Chapter 2
The Policy Dilemma

Contents

FIGURE

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Fossil fuels are vital to the U.S. economy's production of goods and services. However, burning these fuels also produces large quantities of pollutants— substances that, once released into the atmosphere, can damage natural resources, health, agricultural crops, manmade materials, and visibility. Consequently, our Nation's laws and policies must strike a balance between the economic benefits and the environmental risks of fossil fuel combustion and other pollution-producing activities.

This assessment focuses on one class of air pollutants: those that are transported over large regions, either in their original form or as chemically transformed products. Such pollutants include acid deposition, ozone, and airborne sulfate. The current Clean Air Act[1] was designed to ameliorate local-scale pollution problems, and does not directly control pollution transport across hundreds of miles.

Over the past several years, controlling pollutants that contribute to acid rain has become a major policy issue. The House Committee on Energy and Commerce and the Senate Committee on Environment and Public Works—the committees that oversee the Clean Air Act—requested OTA to assess what is known about transported air pollutants, including the benefits and costs of controlling them. OTA's assessment primarily addresses potential effects in the eastern half of the United States, focusing on the risks of damage to sensitive resources, the economic risks that arise from further controlling pollution emissions, and how these risks are distributed among different groups and regions of the country. Policy alternatives available to Congress are also presented.

[1]Clean Air Act Amendment of 1977, Public Law 95-95 (Aug. 7, 1977), as amended,

THE POLLUTANTS ADDRESSED IN THIS STUDY

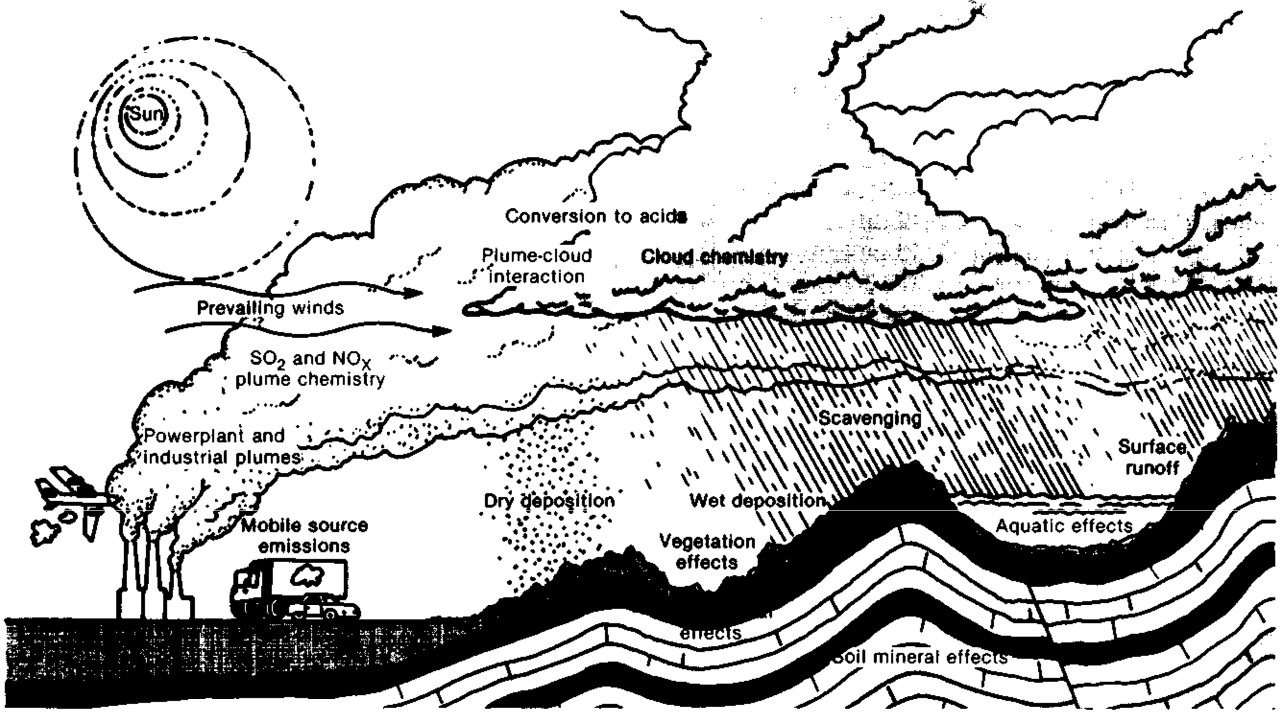
Acid deposition, ozone, and airborne sulfate are produced from three air pollutants: sulfur dioxide, nitrogen oxides, and hydrocarbons. Acid deposition, commonly referred to as "acid rain, involves a variety of pollutants deposited in both wet and dry forms; it results from sulfur and nitrogen oxide gases, sulfates and nitrates (transformation products of these gases), and from interactions with other chemicals in the atmosphere. Figure 10 illustrates the pathways these pollutants travel through the environment. Both ***directly emitted or ''primary*** pollutants and *transformed or "secondary* pollutants contribute to acid deposition. Both can be of concern on the local scale as well as on a regional scale. A pollutant can be returned to the Earth's surface within an hour or travel in the atmosphere for longer than a week, depending on its chemical properties, and factors such as weather patterns and other pollutants present in the atmosphere.

Besides contributing to acid deposition, the secondary pollutants addressed in this study —sulfates, nitrates, and ozone—are of concern for other reasons. Regional visibility degradation is closely correlated with concentrations of airborne sulfate particles. Sulfate particles in the atmosphere are also small enough to be deeply inhaled, and are thus of concern for their effects on human health. Ozone—formed in the atmosphere from nitrogen oxides and hydrocarbons—is injurious to plant life and of concern to human health.

Secondary air pollutants have several factors in common:

1. they can form over periods ranging from hours to days and travel hundreds to possibly thousands of kilometers;
2. they cannot be controlled directly, but only by controlling the pollutants from which they

Figure 10.—Processes and Environmental Effects of Acid Deposition



SOURCE: Adapted from *The Acid Precipitation Problem* (Corvallis, Oreg.: U.S. Environmental Protection Agency, Environmental Research Laboratory, 1976).

are formed (and possibly other pollutants that determine their rates of transformation);

3. different secondary pollutants result from the same primary pollutants—e. g., nitrogen oxides can react to form both nitrates and ozone; and
4. they manifest themselves in several ways—e. g,, sulfate contributes both to acid deposition and to reductions in visibility.

WHY TRANSPORTED AIR POLLUTANTS ARE AN ISSUE

Public Concerns

Current evidence indicates that acid deposition has significant adverse effects on lakes and streams. Additionally, scientific concerns have been voiced over potentially significant effects on forests and soils, agricultural crops, manmade and natural materials, visibility, and human health. Recognizing this risk of damage, some individuals and groups have called on the Federal Government to control pollutant emissions more stringently than current laws require. They cite large numbers of acidified lakes and streams, observed forest declines in polluted areas of Western Europe and Eastern North America, experiments showing crop damage, and deterioration of historic structures as evidence that air pollutants are causing widespread damage to important natural, economic, and cultural resources. Recommendations for additional emissions control have come, for example, from the National Commission on Air Quality, the National Governors' Association, the State and Territorial

Air Program Administrators, study groups of the National Academy of Sciences, and the 1982 Stockholm Conference on the Acidification of the Environment.

Others, pointing to uncertainties about the causes and consequences of transported pollutants, are concerned that further emissions controls may be mandated prematurely. They suggest that pollution transport processes, potential effects, and alternative mitigation strategies are poorly understood; thus, further controlling emissions now may waste money and impose unreasonable costs on industry and the public. Over the past several years, such concerns have been voiced by the U.S. Environmental Protection Agency (EPA), the Department of Energy, the Business Roundtable, and the U.S. Chamber of Commerce. Reducing total sulfur dioxide emissions by more than about 25 percent in the Eastern United States is estimated to cost in the billions of dollars annually. Efforts to control transported air pollutants through stringent sulfur dioxide emissions controls could increase electricity rates as well as displace mining jobs by reducing demand for high-sulfur coal.

Transported air pollutants also raise significant equity issues. Those served by the activities generating acid rain and ozone can be different from those who incur resource damage. Similarly, particular groups and regions might bear an unequal share of the costs of controlling transported air pollutants.

Why Transported Pollutants Are a Federal Concern

Transported air pollutants have become an issue for potential Federal action because they cross political boundaries. The current Federal system of pollution control relies on State-level abatement programs to limit pollution levels within individual States. * However, no effective means of controlling extensive pollution transport across State lines currently exists. Transported pollutants also cross the ***international*** boundary both into and from Canada. Article 1, Section 10 of the Constitution prohibits States from entering into agreements with foreign nations without the consent of Congress; thus, any pollution control agreements with Canada would require Federal action. * *

Existing Federal air pollution control mechanisms are governed primarily by the Clean Air Act, which Congress is now considering for reauthorization. To date, control strategies developed under the Act have focused on controlling local ambient air concentrations. However, many observers have questioned the effectiveness of this approach for controlling transported air pollutants.

● National emissions limits for new sources of pollution (New Source Performance Standards) are in place to control future pollution emissions.

•● The United **States** and Canada signed a Memorandum of Intent in August 1980, establishing a bilateral research plan to investigate transboundary air pollution and pledging work toward a bilateral accord on transboundary air pollution. Negotiations began on June 23, 1981, and are still in progress.

Ph redl Canadian

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m d p m m
U S d C d m g EPA
Adm W R S ry S G
S Am Am d P R b D
P m M A M E C ad Am d
A G b d M E m C C

CHARACTERISTICS OF THE POLICY DEBATE

Several aspects of transported air pollutants have shaped the public policy debate over whether or not to further control pollutant emissions at this time. First, ***scientific uncertainty*** exists over the current severity and geographic extent of the damages attributable to transported air pollutants, as well as over the timeframe in which further damage might occur. Second, and of great political importance, transported air pollutants pose a ***distributional problem,*** having intersectoral, interregional, international, and intergenerational equity aspects. Third, significant ***disagreements in values*** exist over how to balance the costs of controlling pollutants and the environmental risks posed by pollution.

Disagreements Over Facts

Debate over scientific understanding of transported air pollutants is perhaps the most visible aspect of the policy controversy. Many assert that the causes and consequences of acid deposition are both sufficiently understood and significant to warrant immediate action to control it. Others emphasize the complexity of the phenomena involved, and argue that no regulatory strategy can be justified on the basis of existing scientific knowledge.

Scientific uncertainty is not new to air pollution policy. The continuing controversy over the nature and magnitude of health risks—the critical measure for setting local air quality standards—illustrates the difficulty of unambiguously documenting the scientific basis for regulation. Similarly, the extent to which transported air pollutants affect health, crops, visibility, materials, forests and soils, and lakes and streams is uncertain. Current inability to quantify these relationships precludes agreement as to whether the benefits of reducing pollutant levels would justify the costs involved in further controlling emissions.

Because some types of air pollutants can be transformed, dispersed, and transported over long distances, identifying the specific emission sources responsible for resource damage in a particular area is extremely difficult. Consequently, designing emission control policies for transported pollutants becomes difficult both analytically and politically: analytically, because the sources that can most efficiently reduce deposition in the affected areas may not be readily identifiable; politically, because placing the burden of control on certain regions may appear to be arbitrary or inequitable,

Distributional Issues

The distributional aspects of transported air pollutants further complicate the policy dilemma. Pollution control, by affecting the relative prices of various products, benefits economic activities that are inherently less polluting, or that can reduce pollution less expensively, at the expense of more pollution-intensive goods and services. But the geographical scope of transported air pollutants creates several distributional issues not present in conventional, local air pollutant problems.

Within the United States, winds carry pollutants over long distances, so that activities in one region of the Nation may contribute to resource damage in other regions. Many of these activities primarily benefit the source region, while some of their costs, in terms of resource damage caused by their waste products, fall elsewhere. Long-range pollution transport thus redistributes benefits and costs among regions. Programs to control transported air pollutants would also have *interregional* distribution aspects. The costs of controlling emissions might be imposed primarily on source regions (depending on the scheme for allocating costs), while the major benefits of reducing emissions might accrue primarily to downwind, receptor regions.

Winds also carry pollutants over national borders, posing an ***international*** as well as an interregional distribution problem. About three to five times more pollution is transported from the United States to Canada than reaches this country from Canada.[2] The Canadian Government asserts that fossil fuel combustion in the United States is damag-

[2]United States-Canada Memorandum of Intent on Transboundary Air Pollution, Executive Summary, Work Group Reports, February 1983.

ing lakes and streams, and might damage forests, in Eastern Canada; consequently, Canada is paying some of the costs of U.S. economic activities. Federal and provincial Ministers of the Environment have pledged to reduce sulfur dioxide emissions by 50 percent in Eastern Canada by 1994 and urged the United States to undertake parallel emissions reductions. Distributional equity questions would still exist if the two nations undertake further control programs, in that the United States and Canada might benefit differentially from reduced transboundary pollution.

The intergenerational aspects of transported air pollutants raise yet another equity issue. Both the appearance of harmful effects and the recovery of damaged resources may lag behind changes in pollution levels. For instance, lake and stream acidification and forest damage may take on the order of decades to occur. Because acid deposition may diminish a watershed's ability to neutralize future acid inputs, *future* resource damages may depend on the total amount of deposition an area has already received. In addition, resources may require a relatively long period of time to recover following a reduction in the level of acidic inputs. If both the onset and amelioration of adverse effects involve extensive delays, the amount of acid deposition produced by one generation could affect the quality of ecological and other societal resources available to future generations.

Disagreements Over Values

Even if a scientific consensus existed on the magnitude of the problem of transported pollutants, policy choices would still be complicated by lack of agreement over how to promote economic development while protecting the environment. Although the concept of a tradeoff between these *two* values is widely accepted, various individuals and groups differ sharply on where the balance should be struck.

Disagreements over facts and values are intertwined. Differing value structures lead various individuals and groups to draw quite different conclusions from the same body of scientific information. Widespread recognition of scientific uncertainties has focused the policy debate on whether both the magnitude of damage involved and the effectiveness of control efforts are sufficiently known to pursue emissions reductions. This dispute involves both relatively objective issues of science, e.g., how reducing sulfur emissions might affect sulfur deposition in certain areas, and subjective issues of values, e. g., what level of scientific certainty and/or what degree of damage is required to justify undertaking a control program.

RISK AND UNCERTAINTY

Scientists can describe potential resource damage and regions of the United States most susceptible to damage from transported pollutants, but they cannot *precisely quantify* what levels of damage have already occurred or could occur in the future. Similarly, analysts can estimate the costs of alternative control strategies, and who might bear these costs, but how *effective* these control strategies would be for avoiding resource damage cannot be calculated with confidence. Given the difficulty of quantifying the relationship between reducing emissions and preventing resource damage, Congress must base near-term policy decisions on the risks of resource damage, the risks of unwarranted control expenditures, and the distribution of these risks among different groups and regions of the country.

Risk, in the sense used in this report, refers to some possible, harmful outcome—either resource damage or excessive control costs. Three concepts are important:

1. a potential for harm exists;
2. there is some uncertainty about whether the harm will actually come to pass; and
3. if it does, there is uncertainty about how extensive it will be.

Throughout this report, OTA describes the risks of controlling or not controlling transported air pollutants, emphasizing those risks with potentially significant consequences for society. To put this information in perspective, wherever possible, we have tried to describe the uncertainty in estimates of the ***magnitude and extent*** of the potential harm, as well as how likely such harm is to occur.

Assessments of risk such as those presented in chapter 3, and the regional descriptions presented in chapter 5, focus on ***potential*** consequences, not necessarily the consequences that will, in fact, occur. Uncertainty—stemming from limitations in data and understanding—precludes drawing definitive scientific conclusions. Nonetheless, uncertainty does not remove the risks to which society is actually subjected, although it makes these risks substantially more difficult to describe. Five key uncertainties, chosen for their relevance to the policy debate, are presented below.

KEY SCIENTIFIC UNCERTAINTIES

Later chapters of this report will describe what is at stake in decisions to control or not to control transported air pollutants. This chapter outlines key uncertainties to provide an overview of current debates within the technical and scientific community. Each of these uncertainties will also be discussed throughout the report as appropriate to the issue being addressed.

Five key uncertainties are especially relevant to congressional decisions about transported air pollutants. These include controversies about:

1. the extent and location of current damages,
2. future damages (whether they are cumulative and/or irreversible),
3. the geographic origins of observed levels of pollution,
4. the effectiveness of emissions reductions for reducing current levels of transported pollutants, and
5. whether a research program will provide significant new results.

These scientific uncertainties affect several policy concerns, including:

- making air pollution control policy as fair as possible, i.e., providing some legal recourse to those bearing the risks of damage, and (if a control program is adopted) distributing costs of control fairly;
- minimizing cumulative and irreversible damage, and their intergenerational implications;
- weighing the risk of damage against gains that might be achieved by waiting for better information or improved technology; and
- assuring that the societal benefits of a control program justify the cost.

Uncertainty About the Extent and Location of Current Damages

Scientists are certain that transported air pollutants have caused some damages. **At** issue is the severity of the damage, whether it is fairly localized or widespread, and which resources are affected. For example, there is little question that acid deposition damages lakes, and ozone harms crops. The uncertainties revolve around how ***many*** lakes and streams and *what quantity* of crops. For these and other resources, the ***risks*** of extensive damage over large parts of the United States are substantial. Chapter 3 summarizes the aggregate risks in the Eastern United States for a number of affected resources; chapter 5 describes the regional ***patterns*** of these risks using an extensive series of maps. Appendixes discuss each resource of concern in greater detail.

For certain concerns, such as the extent of damage to forests from acid deposition, the uncertainties are so large that it is difficult to describe the patterns or magnitude of the risk. Damage to forests from ozone, and the effects of toxic metals released into drinking water due to acid deposition, also fall into this category. The report also discusses these types of risks, presenting geographical patterns where possible.

Uncertainty About Future Damages

Growing scientific recognition that transported pollutants are linked to observed damages intensifies concern over the potential for future damage, even if current damages are not extensive. Of particular importance is the extent to which damages are *cumulative* and/or *irreversible.*

The Extent to Which Damages Are Cumulative

For some resources, pollution-related damages might ***worsen*** over time if pollution remains at about current levels. For short-lived species, such as crops harvested annually, this is not a relevant concern. Damage to this year's crops from ozone—and potentially from acid deposition—is caused only by current levels of pollution. However, for longer lived species such as trees, ***cumulative*** damage is of concern. Ozone injury and potential acid deposition-related damage to forests maybe sma11 in any one year, but continued stress over many years could ultimately reduce productivity.

The portion of ***current*** aquatic resource damage attributable to the cumulative effects of deposition over many years is also uncertain. One major unknown is the degree to which years of exposure to acid deposition deplete the neutralizing capability of soils in the surrounding watersheds.

The extent to which damages accumulate—and over what time scale-has played a major role in the policy debate over the risks of delaying control action. If damages are not significantly cumulative, delaying control action while awaiting further information would not increase the level of damage

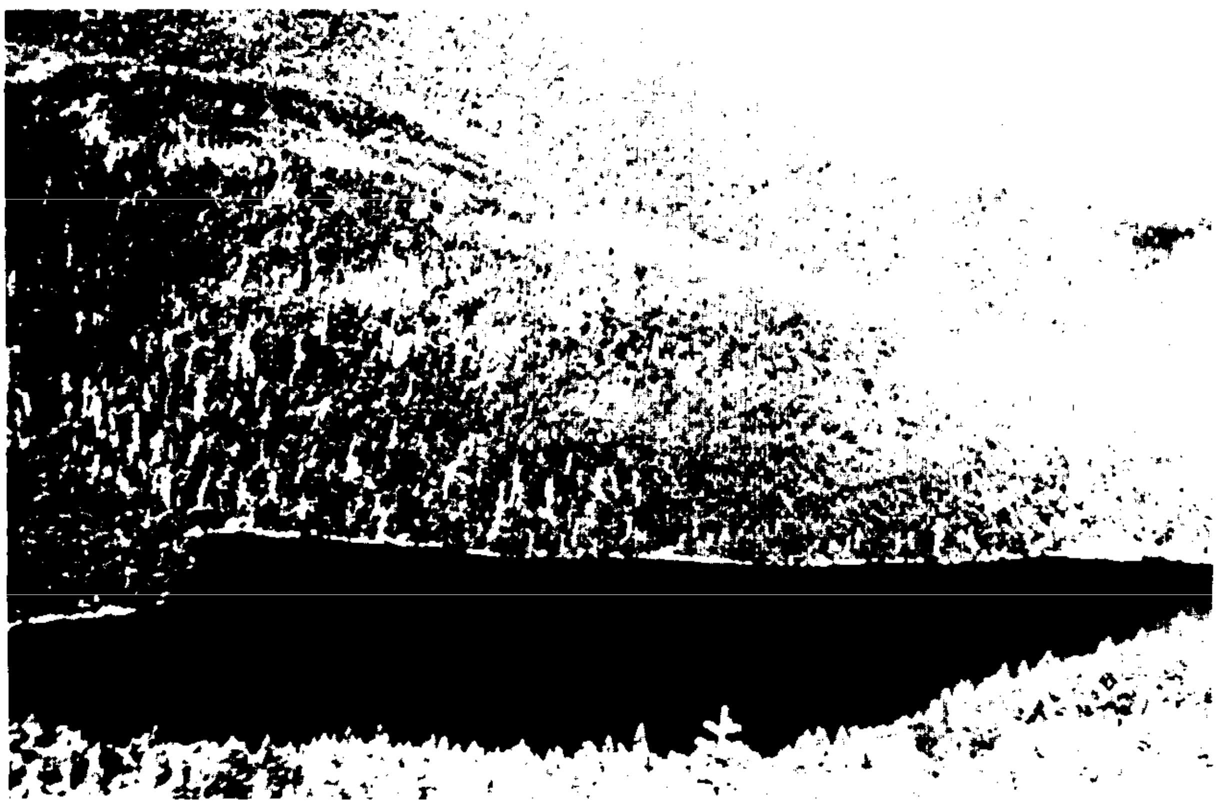

Photo credit: New England Interstate Water Pollution Control Commission

Much of the acid deposition **that eventually enters a lake or stream first reaches the ground in the surrounding watershed, and travels with runoff water over soils and bedrock** from year to year (assuming that the level of pollution remains fairly constant). However, for those effects of transported pollutants that are cumulative, the longer control actions are delayed, the greater the severity of the damage.

The Extent to Which Damages Are Irreversible

A closely coupled concern is whether damage can easily be reversed, and if so, over what time period? Again, once ozone concentrations are reduced below damaging levels, direct crop damage is easily eliminated the following year. At the other extreme, damage to monuments or other unique art objects from air pollution would be irreversible.

If acid deposition is reduced, fish populations may be restored either by restocking or by natural means. However, if surrounding soils have lost their acid-neutralizing capability, even moderate inputs of acid may prevent fish from returning for decades unless the water body is periodically treated with lime. Similarly, if acid deposition causes nutrients to be lost from a forest floor, forest productivity may be impaired for many decades. The effects of a severe series of ozone episodes, or the potential cumulative effects of acid deposition, will persist in the forest community until a new forest grows.

Photo credit: New England Interstate Water Pollution control Commission

Acid deposition might harm trees directly or alter the soils in which they grow. However, more research is necessary to determine to what extent current levels of acid deposition and other transported pollutants are involved in observed declines in Eastern U.S. forest productivity

The potential irreversibility of resource damage makes delaying control action until better information is obtained highly controversial. For those damages that are reversible, it is important to know how alternative levels of pollution reduction would affect the extent of resource improvement. Chapters 3 and 5 present estimates of the benefit to crops and aquatic resources of reducing ozone and acid deposition levels, although considerable uncertainty surrounds these preliminary estimates. However, to the extent that damages are ***both*** significantly cumulative and irreversible, waiting for better information would irreparably harm resources for this generation and the next several to follow.

Uncertainty About the Origin of Observed Levels of Transported Pollutants

Pollutants Leading to Acid Deposition

The previous sections have outlined uncertainties concerning the potential benefits of reducing current levels of transported pollutants. If policymakers wish to reduce current levels of pollutants, the next logical question is, "Where are they coming from?" Three questions are important: 1) whether the precursor pollutants are of natural or manmade origin; 2) whether they come from local sources or from distances exceeding hundreds of kilometers; and 3) whether it is possible to define the geographic origin of pollutants deposited in a particular region. These questions are addressed briefly in chapter 4, and in greater detail in appendix C.

The first two questions are not key uncertainties. Though pollutants of natural origin cause some acid deposition, deposition over large areas of the Eastern United States far exceeds the level

attributable to natural sources of pollutants. In addition, while local sources (i. e., within 30 miles) do contribute to acid deposition, most analyses indicate that a large share of the deposition— in some cases, over half-originates from both medium-range and distant sources (i.e., greater than 300 miles away) as well.

The key uncertainty is whether scientists can reliably determine how ***much*** of the deposition in any one region originates from emissions in any other. Computer models of varying sophistication are available to perform such analyses, but their accuracy in portraying this relationship is uncertain. The inherent variability of weather patterns and the complexity of atmospheric chemistry make it unlikely that models will ***ever*** **be able to predict how much one individual source of emissions contributes to deposition in a small area.** However, these models can be used to assess current annual average patterns of pollutant transport over *large* geographic regions—on this scale, models reproduce observed patterns of annual sulfur deposition in rainfall reasonably well. Their capacity to synthesize extensive meteorological data makes these models the best available tools for describing the current relationship between emissions in one area and deposition in another. Model-based estimates of the extent of interregional transport for sulfur pollution are presented in chapter 4.

Model adequacy is a critical element in several suits and petitions by States to control transported air pollutants under the interstate provisions of the current Clean Air Act. EPA considers available models inadequate to reliably analyze long-range pollution transport; consequently, the Agency does not assess the effects of pollution that travels beyond 50 kilometers (30 miles). However, the petitioning States assert that available ' 'long-range transport' models reflect the state of the art and should therefore be used by EPA.

In addition, policy-level attempts to reduce pollutant deposition ***in identified, sensitive regions*** would rely to a large extent on model-based abilities to determine the sources of such deposition. However, no amount of accurate, detailed modeling information would be sufficient to eliminate policy disputes over which region's resources ***should*** be protected, or which region's emissions ***should*** be controlled.

Photo credit: Ted Spiegel

Tracking this weather balloon by radar helps to determine how air masses travel and mix under a variety of atmospheric conditions. Such data are important for understanding how pollutants are transported and transformed when they are aloft

Because many regions have sensitive resources, and all of them receive some deposition from each of many emitting regions, a variety of possible strategies could be used to reduce deposition on sensitive resources. For example, decisionmakers, in response to equity concerns, could develop control programs under which multi-state regions responsible for "large" shares of deposition in "several' sensitive areas bear the "greatest share' of emissions reductions. Whether the broad regional patterns of transport described by the models are accurate enough for this purpose is as much a policy question as a scientific one.

Pollutants Leading to Ozone Formation

The same three questions apply to ozone: whether the precursor pollutants are of natural or manmade origin, whether they are of local or distant origin, and whether it is possible to pinpoint the geographic source of deposition in a specified region. As with acid deposition, ozone levels over broad regions of the United States exceed natural background levels. Though locally produced ozone is a problem in many of the Nation's urban areas, ozone's chemical precursors can travel long distances, and elevated ozone levels are found in rural areas downwind from emission sources. However, models of long-range ozone transport are in a rudimentary stage of development. Because the chemistry of ozone formation is very complex, major uncertainties exist over the geographic origin of elevated ozone concentrations in rural areas.

Uncertainty About the Effectiveness of Emissions Reductions for Reducing Levels of Transported Pollutants at Desired Locations

Uncertainty about the ***effectiveness*** of reducing emissions as a means of controlling transported pollutants stems from two factors. The first-uncertainty about how well current models describe the relative contribution of one area's emissions to another's pollution—has been explained in the previous section. While this "source-receptor' relationship cannot be defined precisely, existing models can synthesize extensive meteorological information to provide broad regional descriptions. Still, the remaining uncertainty raises questions about the extent to which emissions reductions in any specific area would reduce pollution in another area.

The second unknown concerns the chemical processes that transform pollutants in the atmosphere. It is known that numerous complex chemical reactions are involved in forming ozone, airborne sulfates, and acid deposition. Uncertainties exist about how effective reducing emissions of each precursor pollutant will be in controlling the transformed products.

For example, sulfur dioxide emissions are transformed to sulfate, a major constituent of acid deposition, Reducing the total amount of sulfur dioxide emitted will undoubtedly reduce the overall amount of deposited sulfate, but it is difficult to quantify the reduction in deposition that a specific emissions cutback will produce ***in a specific area.*** **Most analyses indicate that reducing sulfur dioxide emissions within a broad control region will *significantly, but not quite equally,* reduce the amount of sulfur deposited in various forms in that region.** However, some scientists are uncertain that reducing sulfur dioxide emissions ***alone is*** the most efficient way to control acid deposition. Because other pollutants (e. g., hydrocarbons and nitrogen oxides) can enhance or impede chemical transformations of sulfur dioxide, these other pollutants might also be controlled simultaneously to reduce acid deposition in specific geographic regions. Chapter 4 and appendix C discuss this in greater detail.

Uncertainties about which pollutants to control, as well as the uncertain relationship between emissions reductions and deposition reductions, complicate the policy objective of reaping the greatest possible benefit from the costs of controlling emissions. Scientists are unable to confidently project the precise pattern of deposition reductions that would result from a specified emissions control plan. Under these circumstances, a control program designed and implemented today might not produce the maximum benefits achievable for a given cost.

Uncertainty About Whether a Research Program Will Provide Significant New Information

One of the most difficult decisions facing Congress is whether to act during this reauthorization of the Clean Air Act, or to await results from ongoing, multimillion dollar Federal and private research efforts on acid deposition. While the research efforts are intended to reduce the uncertainty discussed above, how much new insight 4 to 6 years of further research will provide is unknown.

For example, years to decades are required to observe changes in many ecological processes. Patterns of crop yield and forest productivity typically vary from year to year; separating the effect of acid deposition from normally expected year-to-year fluctuations requires many years of data. The processes of soil formation and depletion proceed on the time scale of decades. These mechanisms

Photo credit: Ted Spiegel

Collecting and testing water droplets from clouds high above the ground in southern Ohio. Researchers also use this airborne laboratory to analyze gaseous and particulate pollutants in the atmosphere

can be artificially accelerated and studied in laboratories, but the extent to which such experiments reflect real-world conditions is uncertain.

While scientists understand the basic mechanisms of acid formation and deposition, detailed knowledge of the complex chemistry and meteorology involved will require many more years of research. Ongoing efforts to evaluate the current generation of computer models that simulate atmospheric processes have already taken several years, Efforts to develop new transport and transformation models are underway; the number of years needed to significantly improve existing models is unknown.

Uncertainties about the progress of research programs are important in considering the timetable for policy decisions. Given the planning and construction efforts required to significantly reduce pollutant emissions, a decision to control emissions now may still require 6 to 10 or more years to implement. **Waiting another 4 to 6 years for the results of a research program before making control decisions increases the time required to reduce deposition to 10 to 16 years. Delaying control action increases the risk of resource damage but reduces the risk of inefficient control expenditures.** Congress could avoid this delay by mandating controls now, while retaining the option to change the law if new research results point to alternative courses of action. To achieve compliance within a decade, however, expenditures would have to begin within 6 to 8 years. If results suggesting an alternative control strategy appear much after this time, major expenditures may be irrevocable.