulted from improvements in PM2.5 measurement process during the mid-1990's [particulate matter smaller than 2.5 microns.]. It is our understanding that the NPS will submit comments and/or new data to the GAO which explains the effect of these measurement issues on visibility trends in the Smoky Mountains and elsewhere in the eastern United States.

From 1999-2000, annual ambient sulfate concentration data from the Clean Air Status and Trends Network (CASTNet) show negligible decreases at the Great Smoky National Park site. However, these annual comparisons should be viewed with caution, since 2000 was an abnormal year meteorologically. A more comprehensive picture of long-term trends in sulfate concentration is offered through analysis of CASTNet data from the Cranberry, NC site, about 100 miles northeast Great Smoky National Park. The data show a 5 percent reduction in ambient

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sulfate concentrations from 1990-1992 compared to 1998-2000 period. The highest ambient sulfate concentrations occurred during the summer months within these periods. In analyzing CASTNet data for the summer months, ambient sulfate concentrations declined 12 percent from 1990-1992 compared to 1998-2000.

Relationship between Air Pollution and Human Health

The EPA notes that the discussion summarizing concerns about the health effects of elevated ozone and particulate matter levels in the Great Smokies region correctly identifies the extensive peer reviewed scientific literature and related assessments as the major basis for our understanding of health risks from these pollutants. The location-specific comparisons of health effects in the States of North Carolina and Tennessee, and in counties near the park, are interesting, but should be viewed with considerable caution. The report appropriately notes that the analyses were not intended to be a comprehensive health assessment. Indeed, without appropriate controls for a number of socioeconomic and personal factors such as smoking and occupation, such comparisons are subject to substantial uncertainties

Thank you again for the opportunity to comment.

Sincerely,

Henry Thomas
John S. Seitz
Director
Office of Air Quality Planning
and Standards

Appendix III: Comments From the Tennessee Valley Authority

Tennessee Valley Authority, 400 West Summit Hill Drive, Knoxville, Tennessee 37902-1401

Kathryn J. Jackson, Ph.D.
Executive Vice President
River System Operations & Environment

May 21, 2001

Mr. David Marwick, Assistant Director
Natural Resources and Environment
United States General Accounting Office
Washington, D.C. 20548

Dear Mr. Marwick:

COMMENTS BY THE TENNESSEE VALLEY AUTHORITY (TVA) ON THE DRAFT BRIEFING REPORT, *AIR QUALITY AND RESPIRATORY PROBLEMS IN AND NEAR GREAT SMOKY MOUNTAINS*

TVA appreciates the opportunity to comment on the subject report. The relationship between air pollution and health and environmental problems is a very difficult and uncertain subject. This is especially true in and near the Great Smoky Mountains National Park where terrain is complex and a large number of pollution sources contribute to the park's problems. Overall, we commend the report writers for their efforts to address such a complicated subject in a fairly reasonable and understandable manner.

Despite the report's careful effort to note the uncertainties and complexity of the air quality problems in and near the Smokies, we are concerned that readers will assume an association between identified health problems and emissions from TVA's coal-fired power plants merely because TVA is one of the primary focuses of the report. For example, the report finds slightly higher mortality from pneumonia and influenza in counties near the park. We are aware of no health studies that have found air pollution causes the flu, much less that emissions from TVA's plants result in flu- and pneumonia-related deaths. Enclosed are a number of other, more specific comments on the report.

Sincerely,

Kathryn J. Jackson
Executive Vice President
River Systems Operations & Environment

Enclosure

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