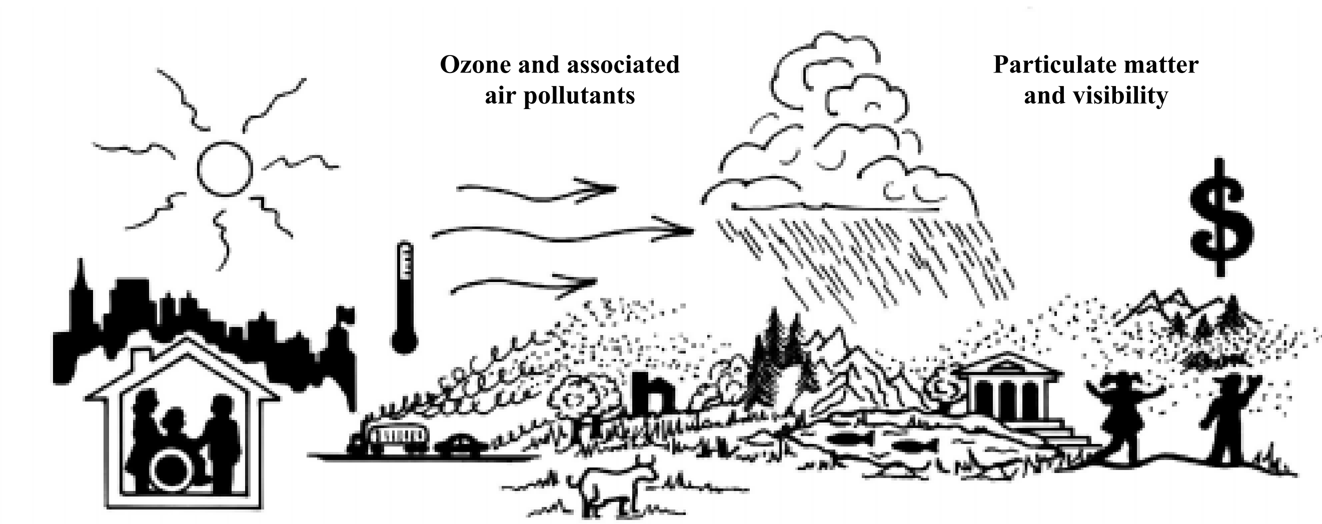
Air Quality Research Subcommittee Strategic Plan



Committee on Environment and Natural Resources
National Science and Technology Council

November 1998

About the National Science and Technology Council

President Clinton established the National Science and Technology Council (NSTC) by Executive Order on November 23, 1993. This cabinet-level council is the principal means for the President to coordinate science, space, and technology policies across the Federal Government. The NSTC acts as a "virtual" agency for science and technology to coordinate the diverse parts of the Federal research and development enterprise. The NSTC is chaired by the President. Membership consists of the Vice President, the Assistant to the President for Science and Technology, Cabinet Secretaries and Agency Heads with significant science and technology responsibilities, and other senior White House officials.

An important objective of the NSTC is the establishment of clear national goals for Federal science and technology investments in areas ranging from information technology and health research, to improving transportation systems and strengthening fundamental research. The Council prepares research and development strategies that are coordinated across Federal agencies to form an investment package that is aimed at accomplishing multiple national goals.

To obtain additional information regarding the NSTC, contact the NSTC Office of the Executive Secretary at (202) 456-6100.

About the Office of Science and Technology Policy

The Office of Science and Technology Policy (OSTP) was established by the National Science and Technology Policy, Organization, and Priorities Act of 1976. OSTP's responsibilities include advising the President on policy formulation and budget development on all questions in which science and technology are important elements; articulating the President's science and technology policies and programs; and fostering strong partnerships among Federal, State, and local governments, and the scientific communities in industry and academia.

To obtain additional information regarding the OSTP, contact the OSTP Administrative Office at (202) 395-7347.

About the Committee on Environment and Natural Resources

The Committee on Environment and Natural Resources (CENR) is one of five committees under the NSTC, and is charged with improving coordination among Federal agencies involved in environmental and natural resources research and development, establishing a strong link between science and policy, and developing a Federal environment and natural resources research and development strategy that responds to national and international issues.

To obtain additional information about the CENR, contact the CENR Executive Secretary at (202) 482-5181.

Air Quality Research Subcommittee Strategic Plan

National Science and Technology Council
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Executive Office of the President
National Science and Technology Council
Committee on Environment and Natural Resources
WASHINGTON

Dear Colleague,

We are pleased to transmit the Strategic Plan of the Air Quality Research Subcommittee of the Committee on Environment and Natural Resources. Under the Clean Air Act, the Nation has made substantial investments to reduce air pollution, with notable success. The Nation's air quality has steadily improved over the last three decades, and man-made emissions to the atmosphere continue to decrease. Nevertheless, in some areas of the United States, the public is still exposed to unhealthy levels of air pollutants. There are, therefore, still important roles for science and technology to play in improving our understanding of the formation and transport of air pollution and our ability to reduce and manage it.

This document describes the broad elements of an interagency research plan to focus the resources of the member agencies of the Air Quality Research Subcommittee on addressing the most pressing air quality issues facing the nation today. To achieve the goal of further air quality improvement, we must use science and technology to develop new and innovative approaches to manage air pollution while sustaining economic growth. This plan is an important step toward development of such approaches.

Sincerely,

Rosina Bierbaum
Co-Chair
Associate Director for Environment,
Office of Science and Technology Policy

D. James Baker
Co-Chair
Administrator, National Oceanic
and Atmospheric Administration

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Introduction

The Nation is committed to the goal of clean air. The Congress has articulated, through the Clean Air Act (CAA) and its Amendments, national air quality goals, including ambient air quality standards for the protection of human health and welfare. The Nation has invested substantial resources in reducing air pollution and will continue to invest tens of billions of dollars annually to meet its clean air goals. While the Nation's commitment to better air quality is clear and unequivocal, the best means of attaining it are far less clear. Public debate often highlights the difficult issues associated with managing the Nation's air quality. What is "acceptable air quality"? How sure of the linkage between emissions and effects must we be before we act? Can we demonstrate the benefits that accrue from our investment in reducing emissions?

Subcommittee Goals

- To enhance the effectiveness and productivity of U.S. air quality research.
- To improve information exchange between research and policy on air quality issues including the scientific knowledge base for air quality standards and for assessing compliance.

Strategic Action Plan

The breadth and complexity of air quality issues necessitate a strategic approach to the development of truly complementary and collaborative efforts among the member agencies. The main elements of this plan are as follows:

- Define the high priority scientific questions whose answers are most needed by policy makers, placing special emphasis on those uncertainties in atmospheric science that apply to multiple phenomena/issues.
- With the participation of the relevant stakeholders, set a national research agenda and associated priorities.
- Track and coordinate research done by participating organizations and researchers.
- Update and revise the research strategy as new research results and policy relevant scientific needs emerge.
- Review progress and prepare periodic assessments of the state of scientific understanding, with summaries describing the relevance to decision making.
- Promote public education and awareness of air pollution understanding and issues.

Focus Issues

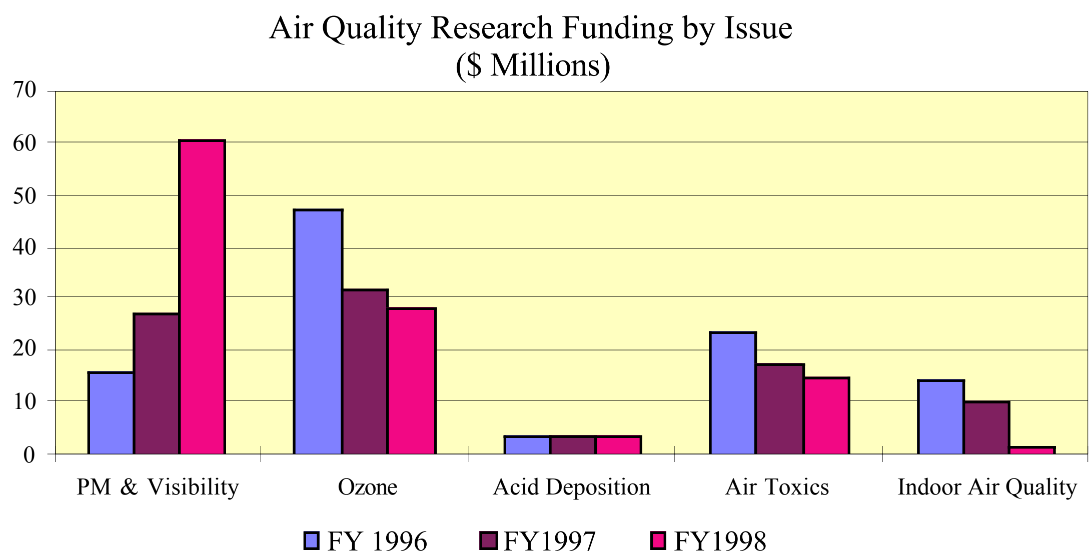
The Subcommittee is currently focusing its efforts on the following areas:

- ***Particulate Matter and Visibility***
- ***Ozone and Associated Air Pollutants***
- ***Acidic Deposition***
- ***Hazardous Air Pollutants (Air Toxics)***
- ***Indoor Air Quality***

Clearly, many of the phenomena associated with these issues are interrelated. For example, particulate matter plays a role in acidic deposition. Similarly, the oxidizing capacity of the atmosphere influences the formation of acidic compounds, particulate matter and surface ozone.

Allocation of Resources

The resources available to the Departments and Agencies that make up the Air Quality Research Subcommittee are allocated among the issues / phenomena listed above based on the mission of each individual agency and priorities established jointly through the Subcommittee.



Total funding was $104.7 million for FY 1996, $ 90.9 million for FY 1997 and $116.1 million for FY 1998. The 28% increase that occurred between FY 1997 and FY 1998 was due primarily to a $23 million congressional appropriations supplement to EPA for particulate matter research. The redistribution of resources reflects an increasing emphasis on fine particle research, driven by a growing body of evidence linking fine particle exposure to significant health effects.

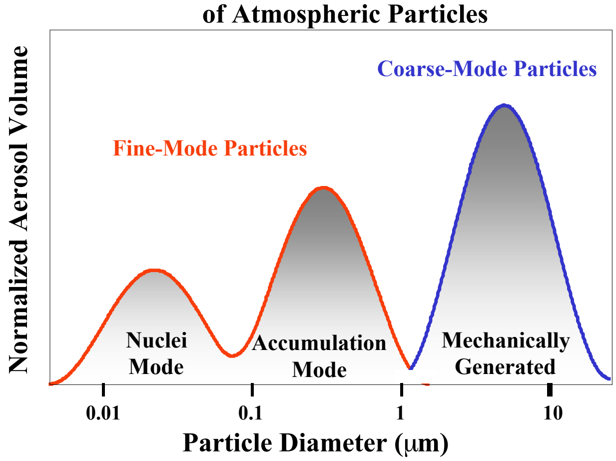
Particulate Matter and Visibility

There is a growing body of evidence linking adverse public health impacts to fine particle exposure. Fine particles also contribute to deteriorating visibility in pristine areas of the country. In response to these concerns, the Environmental Protection Agency has recently promulgated new National Ambient Air Quality Standards for fine particulate matter $PM_{2.5}$ (particles with diameters at or below 2.5 micrometers - µm), and has also proposed new regulations addressing regional haze.

Current Understanding

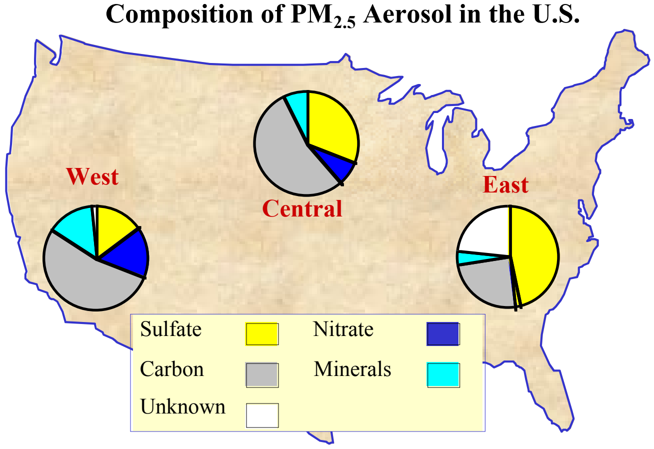
Airborne particles may have many sources and contain hundreds of inorganic and thousands of organic components. They are distributed by size into fine and course modes with a split at about 2.5 µm. Both fine and coarse atmospheric particles find their way into the human respiratory tract. The deposition and clearance of inhaled particles are strongly dependent upon particle characteristics (e.g., size, density, and solubility) and respiration (i.e. mouth breathing versus nose breathing).

Idealized Volume Size Distribution of Atmospheric Particles



Different sources, chemical composition, and atmospheric behavior characterize each mode. Much of the fine particle mass found in the atmosphere is not emitted by any one source but rather is formed in the atmosphere as a result of chemical conversion of man-made and natural emissions. By mass, fine particles are primarily sulfate, nitrate, and ammonium ions, carbon soot, and organics, as well as mineral dust in some locations.

Composition of $PM_{2.5}$ Aerosol in the U.S.



Indications from epidemiological studies of an association between ambient particles and human health endpoints suggest decreased emissions could lead to reductions in premature death and illness from cardiovascular and respiratory causes. However, the biological mechanism(s) by which particulate matter at low ambient levels could cause illness and death is uncertain.

Ambient fine particulate levels vary greatly both regionally and seasonally. Regional background fine particle levels (and associated visibility impairment) are typically highest in the eastern U.S. in the summer months while levels typically peak in the winter months in southern California. Average visual range in most of the western U.S. is 60-90 miles, or about one-half to two-thirds of what it would be without man-made pollution. In most of the East, the average visual range is less than 18 miles, or about one-fifth of the visual range that would exist under natural conditions.

Selected Recent Accomplishments

- Analysis of data collected during the past decade as part of the Interagency Monitoring of Protected Visual Environments (IMPROVE) program has provided important new insights into the distribution, sources and impacts of fine particles in the rural environment. The results highlight seasonal and spatial differences in fine particle concentrations. While urban particle concentrations appear to be decreasing, no such trend appears in the rural data, suggesting that different factors may control particulate levels in these regions.
- The scope of the NARSTO program (description provided below) has been expanded from its original focus on ground-level ozone research to include PM. This program provides an effective mechanism for collaboration and cooperation on PM research between the public and private sectors.

Key Information Gaps

The scientific, technical and economic information needed to develop robust policies to deal with the PM issue are as follows:

- What are the acute and chronic effects of exposure to various components and mixtures of particulate matter?
- What evidence substantiates the biological plausibility for health effects due to low ambient particulate matter exposures?
- What are the current levels of risk for death and various types of illness in the total population and for sensitive or highly exposed groups?
- What are sources, processes, distributions, and trends of particulate air pollution (both primary fine particles and gaseous precursors of secondary particles), and visibility impairment?
- What are the predicted and actual impacts of emissions control on human health and visibility?
- What are the relationships between the control strategies designed to manage PM and those designed to manage other pollutant regimes of interest?
- What are the sources of visibility-reducing particles in Class I areas (National Parks and Wilderness Areas), and what control strategies can be developed to maintain and improve visual air quality in these areas?

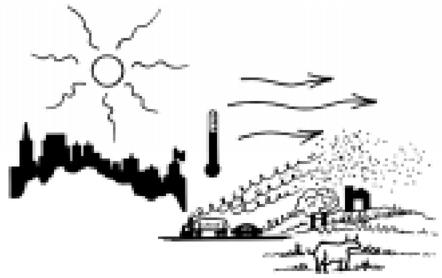
Research Strategy

Research is conducted to understand the risks and causal mechanisms by which fine particles adversely affect human health and reduce visibility. The processes that control ambient PM concentrations that are tied to human exposure (emissions, atmospheric transport, chemical and physical transformations, and deposition) must also be well understood to ensure that current and future regulatory actions are effective. The problem is exacerbated by the lack of a clearly identified agent responsible for the statistical relationship between fine particles and the observed health impacts. It is therefore critical that, for this issue more than any other, there be a close linkage between the health effects and atmospheric research communities. In fact, the National Academy of Sciences long-range research portfolio for PM research addresses the need for such a connection and the Subcommittee is working to foster such a linkage.

Continued and expanded monitoring of PM and its constituents, visibility and the atmospheric characteristics responsible for visibility degradation, and adverse health responses is needed to determine trends and establish associations between air quality and human exposure and health endpoints. These data will also aid in identifying sources responsible for current PM levels and visibility impairment. They can be used to assess effects of changing emissions, and applied to the evaluation of air quality models.

Additional development work is needed to provide improved methods for the characterization of PM size, shape, and composition to be used in monitoring programs and intensive field campaigns. Research is also needed to refine existing, limited analytical PM_{10} (PM with diameters less than or equal to 10 micrometers) models and to develop new reliable $PM_{2.5}$ predictive models.

Ozone and Associated Air Pollutants



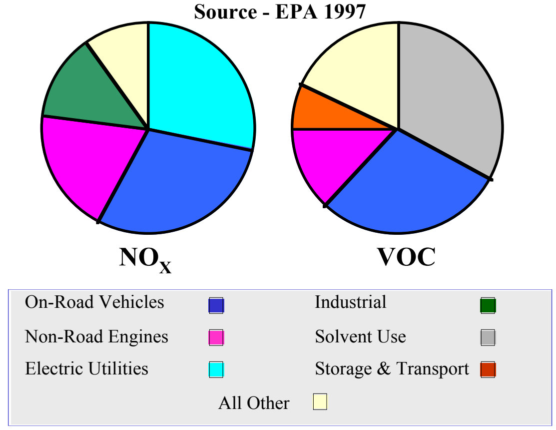
Regulatory efforts to control surface ozone in the United States span nearly three decades. Although significant progress has been made, elevated concentrations of ozone continue to be a problem in many parts of the Nation. The EPA has recently promulgated a new 8-hour air quality standard for ozone that is expected to result in a significant increase in the number of areas designated as "nonattainment". The EPA is calling for a significant reduction in nitrogen oxide or NO_X emissions, primarily from power plants in the eastern U.S., in an effort to reduce both locally formed and transported ozone.

Current Understanding

Ozone at the surface is formed as the result of a complex series of chemical reactions between two families of compounds: oxides of nitrogen (NO_X) and volatile organic compounds or VOCs, in the presence of sunlight. Weather conditions such as high temperatures, intense sunlight and air mass stagnations contribute to the formation of high ozone episodes. Manmade emissions are by far the dominant source of NO_X; however, naturally occurring VOC emissions, primarily from forests, play a significant role, especially in heavily vegetated regions such as the Southeast.

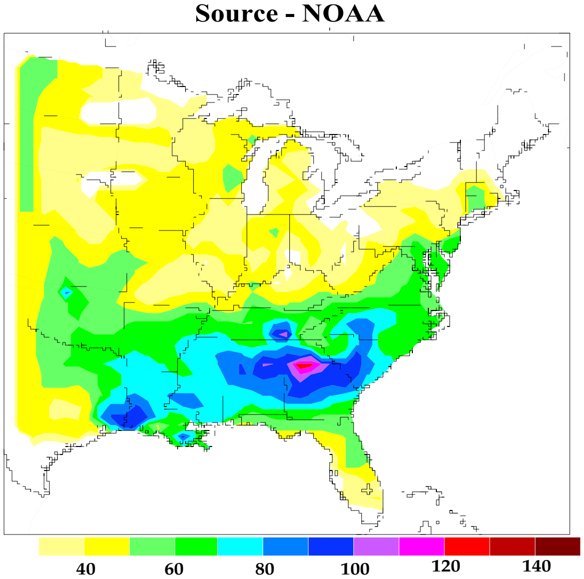
Man-Made Emissions

Source - EPA 1997



Ozone Distribution - June 20, 1990

Source - NOAA



Ozone Concentration (ppb)

Ozone episodes are often regional in nature with elevated ozone concentrations covering several states. This phenomenon is a result of weather patterns producing conditions favorable to ozone formation over a large area and the effective intermixing of emissions from sources located throughout the region. An example of a regional ozone episode, in this case one that covered a large portion of the Southeast, is shown in the figure on the left.

The relative effectiveness of VOC and NO_X controls on ozone will differ by location and region of the country due to differing relative abundances of VOC and NO_X, varying levels of natural emissions and the relative contribution of locally formed and transported ozone.

Extended exposure to elevated ozone levels can result in adverse effects on human health, and cause damage to agriculture and natural ecosystems. There appears to be no ozone threshold concentration below which the public is completely protected from health effects. This observation implies that ozone exposure may elicit a physiological response even at concentrations considered to be at "background" levels.

Selected Recent Accomplishments

- NARSTO - This program effectively integrates public and private sector ozone and PM research in Canada, the United States and Mexico, providing a forum for collaboration and information exchange. Such collaborative efforts ensure that the maximum benefits are realized for resources expended and that no unwarranted duplication occurs.

- Ozone state-of-science assessment - The NARSTO assessment, which is nearing completion, will provide a single source of policy-relevant scientific information on ground level ozone in the form of authoritative, peer-reviewed statements representing a consensus view of the international scientific community.

- Important new information from collaborative field programs - Major multi-agency measurement campaigns have resulted in new perspectives for ozone management. Research results have emphasized the need for flexible strategies that account for regional differences in the chemical and transport processes controlling ozone accumulation.

- Better tools = better strategies - There has been a significant improvement in the quality and accessibility of air quality models and observations that are used for the development of ozone management strategies.

Key Information Gaps

The scientific, technical and economic information needed to develop robust policies to deal with the ozone issue are as follows:

- What are the effects of chronic exposure to ozone and its precursors on humans and managed and natural resources?
- What are the causes of elevated ozone exposures, both episodic and longer-term, in both urban and rural areas?
- What is the relative role of man-made and natural (i.e. biogenic VOCs) precursors in ozone formation in rural and urban areas?
- What are the predicted and actual changes in ambient concentrations of ozone in response to ozone precursor controls?
- What are the available and potential technical options for future reduction of precursor emissions to reduce residual risk beyond those planned in the CAA?
- What are the relationships between the control strategies designed to manage ground-level ozone and those designed to manage other pollutants of interest (e.g., particulate matter)?

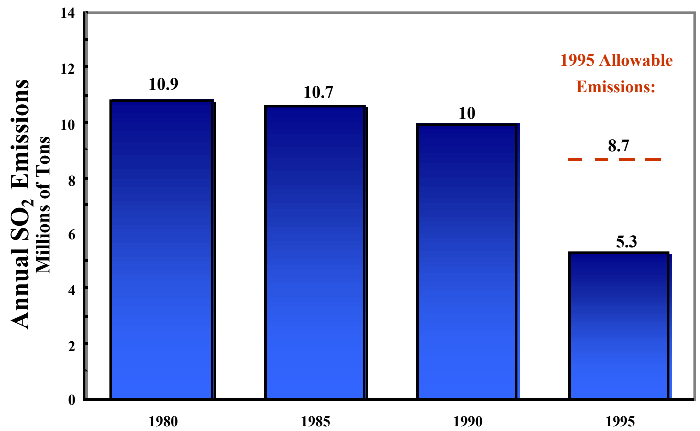
Research Strategy

The NARSTO state-of-science assessment will describe what we now know about this issue, what we have learned since the 1991 National Academy of Sciences report, and evaluate the implications of this new knowledge for ozone management strategies. The assessment is also designed to identify specific research that is needed to improve future policy. It will also point out how well the components of our current observational/interpretative/predictive “toolbox” work, and which need fixing or improvement. The guidance obtained from the assessment process will form the basis for future research program development.

Acidic Deposition

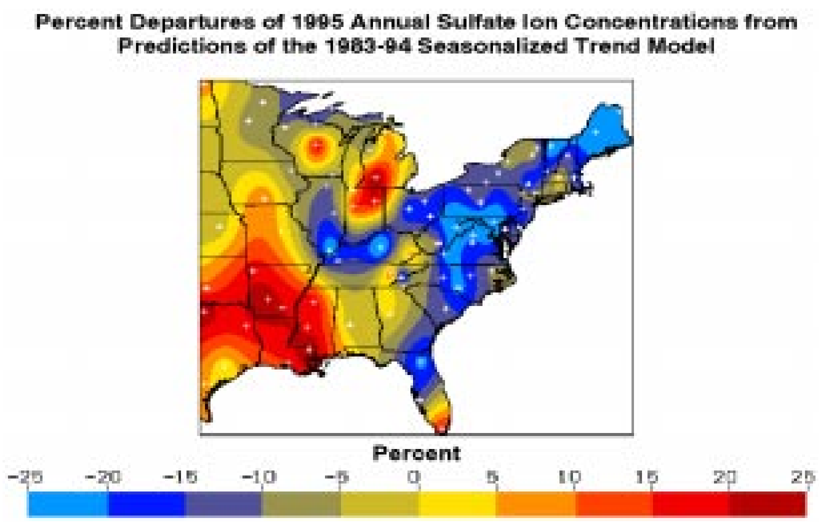
Throughout the 1970's it became increasingly evident that the deposition of acidic air pollutants, or acid rain, was having an adverse impact on the Nation's sensitive ecosystems. In 1980 the Congress created the National Acid Precipitation Assessment Program (NAPAP), a comprehensive research, monitoring and assessment program on the causes, effects and controls of acid rain. The findings of this ten-year program formed the basis of the acid rain provisions in Title IV of the Clean Air Act Ammendments of 1990 (CAAA-90). The legislation places a cap on utility emissions to achieve a total reduction of 10 million tons of sulfur dioxide (SO_2) emissions below 1980 levels by 2010 and calls for an overall 2 million ton reduction of nitrogen oxide (NO_X) emissions from 1980 levels. These reductions are occurring in two phases, Phase I began in 1995 for SO_2 and 1996 for NO_X.

445 Phase I Affected Utility Units



Current Understanding

The acidic substances that are present in our atmosphere result primarily from the combustion of fossil fuels. Gaseous SO_2 and NO_X emitted from power plants and cars are chemically transformed in the atmosphere to sulfuric and nitric acids and to sulfate and nitrate particles. These secondary pollutants are deposited on the earth's surface in wet (rain and snow) and dry (gases and particles) forms. This acidic deposition causes acidification of lakes and streams, resulting in a loss of habitat for certain fish species; contributes to nitrogen saturation and leaching of soil nutrients; contributes to damage of high elevation forests; and damages historic buildings and monuments.



Emissions of SO_2 by power plants affected by Phase I (the highest emitting utility units) have substantially decreased since 1980, with the largest decrease in 1995, exceeding the regulatory goal of Phase I by more than 3 million tons. Only a modest decrease in NO_X emissions from electric utilities occurred between 1980 and 1995.

The benefits of the emission reduction program are already evident in data from wet and dry deposition monitoring networks. Analysis of precipitation chemistry data from the National Atmospheric Deposition Program / National Trends Network (NADP/NTN) indicates that the concentration of sulfate in precipitation generally decreased from 1983 to 1994. Results from the Clean Air Status and Trends Network (CASTNet) indicate an approximate 25% reduction in ambient sulfate levels occurred at the Network's eastern sites between 1989 and 1995. In 1995, sulfate concentrations in precipitation decreased an additional 10-25% in the East. The 1995 change may have been due wholly or in part to the SO_2 Phase I emission reductions in 1995. Unlike sulfate concentrations, nitrate concentration trends for the period 1983 to 1995 do not exhibit a consistent spatial pattern, with the number of sites exhibiting increasing trends nearly equal to those exhibiting decreasing trends.

Reduced emissions of acid rain precursors are expected to produce benefits beyond a decrease in acidic deposition. Reduced emissions of nitrogen oxides are expected to decrease ambient ozone levels and nitrogen loadings onto other sensitive ecosystems such as estuaries. Reductions in sulfur dioxide emissions are expected to reduce visibility impairing particles and adverse health effects associated with fine particles.

Selected Recent Accomplishments

NAPAP reports to Congress the state of current knowledge and effects of the CAA mandated emission reductions through a series of periodic assessments. The most recent Biennial Report to Congress has just been completed and it contains several new insights into the acid deposition phenomena.

- Observed decreases of acidity and sulfate concentration (i.e. up to 25%) in wet and dry deposition were consistent with SO_2 emission reductions.
- Over the last 15 years, lakes and streams throughout many areas of the United States have experienced decreases in sulfate concentrations in response to decreased emissions and deposition of sulfur. Although there is evidence of recovery from acidification in New England lakes, the majority of Adirondack lakes have remained fairly constant, in terms of acidity, while the sensitive Adirondack lakes have continued to acidify.
- Economic analysis of allowance trading, a unique aspect of Title IV, shows the market of SO_2 allowances is functioning, and effective and can serve as a model for other air pollution control programs.

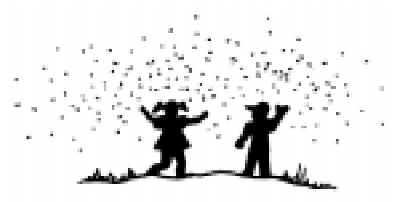
Key Information Gaps

- What are the observed and projected effects of the Title IV requirements on the following impacts:
  - aquatic, coastal, and terrestrial ecosystems, visibility, materials and human health?
  - socio-economic sectors (recreational resources, fisheries, agriculture, forestry)?
  - role of atmospheric nitrogen in base cation leaching from and nitrogen saturation of forest soils and the acidification of lakes and streams?
- What resources remain at risk following implementation of Title IV and what further emission reductions are needed to protect those resources?
- For specified future emission-reduction scenarios, what is needed to gain higher-confidence-level predictions of regional patterns of acid deposition, including the effects of meteorology and climate on the production, loss and redistribution of atmospheric pollutants?
- What are the relationships between the control strategies designed to reduce acidic deposition and those designed to reduce other pollutant regimes of interest?
- What is needed to reduce uncertainty in economic benefit estimates in the areas of human health, ecosystem health, materials, cultural resources and visibility?

Research Strategy

The acidic precipitation research paradigm was established by NAPAP during the 1980s. Throughout its existence NAPAP has acted to facilitate cooperation and collaboration among its member agencies and the public and private sector research communities. NAPAP reports to Congress through periodic, policy-relevant assessments that rigorously examine all the links in the causal chain and identify areas of research needed to address key uncertainties. As the emissions of acid precursors are reduced, it is critical that a comprehensive observing system be maintained to determine if the expected environmental responses are indeed occurring and to identify any confounding factors. Changing deposition patterns also provide an opportunity to test and refine our understanding of the source ⇨ receptor ⇨ impact relationships and assess whether further emission reductions are needed to protect sensitive resources.

Hazardous Air Pollutants (Air Toxics)



Hazardous air pollutants (HAPs) or "air toxics" are those pollutants that are known or suspected to cause serious health effects, such as damage to the reproductive system, birth defects, and cancer, or to cause adverse environmental effects. They are emitted as gases, liquids or solids and, though some (e.g., radon) have significant natural sources, most enter the atmosphere as a result of human activities. They are produced by factories, power plants and cars and by daily use of certain chemical-containing materials. Examples include benzene, 1, 3 butadiene, vinyl chloride, dioxins, mercury, lead compounds, and formaldehyde.

The CAAA-90 established a list of 189 toxic air pollutants to be regulated. Under that law, the EPA is mandated to identify the Maximum Achievable Control Technology (MACT) and require the installation of this technology on industrial sources with significant air toxics emissions. The law also contains provisions for regulating toxic emissions that impact urban areas and the Great Lakes and other water bodies.

Current Understanding

The 1993 National Toxics Inventory (NTI) estimated that 3.7 million tons of toxic pollutants were emitted into the air. Of this total, mobile sources, such as cars and trucks, contribute 40%, area sources such as small incinerators, dry cleaners, and chrome platers contribute 35%, and point sources such as chemical, steel, and paper manufacturers contribute 25%.

An analysis of data collected from urban areas indicated that lifetime cancer risk due to air toxic emissions could be as high as 1-in-10,000. Individuals residing in the immediate vicinity of industrial facilities may experience similar risks. Some people, such as Native Americans and low income minority anglers who consume fish from the Great Lakes and other affected water bodies, may experience increased lifetime cancer risks due to persistent bioaccumulative toxic pollutants that are emitted to the air and deposited into water.

Selected Recent Accomplishments

An assessment of the U.S. oxyfuels program was completed by a group of experts from various federal agencies, academia, and the private sector. The use of oxyfuels (gasoline with at least a 2.7% oxygen content) was mandated under the CAAA-90 in areas that did not meet the National Ambient Air Quality Standard for carbon monoxide (CO). Oxygenated gasoline is designed to increase the combustion efficiency of gasoline, thereby reducing CO emissions. The assessment was initiated partly in response to public concern regarding possible health risks associated with using oxygenated gasoline. The report, ***Interagency Assessment of Oxygenated Fuels***, produced numerous significant findings on the risks and benefits that result from use of oxygenated gasoline. With respect to air toxics, the assessment concluded that studies conducted to date do not support evidence that methyl tertiary-butyl ether (MTBE - the primary oxygenate in use) caused acute symptoms in the general public or exposed workers (e.g., service station attendants). The report also provides an overall evaluation of the toxicological database on MTBE.

EPA recently produced three technical reports that address important aspects of the air toxics problem including:

- ***Mercury Study Report to Congress***: provides an analysis of environmental and public health impacts of mercury emissions.
- ***Study of Hazardous Air Pollutants (HAP) Emissions from Electric Utility Steam Generating Units -- Final Report to Congress***: provides an analysis of HAP emissions, exposure and risk including available control technologies and costs.
- ***Deposition of Air Pollutants to the Great Waters -- Second Report to Congress***: analyzes sources and impacts of HAP emissions to the Great Lakes and other boundary waters and the Chesapeake Bay.

Key Information Gaps

This area of research is focused on health and exposure-related issues that underlie the evaluation of risks from HAPs and on providing the science-based input to support decisions on appropriate prevention and control measures. The scientific, technical, and economic information needed to develop robust policies to deal with this issue are as follows:

- What are the cancer and non-cancer health risks from exposure to air toxics, both individually and in mixtures. What populations are most susceptible?
- What are the ecological effects of exposure to and deposition of air toxics (e.g. deposition of mercury and its uptake in the food chain)?
- What are the emissions from mobile, area, and stationary sources of air toxics?
- What are the source, transport, and fate relationships for air toxics and their mixtures?
- What are the most cost-effective means of preventing and/or controlling air toxic emissions from major area sources?
- What are the residual risks in and around urban areas where MACT controls are instituted?
- What are the alternative processes or substitutions that can reduce toxic use and emissions?
- What are the benefits of reducing toxic emissions and the economic impacts of alternative control technologies?

Research Strategy

Ongoing research on HAPs is focused on gaining a better understanding of the nature of these pollutants and their sources and sinks. Research on health effects mechanisms of air toxics and the relationship of concentration versus duration of exposure is ongoing to provide a sound science basis for determining risks from exposure to HAPs. New approaches need to be developed to provide improved assessments of air toxic exposure, including improved monitoring and modeling techniques and protocols. Risk analysis techniques are fundamental to the effective management of air toxics and multi-pathway (e.g., inhalation, ingestion and dermal contact) risk analysis approaches are under development. Research on pollution prevention and cost-effective controls is ongoing to facilitate risk management of HAPs.

Indoor Air Quality

Because most people in modern society spend a significant portion of their time indoors, it is important to understand what pollutant exposures might occur in this environment and how these relate to ambient pollutant concentrations. Exposures may occur through multiple pathways, to multiple agents and in conjunction with non-traditional stressors (e.g., heat, light, and sound). Pollutants found indoors can include radon, volatile organics, microorganisms, passive cigarette smoke and other combustion products, as well as pollutants that have infiltrated from outside. The nature of indoor pollutants depends on an enormous number of variables, such as the building design, furnishings, the indoor activities of its occupants, and the nature and rate of air exchange with the outside. The only real indoor air quality standards for specific chemical constituents are those set to control occupational exposures. These standards are based on the ***Threshold Limit Values (TLVs) of Airborne Contaminants*** established by the American Conference of Government and Industrial Hygienists (ACGIH). In the past, risk assessments for exposure to air toxics in ambient air have often been based on the TLVs set for those substances in occupational settings multiplied by an adjustment factor to be more protective for the general population.

Current Understanding

Indoor air quality is judged by the ability of inside air to provide safety and comfort to indoor occupants. Comfort and safety variables include temperature, humidity, noise, odor, and contaminants in the air. Outdoor contaminants can infiltrate indoors through open doors, windows, ventilation shafts, and through leaks. Some pollutants that are of concern outdoors, such as ozone and sulfur dioxide, are generally found in much lower concentrations indoors due to their reaction and loss on building materials and furnishings. Carbon monoxide, nitrogen oxides, formaldehyde, and other organic compounds may be found in higher concentrations indoors due to indoor sources such as cigarette smoking, wood burning, the use of natural gas, various commercial products, and building materials. Microbes, including molds, bacteria, viruses, fungi, spores, and pollen are often significant indoor contaminants. Microbes are generally found in the larger size range of 5-100 μm and can be responsible for a variety of adverse health effects from mild allergic reactions to life-threatening asthma conditions. Indoor dusts in the fine range (less than 2.5 μm) may contain enhanced concentrations of metals from sources such as paints, cleaning products, cigarette ash, and pesticides, over those found outdoors.

There are also many indoor sources of both gaseous and particulate organics including combustion activities, the outgassing of chemicals from new carpets and furnishings, and the use of adhesives, polishers, cleansers, air fresheners, and sprays. Radon is probably the most heavily studied indoor contaminant. Radon gas from natural sources such as some types of soils and rock can seep into homes, become trapped, and the concentration may build up to an unhealthy level. Testing homes and indoor buildings for radon buildup has become fairly common and problems can generally be alleviated by sealing cracks and improving ventilation. Asbestos fibers, primarily from insulation material, are also a well-studied indoor pollutant and extensive efforts have been made to contain or remove such material from public buildings.

Key Information Gaps

- What are the important contributors to health effects from indoor pollutants (e.g., biologicals, organic vapors? How can multiple chemical sensitivity be objectively defined and identified?
- What are the important sources of indoor pollutants that are a concern for health and what is their relative contribution to the total human exposure to these pollutants?
- What is the distribution of infiltration rates of various pollutants for the many different types of indoor environments? How do these vary diurnally and seasonally?
- What is the relative importance of different building characteristics (e.g. architectural design, building materials, ventilation systems, and furnishings) on indoor air quality?
- What are the removal rates of various pollutants indoors and how do they vary with different indoor parameters?
- What additional atmospheric chemical reactions may be catalyzed on indoor surfaces?
- How well do personal monitors characterize indoor exposures? How much information is needed on human activity patterns and microenvironmental pollutant concentrations to characterize total exposure?

Research Strategy

Ongoing research on indoor air quality is focused on gaining a better understanding of the nature of indoor air pollutants and their sources and sinks. New measurement methods are being developed specifically for indoor air monitoring and for exposure and risk analysis. There are also efforts to further evaluate the influence of various building designs and construction on the quality of indoor air. A database is being developed to rank consumer/commercial products and building materials that affect indoor air quality and to identify high priority products and materials for further evaluation with respect to potential health risks. Finally, studies are being conducted on the effects of biological contaminants and methods are under development to measure symptoms associated with organic vapor exposures, particularly in individuals who report chemical sensitivity.

Collaborative Programs

The Air Quality Research Subcommittee reaches out to the larger stakeholder community through formalized collaborative programs. These programs were established to focus on specific issues and provide a forum where research initiatives from the federal agencies can be integrated with those of industry, the university community and other public sector organizations.

NARSTO is a public/private partnership, whose membership spans government, the utilities, industry, and academe throughout Mexico, the United States, and Canada.

Its primary mission is to coordinate and enhance policy-relevant scientific research and assessment of tropospheric ozone and PM behavior, with the central programmatic goal of determining workable, efficient, and effective strategies for local and regional ozone and PM management. In accomplishing this goal, NARSTO is charged with establishing and maintaining effective communication channels between its scientific effort and its client community of planners, decision-makers, stakeholders, and strategic analysts. It is also charged with providing a cross-organization planning process that determines the most effective strategies for scientific investigation. NARSTO coordinates the allocation of financial resources to implement these strategies, and monitors progress of its efforts toward fulfillment of its programmatic goal.

The NARSTO vision is that of a focused and coordinated research and development program established for the study of tropospheric ozone and PM concentrations, sources, formation mechanisms and transport phenomena across the North American continent. This continental research program will involve scientists and policy makers from Canada, Mexico and the United States of America.

Under the guidance of its Analysis and Assessment Team, NARSTO is scheduling publication of the first of its ozone assessment documents for late in 1998. This initial document will be targeted toward a variety of end users, including policy analysts, decision makers, the scientific community, and the interested public.

Additional information may be found on the NARSTO home page at:
http://www.cgenv.com/Narsto

The National Acid Precipitation Assessment Program (NAPAP) is an interagency scientific research, monitoring and assessment program on the effects of sulfur and nitrogen oxides on the environment and human health.

NAPAP acts as a coordinating office between six Federal agencies, which also fosters cooperation among its members, other governments, states, universities, and the private sector. The participating agencies are the National Oceanic and Atmospheric Administration (NOAA), the Environmental Protection Agency (EPA), the Department of Energy (DOE), the Department of the Interior (DOI), the Department of Agriculture (USDA), and the National Aeronautics and Space Administration (NASA). NAPAP is a mature program that, through coordination, capitalizes on the different strengths of the participating agencies.

NAPAP was established by Congress in 1980 to conduct a comprehensive ten-year research, monitoring and assessment program on the causes, effects and control of acid rain. During the 1980's, the NAPAP greatly improved our technical understanding of acid rain and produced a wealth of information that is embodied in NAPAP's 27 ***State of Science and Technology Reports*** and the ***1990 Integrated Assessment Report***.

NAPAP was reauthorized under Section 901j, of Title IX of the CAAA-90 to continue coordination of federal acid deposition research and monitoring of emissions, acidic deposition, and its effects. NAPAP reports to Congress on these activities as well as assesses the costs, benefits, and effectiveness of the Acidic Deposition Control Program in a form that is useful to policymakers. The policy-relevant assessment approach rigorously examines all the links in the causal chain and emphasizes research to sort out alternative hypotheses and peer review to ensure credibility of the results.

Additional information may be found on the NAPAP home page at:
http://www.oar.noaa.gov/admin/napap.html

Acronym List

ACGIH	American Conference of Government and Industrial Hygienists
CASTNet	Clean Air Status and Trends Network
CAA	Clean Air Act
CAAA-90	Clean Air Act Amendments of 1990
CENR	Committee on Environment and Natural Resources
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
DOT	Department of Transportation
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FY	Fiscal Year
HAP	hazardous air pollutant
IMPROVE	Interagency Monitoring of Protected Visual Environments
MACT	Maximum Achievable Control Technology
μm	micrometer
MTBE	methyl tertiary-butyl ether
NADP	National Atmospheric Deposition Program
NAPAP	National Acid Precipitation Assessment Program
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NIEHS	National Institute of Environmental Health Sciences
NIH	National Institutes of Health
NIOSH	National Institutes of Occupational Safety and Health
NOAA	National Oceanic and Atmospheric Administration
NO_X	nitrogen oxides
NSF	National Science Foundation
NSTC	National Science and Technology Council
NTN	National Trends Network
OMB	Office of Management and Budget
OSHA	Occupational Safety and Health Administration
OSTP	Office of Science and Technology Policy
PM	particulate matter
$PM_{2.5}$	PM with diameters less than or equal to 2.5 micrometers
PM_{10}	PM with diameters less than or equal to 10 micrometers
R&D	research and development
SO_2	sulfur dioxide
TLV	Threshold Limit Values
TRI	Toxic Release Inventory
USDA	U.S. Department of Agriculture
VOC	volatile organic compound

Abstract

The *1998* ***Air Quality Research Subcommittee Strategic Plan*** describes the broad elements of an interagency plan that focuses the resources of the departments and agencies that make up the Subcommittee on the most pressing air quality issues that face the Nation today. The critical gaps in our understanding that prevent effective solutions to these problems are identified. The Strategic Plan provides a framework for the allocation of federal R&D dollars that maximizes the benefits of individual departmental and agency programs while promoting a collaborative approach to the development of needed information. The Subcommittee has identified five areas that require special attention:

- Particulate matter and visibility
- Ozone and associated air pollutants
- Acidic deposition
- Hazardous air pollutants (air toxics)
- Indoor air quality

Collaborative programs that engage the larger stakeholder community are an important part of the solution to these difficult problems. The Subcommittee reaches out to this community through two formal programs – NARSTO and the National Acid Precipitation Assessment Program (NAPAP).

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Also available on the NSTC Home Page via link from the OSTP Home Page at:
http://www.whitehouse.gov/WH/EOP/OSTP/NSTC/html/NSTC_Home.html

and the CENR Home Page:
http://www.nnic.noaa.gov/CENR/cenr.html

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