JOINT REPORT OF
THE SPECIAL ENVOYS
ON ACID RAIN

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I. BACKGROUND

The United States and Canada share a long tradition of mutual friendship and co-operation and share similar points of view on many international issues. We are also each other's largest trading partners, an economic relationship involving billions of dollars' worth of manufactured goods, services, and raw materials. These common bonds between close neighbors and good friends are valued aspects of a shared history on which both countries continue to build.

Over the past two decades, scientists and government officials on both sides of our border have become aware of the serious environmental problems associated with airborne pollutants transported over long distances. The most serious of these problems is acid rain. Although we do not understand all the mechanisms of the formation and transport of acid rain or the full extent of its effects, it is clear that those causes and effects are shared by both countries. Air emissions from sources in both the United States and Canada have increased significantly the deposition of sulfates and nitrates on both U.S. and Canadian ecosystems.

On March 17 and 18, 1985, Prime Minister Brian Mulroney and President Ronald Reagan met in Quebec City to discuss a wide range of bilateral issues such as mutual defense, trade, and the environment. That meeting, later referred to as the "Shamrock Summit," was viewed as a unique opportunity to reinforce ties between the two countries. At that meeting acid rain was recognized by both leaders as a serious concern affecting bilateral relations.

Noting the 75-year history of environmental co-operation between the two countries, the President and the Prime Minister expressed their determination to address current U.S.-Canadian environmental issues, including acid rain, in the same spirit of responsibility and co-operation. Consequently, each agreed to appoint a personal Special Envoy to examine the acid rain issue and report back before their next meeting, scheduled for the spring of 1986. For the first time, Special Envoys appointed by both the U.S. and Canadian governments were to review jointly this serious environmental issue affecting both nations. These special appointments emphasized the need for both countries to work together to resolve a shared transboundary problem.
II. U.S.-CANADIAN ENVIRONMENTAL RELATIONS

While of relatively recent origin, Canadian and U.S. efforts to address problems associated with the long-range transboundary transport of airborne pollutants have occurred within the context of a 75-year tradition of environmental co-operation.

The cornerstone of our bilateral environmental relationship is Article IV of the Boundary Waters Treaty of 1909, wherein each country agreed not to pollute boundary waters to the injury of health or property in the other country. With the Article IV obligation as a foundation, both countries have built a long tradition of generally successful resolution of a wide variety of transboundary environmental problems, both through the International Joint Commission and on a government-to-government basis. Notable among recent achievements have been the Great Lakes Water Quality Agreements of 1972 and 1978, which were ambitious joint efforts to improve Great Lakes water quality through the adoption and gradual refinement of water quality objectives, both general and specific.

Bilateral efforts to protect transboundary air quality date to the Trail Smelter case in 1949. An arbitration panel established to resolve an air pollution problem caused by the Trail Smelter held that "no State has the right to use or permit the use of its territory in such a manner as to cause injury by fumes in or to the territory of another."

Both Canada and the United States also subscribe to Principle 21 of the 1972 Stockholm Declaration which, like Article IV and the Trail Smelter case, provided that States have the responsibility "to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States." Additionally, both countries are parties to the 1979 Convention on Long-Range Transboundary Air Pollution, under which signatory States from the Economic Commission for Europe (ECE) expressed a determination to "endeavour to limit and, as far as possible, gradually reduce and prevent air pollution including long-range transboundary air pollution."

Acid rain became recognized as an important bilateral environmental problem in the mid-1970s. The first response of both the U.S. and Canadian governments was to establish in 1978 the Bilateral Research Consultation Group to report on the extent and significance of long-range air pollution problems, including acid rain, with special reference to the overall transboundary pollutant flux.
In 1978, the U.S. Congress passed a formal resolution which called upon the President to "make every effort to negotiate a co-operative agreement with the Government of Canada aimed at preserving the mutual airshed of the United States and Canada." Subsequent to this Resolution, representatives from the two governments mapped out a comprehensive strategy designed to lead in a step by step manner to the goal of a bilateral air quality agreement.

On July 16, 1979, both governments issued a *Joint Statement on Trans-boundary Air Quality* in which they recognized "the importance and urgency" of transboundary air pollution problems, including acid rain, and pledged to work toward "a co-operative bilateral agreement on air quality" in accordance with certain declared principles and practices. Then, on August 5, 1980, a *Memorandum of Intent* (MOI) was signed, in which both governments explicitly recognized the seriousness of the acid rain problem, and committed themselves to work toward a bilateral air quality agreement "as soon as possible." They further agreed to set up a framework for negotiations. Five bilateral working groups were established to provide expert scientific and technical advice to a Co-ordinating Committee, which was to commence formal negotiations not later than June 1, 1981. Pending conclusion of the agreement, both countries agreed to take appropriate interim actions to "promote the vigorous enforcement of existing laws and regulations . . . in a way which is responsive to the problems of transboundary air pollution."

Although a bilateral air quality agreement was not reached, considerable scientific and diplomatic activity took place subsequent to the MOI. For example, bilateral co-operation continued at the level of co-ordination of scientific research. The executive committee of the U.S. National Acid Precipitation Assessment Program (MAPAP) and the Canadian Research and Monitoring Co-ordination Committee have met annually to exchange information, co-ordinate research, and plan co-operative research activities.

The new initiative resulting from the appointment of the Special Envoys significantly furthers the development of a bilateral response to the North American transboundary air pollution problem. The foundations of that response — the *Joint Statement* and the *Memorandum of Intent* — are already in place. A precedent for that response already exists in the *Great Lakes Water Quality Agreements*. What remains is to borrow from that precedent and build upon those foundations a bilateral accord which will jointly address a common problem in the best tradition of U.S.-Canadian environmental relations.
On March 17, 1985, President Reagan appointed Drew Lewis, former Secretary of Transportation, to be U.S. Special Envoy on Acid Rain. Prime Minister Mulroney appointed William Davis, former Premier of Ontario. As Special Envoys, our overall responsibility was very clear: we were to assess the international environmental problems associated with transboundary air pollution, and then recommend actions that would help solve them. Even though domestic acid rain is causing widespread concern in both countries, we were committed to working together to address the problem expressly in terms of its international implications.

In order to support this overall responsibility, we were assigned four specific tasks:

1. to pursue consultation on laws and regulations related to pollutants thought to be linked to acid rain;
2. to enhance co-operation in research efforts, including research on clean fuel technology and smelter controls;
3. to pursue means to increase exchange of relevant scientific information; and
4. to identify efforts to improve the U.S. and Canadian environments.

Soon after our appointments, we began an intensive educational effort designed to provide us with a quick but comprehensive overview of this scientifically complex issue. We were afforded access to the foremost authorities on acid rain, and all principal research findings were made available to us. We reviewed data and conclusions and attended a variety of briefings and presentations. To date, we or our staffs have met, either individually or jointly, with key people from government, industry, labor, academia, and the environmental and scientific communities. The individuals and groups we have met include:

- senior officials in Washington and Ottawa;
- U.S. cabinet members and Canadian cabinet ministers;
- U.S. and Canadian environmental officials;
- Members of Congress and Parliament;
- U.S. governors and Canadian premiers;
- scientists and researchers in the United States and Canada;
- industrial leaders, notably those in the utility, coal mining, and ore smelting sectors;
• representatives of organized labor, unions, and concerned groups of citizens; and
• leaders of environmental organizations.

We have also made site visits to a power plant in western Pennsylvania and to a research facility in Muskoka, Canada. We have responded to requests for dozens of statements and interviews; we have corresponded with various interest groups and private citizens in both countries.

In short, since March 1985 we have immersed ourselves in the scientific, economic, and political aspects of the acid rain issue. We have not emerged from that experience as experts on all aspects of acid rain. However, we have gained a clearer understanding of the major issues involved and are now in a position to make recommendations for appropriate future activities.

The two most important things we learned can be stated simply:

• Acid rain is a serious environmental problem in both the United States and Canada. Acidic emissions transported through the atmosphere undoubtedly are contributing to the acidification of sensitive areas in both countries. The potential for long-term socio-economic costs is high.
• Acid rain is a serious transboundary problem. Air pollutants emitted by sources in both countries cross their mutual border, thus causing a diplomatic as well as an environmental problem.

At the same time, we also learned something very important about potential solutions to the acid rain problem:

• At the present time, there are only a limited number of potential avenues for achieving major reductions in acidic air emissions, and they all carry high socio-economic costs.

Thus acid rain is not only an environmental and technical problem, but also one with far-ranging socio-economic and political implications which are different in the United States and Canada.
IV. U.S.-CANADIAN EXPERIENCE WITH ACID RAIN

There is no question that acid rain is an environmental problem shared by both the United States and Canada. Emission sources in both countries contribute to acid deposition in both countries.

Yet the shared nature of this problem should not obscure the fact that each of the two countries contributes to this problem in different ways, is affected by it in different ways, and therefore must respond to it in different ways.

In fact, one of the most positive benefits of the Special Envoy process has been the insight it has given us regarding both the similarities and the differences of the U.S. and Canadian experience with acid rain.

It is not the intent of the Special Envoy process to hide or gloss over the differences in the perceptions and policies of our two countries with respect to acid rain. Quite the contrary. We believe it is important that both the similarities and differences in these perspectives and policies be openly acknowledged and understood. It was not until we each had an understanding of the other country’s point of view that we were in a position to formulate findings and recommendations. For this reason we have chosen to include in this report the following summaries of the U.S. and Canadian perspectives on acid rain.

A. U.S. Perspective on Acid Rain

Acid rain is a popular term used to describe a very complex chemical and atmospheric phenomenon that is more properly called acid deposition. It occurs when emissions of sulfur and nitrogen compounds are transported through the atmosphere, transformed by atmospheric chemical processes, and then deposited back again on earth in either a wet or a dry form. The interactions among these four factors—emissions, transport, transformation, and deposition—determine how much acidity is deposited in any particular area. The form and amount of this deposition, interacting with the unique sensitivities of specific receptor areas, together determine the nature and extent of environmental damage. In other words, the extent and magnitude of any damage caused by acid deposition are a function of all the steps of a very complex environmental process.
1. Emissions

Some of the sulfur and nitrogen compounds that are the precursors of acid rain are emitted by natural sources. Sulfur and nitrogen are natural components of the sea, soils, and organic matter; consequently, both sulfur and nitrogen compounds are regularly released to the atmosphere through organic and inorganic processes.

However, in the United States natural emissions of sulfur and nitrogen compounds are relatively insignificant contributors to acid rain. It has been estimated that in the eastern United States natural emissions of sulfur compounds are approximately three percent as large as man-made emissions. In the west they are probably somewhat larger, but still much less than 25 percent of man-made sulfur emissions. Even a major natural disaster such as the volcanic eruptions at Mount St. Helens emits relatively little sulfur compared to human activities. The total sulfur emitted by Mount St. Helens between March 1980 and March 1981, the period of greatest volcanic activity, was approximately the same as the annual sulfur emissions from two large coal-fired powerplants.

Clearly, man-made emissions of sulfur and nitrogen compounds contribute far more to acid rain in the United States than natural sources. They are emitted in much larger quantities and from a variety of widely distributed sources. Sulfur compounds are emitted into the air whenever the sulfur naturally present in fossil fuels and some ores is burned. The major sources of U.S. sulfur emissions are coal-fired electric powerplants, industrial boilers and processes, and ore smelting. Nitrogen oxides, on the other hand, are formed and released into the air when any kind of fuel is burned, because nitrogen and oxygen present in the air combine at high combustion temperatures. The major sources of U.S NOx emissions are transportation vehicles and industrial fuel combustion.

In 1983, U.S. SO$_2$ emissions were dominated by electric utility boilers, which emitted 14 million tons, more than 67 percent of the total 20.8 million tons emitted nationwide. Industrial boilers and processes emitted another 5.2 million tons (25 percent of total national emissions), of which 1.1 million tons were emitted by non-ferrous smelters. All other sources contributed the remaining eight percent of total national SO$_2$ emissions.

The amount of SO$_2$ emitted in 1983 represents a 28 percent decline from the peak level — 28.7 million tons — emitted in 1973. Electric utility SO$_2$ emissions declined by 19 percent between 1973 and 1983, and industrial emissions declined by 46 percent.
U.S. SO₂ emissions are concentrated along the Ohio River Valley in Illinois, Indiana, Ohio, Kentucky, West Virginia, and Pennsylvania. Those six states are among only ten in the country that emit more than one million tons of SO₂ annually. In 1980, 51 powerplants in those states emitted 25 percent of total U.S. SO₂. Two other high-emitting states, Missouri and Tennessee, are adjacent to the other six, and together those eight states emit 46 percent of all U.S. SO₂.

Recent trend data indicate that the nationwide pattern of SO₂ emissions has shifted. Between 1970 and 1980, virtually all increases in SO₂ emissions occurred in southeastern states. All but one of the states south of Missouri and Tennessee experienced increases in annual SO₂ emissions, while SO₂ emissions from all states northeast of Ohio and West Virginia decreased. Despite this gradual shift in emissions density toward the southeast, U.S. SO₂ emissions are still concentrated in the Ohio River Valley.

Total U.S. NOₓ emissions peaked during the 1970s and then declined slightly. In 1979, U.S NOₓ emissions totalled 21.1 million tons; by 1983 they had fallen to 19.4 million tons. Between 1970 and 1983 transportation NOₓ rose by 16 percent, and utility NOₓ rose by 40 percent. Overall, U.S. NOₓ emissions increased by only seven percent, from 18.1 to 19.4 million tons, between 1970 and 1983.

Although NOₓ emissions tend to be more evenly distributed over the United States than SO₂ emissions, the states along the Ohio River are especially high emitters of NOₓ as well as SO₂. Three of the five highest NOₓ-emitting states — Illinois, Ohio, and Pennsylvania — are also among the highest SO₂-emitting states. Thus national emissions of both SO₂ and NOₓ are concentrated in the Ohio River Valley and the immediately adjacent states. Ten states in the central and upper midwestern section of the United States — i.e., Missouri, Illinois, Indiana, Tennessee, Kentucky, Michigan, Ohio, Pennsylvania, New York, and West Virginia — emit 53 percent of total U.S. SO₂ and 30 percent of total U.S. NOₓ.

2. Transport and Transformation

Our understanding of the transportation of these pollutants in the atmosphere is a function of our general understanding of meteorological processes, supplemented by mathematical modelling. Under many meteorological conditions pollutants can be carried for hundreds of kilometers before they are deposited. Because of the high variability of both horizontal and vertical transport under different meteorological conditions, any given source can contribute to acid deposition over a very wide area.
As these pollutants move through the atmosphere, they can undergo significant chemical change. There can be dozens of different chemical reactions, some occurring simultaneously and others sequentially, which convert $SO_2$ and NOx to their acidic forms. The variability of the reactants involved in this chemical process, the presence or absence of clouds and water, and the availability of sunlight all contribute to the variability of atmospheric transformation.

3. Deposition

The process by which sulfates and nitrates are deposited out of the atmosphere back to earth is most commonly called "acid rain." Although rainfall is, in fact, one major way by which acidic compounds are removed from the atmosphere, they are also deposited by snow, sleet and fog. All these forms of deposition are collectively called acid precipitation. In addition to these various kinds of wet deposition, sulfur and nitrogen compounds can also be deposited in a dry form as either particulates or gases. The relative contribution of wet and dry deposition to acid rain is uncertain, but it is thought to vary significantly from location to location. Both wet deposition and dry deposition are believed to contribute to environmental damage, but their relative significance may vary from one kind of environmental effect to another.

Reliably quantifying the amount of acid deposited is a difficult task, especially if levels of acid deposition are to be compared at different times or at different places. Several different chemical species — e.g., sulphate ions, nitrate ions, and hydrogen ions — can be measured as an indicator of deposition, but they are not directly comparable. Because acid compounds are deposited in both wet and dry forms, an accurate quantification of acid deposition at any location would have to include both forms. Yet dry deposition is much more difficult to measure than wet deposition. Whereas a fairly good wet deposition monitoring system is in place (170 locations in the National Atmospheric Deposition Program (NADP) system), dry deposition data are much less precise, and there is yet to be deployed a national dry deposition monitoring network.

Furthermore, the levels of deposition measured at any given site are not easily comparable to levels of deposition at another site. Deposition patterns at a single site often show marked variations over time, depending on rainfall patterns and meteorological conditions. Acid deposition rates can vary widely within the same region; monitors only a few miles apart can measure markedly different rates of acid deposition over the same time period. These different problems, together with the fact that
there was little interest in measuring deposited acidity until the 1970s, has limited current understanding of the patterns of acid deposition, especially insofar as those patterns can be compared from time to time and from place to place.

Despite all these limitations and uncertainties, it is possible to draw some general conclusions about acid deposition patterns in the United States. On the basis of data collected by several different monitoring networks, it is possible to compare the total wet deposition in 1980 of sulfate, nitrate, and hydrogen ions across the United States. The deposition patterns for all three are strikingly similar; the rates of highest deposition are found along a line stretching from the upper Ohio River Valley to northern New York. Areas of high acid deposition extend northeast and southwest from this core area, which encompasses parts of Indiana, Ohio, Pennsylvania, West Virginia, and New York. This area of highest acid deposition also coincides with the U.S. area receiving rainfall with the lowest pH.

For the United States as a whole, the total amount of sulfate wet-deposited in the eastern half of the country over one year is approximately five times greater than the amount of sulfate wet-deposited in the western United States. Approximately three times as much nitrate is wet-deposited in the east as in the west. The pH of rainfall is also lower in the east than in the west.

Beyond these generalities, however, it is very clear that there is a solid link between acidic emissions and acid deposition in the United States. The areas of highest acid deposition coincide with or are downwind and to the northeast of the areas of highest emissions.

4. Effects

The adverse effects of acid rain have been most clearly demonstrated in aquatic ecosystems. After acidifying compounds have been deposited in a watershed, they can be transported by surface runoff or through ground water aquifers to lakes or streams in the area. If the soils in these watersheds have only a limited natural ability to assimilate acidity, then prolonged acid deposition can result in surface water acidification. Such acidification can damage aquatic ecosystems, and in some circumstances it can result in the complete loss of game fish and other aquatic species.

For the past several years U.S. scientific attention has been focused on a number of acidified clear-water lakes in New York and New England. These lakes are found in areas with both high levels of acid deposition
and little natural capacity to neutralize acidity. Until recently, there was no scientifically sound basis for determining whether these lakes were an isolated and unique phenomenon, or whether they were indicative of more widespread surface water acidity in the United States.

The U.S. government, through the Environmental Protection Agency and the National Acid Precipitation Assessment Program, has initiated a national surface water survey to project the population and distribution of lakes and streams at different levels of pH and acid neutralizing capacity. The final results of Phase I of the eastern lake survey are expected early in 1986. However, some preliminary results are now available.

The survey results are based on 1,620 statistically selected lakes found in potentially sensitive areas in the eastern United States. For sensitive areas in the New England area, the survey analysis estimates that 260 lakes (four percent of the total) have a pH lower than 5.0, with a 95 percent confidence that this number does not exceed 343. Approximately 1,360 lakes (19 percent of the total) are estimated to have acid neutralizing capacities below 50 micro-equivalents per litre (μel). The 95 percent upper bound confidence level is 1,533 lakes. The population of lakes with a μel level below 200 is estimated to be 60 percent of the total number of lakes. These data indicate that although the current number of acidic lakes is relatively small, the number of potentially sensitive lakes is relatively large. On the basis of this survey data alone it cannot be predicted what future acidification, if any, would occur if current levels of deposition were to continue. However, major research efforts are underway to address this issue.

Other areas covered by the survey include the upper midwest and the Florida peninsula. Survey data from the upper midwest reveal no acidic lakes. However, data from the Florida study area show a substantial number of lakes with a pH below 5.5 (20 percent of lakes surveyed) and below 5.0 (12 percent of lakes surveyed). The significance of the Florida data is still under review.

The extent to which acid deposition contributes to forest damage is much less well understood. In fact, it is not certain in what circumstances acid deposition may have significant detrimental effects on forest resources. However, forest damage is an area of major concern, and intensive research is being carried out by both U.S and Canadian scientists. This concern is reinforced by unexplained but unprecedented decline observed
in some European forests. Scientists have developed several hypotheses to explain the observed symptoms, and many of these hypotheses involve acid deposition and related air pollutants.

Some changes in U.S. forests have been documented. For example, red spruce growing at higher altitudes in the Appalachian Mountains of New England and the Carolinas have been observed to lose their needles, and some have died prematurely. Some southern pine forests growing at lower elevations in the southeast appear to have experienced growth decline over the last decade. It may be the result of a single factor, or a combination of factors. Air pollution — including acid rain — may be involved either directly or indirectly. Field surveys and mechanisms research are now being initiated that will help to understand this problem better, but at this time the relationship between acid rain and forest damage in the United States is only conjectural.

The potential for acid deposition to degrade building materials is well recognized. Carbonate stone like marble and limestone, carbonate-based paints, and metals like galvanized steel all can be eroded and weakened in the presence of dilute acids like those found in acid deposition. The damage thus caused not only can result in economic loss, but the loss of cultural and historic resources as well. However, the extent of such damage in the United States is not known. Until materials inventories, acid deposition patterns, and the damage functions of specific materials are better understood, it will not be possible to accurately quantify the effects of acid rain on building materials in the United States. Without this quantification, it is difficult to determine the significance of acid deposition damage to building materials.

Finally, acid rain is not known to cause direct human health effects. However, indirect effects resulting from human ingestion of heavy metals dissolved by acids are of some concern. The theoretical mechanisms by which acid deposition could expose people to heavy metals are generally understood; however, to date the available data do not indicate any general occurrence of elevated exposures.

Acidic water can dissolve lead out of lead pipe and soldered joints, thus increasing the amount of lead in drinking water. A survey of New England water systems serving more than 25 people each does not indicate that heavy metal concentrations in the drinking water exceed health standards. Less is known about private water supply systems, and further investigation is warranted.
It is also thought that acidified lake and stream water can contribute to higher levels of dissolved mercury in the water, which in turn can increase mercury concentrations in fish. Although elevated mercury levels have been observed in some fish caught in certain New York lakes, it is not known whether mercury was naturally present in those waters or was primarily the result of acid deposition. In any event, no incidents of human health problems associated with heavy metals dissolved by acid deposition have been reported in the United States.

5. Current U.S. Response

The United States passed major legislation to protect air quality 15 years ago. The Clean Air Act of 1970 and the major amendments passed in 1977 have resulted in an air pollution control effort that has served as a model for many other industrialized nations, and has led to significant, measurable improvements in air quality in many parts of the United States.

Probably the single most important feature of the Clean Air Act is the establishment of National Ambient Air Quality Standards (NAAQS) for the most common air pollutants. The NAAQS require that ambient concentrations of those pollutants be limited to a level that protects public health and welfare. These national standards for both SO₂ and NOₓ have been in effect for more than ten years.

The individual states are responsible for ensuring that the NAAQS are met within their borders. In order to attain the federal standards locally, the states set emission limits on existing facilities. At this time, about 98 percent of the counties in the United States are in compliance with the national standards for SO₂ and NOₓ.

Another part of the Clean Air Act sets emission limits for different classes of new stationary sources. The Congress included this provision in the belief that emissions from new sources could be controlled at much lower cost than emissions from existing sources, and that the requirement to control new sources would encourage the development of more efficient and cost-effective control technologies. Furthermore, the control of new sources could lead to cleaner air as old facilities are replaced by new ones. To date, the United States has set New Source Performance Standards to control the emissions of SO₂ and NOₓ from coal-fired power plants, large industrial boilers, smelters, nitric acid plants, sulfuric acid plants, stationary gas turbines and petroleum refineries.
Besides controlling several kinds of stationary sources, the *Clean Air Act* also limits air emissions from new mobile sources. Standards to limit the emissions of NOx from new cars and light-duty trucks were first implemented in 1973, and they have been tightened since then.

These federal and state actions undoubtedly have helped preserve and protect air quality in the United States, an especially remarkable accomplishment considering the strength of the U.S. economy and the extent of U.S. industrialization. Total national emissions of SO$_2$ and NOx are well below what they would have been without controls. Total U.S. SO$_2$ emissions increased by about 56 percent between 1940 and 1970. After reaching their peak in 1973, total U.S. SO$_2$ emissions declined by about 28 percent between 1973 and 1983, despite the fact that electric utility coal consumption increased by about 60 percent during the same period. Flue-gas-scrubbing systems are now operating on over 47,000 megawatts of coal-fired electricity-generating capacity.

Between 1940 and 1970, total U.S. NOx emissions increased by more than 200 percent. Since 1970, however, total U.S. NOx emissions have remained fairly constant. Emissions from U.S. cars and trucks actually declined by nine percent between 1978 and 1983, despite a five percent increase in the number of vehicle-miles driven.

Yet during the same decade that the United States was making these advances in the control of SO$_2$ and NOx emissions, scientists, government officials, the Congress, and the American public became increasingly aware of acid rain, an environmental problem clearly linked to emissions of SO$_2$ and NOx. At the same time, the international aspect of acid rain was causing more and more concern. The attainment of national standards for SO$_2$ and NOx and the installation of SO$_2$ and NOx controls on new emission sources were not enough to prevent transboundary air pollution from contributing to environmental degradation in Canada.

There are several reasons why the *Clean Air Act*, as presently written, is not an especially good tool for controlling transboundary air pollution. For example, the NAAQS control ambient concentrations, not total loadings, but transboundary pollution is a total loadings problem. In fact, some of the techniques used in the past to attain ambient standards actually may increase total loadings. Tall smokestacks sometimes have been constructed to disperse emitted pollutants over wider areas and thus attain ambient standards locally. These tall smokestacks cause two problems: they allow more total pollutants to be emitted under applicable law; and they allow those pollutants to be transported further.
The New Source Performance Standards have been only marginally effective in reducing the total amount of acidic air emissions, because older facilities are not being replaced by new ones as quickly as once assumed. For example, most coal-fired powerplants once were believed to have useful lives of 35 to 40 years. It now appears that many old coal-fired powerplants may continue to operate for up to 60 or more years.

The fact that the Clean Air Act may not provide adequate protection for acid-sensitive ecosystems in both the United States and Canada has led several members of the U.S. Congress to propose new acid rain legislation. Several proposed bills have been debated in the Senate and the House of Representatives. None of them has been enacted into law, because none of them has been able to overcome the formidable barriers presented by conflicting economic and political interests.

In the United States the acid rain issue has been as politically divisive as any environmental issue the country has faced. The proposed solutions have pitted one region of the country against another; they have threatened the livelihood of coal miners in the east; they have raised the possibility of further increases in electricity rates in the industrial portions of the United States hardest hit by the recent recession.

The acid rain issue has been especially difficult to resolve precisely because proposed solutions must choose from a limited menu of control options. At this time, only three emission control techniques are proven and available for reducing SO$_2$ emissions from coal-fired powerplants: coal-washing, coal-switching, and flue-gas-scrubbing. However, one of these techniques could not be used to achieve substantial SO$_2$ reductions, and the other two impose different kinds of socio-economic costs, all of which are very high.

Coal-washing is a physical cleaning process by which inorganic sulfur is removed from high-sulfur coal, usually at or near the mine. This process is already being applied to some U.S. coal, because the costs of cleaning can be offset by lower transportation costs, higher combustion efficiencies, and lower boiler maintenance costs. However, coal-washing removes less than half the sulfur in high-sulfur coal; it is not used at all to clean low-sulfur coal. So its usefulness as an acid rain control technique is very limited.

Pound for pound of SO$_2$ removed, switching from high-sulfur to low-sulfur coal is usually the cheapest control option for coal-fired boilers. However, low-sulfur coal is much more plentiful in the western half of
the United States; thus even though some low-sulfur coal is mined in the east, coal-switching would cause markets for western coal to increase, and markets for eastern high-sulfur coal to decrease. Eastern coal miners could be thrown out of work, and the communities in which they live — communities that were especially hard-hit during the recent recession — would suffer even more.

Flue-gas-scrubbing is a process by which sulfur is scrubbed out of the exhaust gases emitted by coal-fired boilers. Although the process is very expensive, especially when retrofitted on existing smokestacks, it allows the relatively clean combustion of high-sulfur coal. Thus the use of scrubbers to control $SO_2$ would not cost high-sulfur coal miners their jobs. However, it would raise the electricity rates of the businesses and families served by the utilities that install scrubbers.

Clearly, none of these control options provides a simple solution to the acid rain problem. Coal-washing cannot eliminate enough $SO_2$ to achieve a major reduction; coal-switching would cost high-sulfur coal miners their jobs; flue-gas-scrubbing would raise utility rates sharply. The availability of cheaper, more efficient control technologies would improve our ability to formulate a national response that is politically and economically acceptable.

The long-term value of control technology research has already been recognized by the U.S. government. Both the U.S. Department of Energy and the Environmental Protection Agency are managing research programs that are investigating a wide range of different control technologies. Taken together, this research offers the best hope for a long-term solution to the acid rain problem.

In the summer and fall of 1983, the U.S. government carried out a thorough review of the current status of acid rain knowledge and the options available for its management. From that review, the United States concluded that, although it was clear that acid rain was a serious concern both in the United States and Canada, it lacked the information needed to make a prudent decision on the need for or design of additional emission controls.

This policy was not a decision either for or against additional controls, but instead a choice to defer such a decision until a more adequate scientific and technical base was established. It is not U.S policy to wait for definitive answers on all major acid rain uncertainties before making a decision to act. Decisions on acid rain, like other environmental decisions,
will always have to be made in the face of some scientific uncertainty. The United States is committed to act to control acid rain once it is reasonably certain that that action will achieve its intended results, and those results will justify the social and economic costs entailed.

B. Canadian Perspective on Acid Rain
1. Scientific Consensus

The Canadian public and governmental response to acid rain has been driven by the evidence of cumulative damage, the huge long-term socio-economic costs of allowing the damage to continue, and the view of the problem as presented by the community of international scientists. While recognizing that there are gaps in scientific knowledge, and that research should continue, Canadians generally have found very persuasive both the scientific findings and the urgent calls for action by many of these scientists.

In the past several years, thousands of scientific studies have been carried out and reports written on all aspects of the issue of acid rain. In addition, a number of syntheses and analyses of that work have been conducted. A careful review of the scientific literature indicates that there is a broad consensus within the knowledgeable scientific community on certain components of the acid deposition phenomenon. There follows a brief synthesis of the main areas of consensus. This is not intended to provide a complete picture of acid rain, much less the broader issue of pollutants transported long distances. Instead it seeks to lay out a basis of existing scientific consensus on which policy decisions may confidently be based.

Acid rain is not a natural phenomenon. About 90 percent of atmospheric SO₂ and NOₓ comes from man-made sources. Sulphur compounds are responsible for about two-thirds of the acidity in precipitation but produce most of the long-term acidity in sensitive water bodies.

While not part of the man-made problem, it should be noted that there are some locations where buildup of organic acids causes acidity of water and soil. Such acidification is different chemically from the man-made variety, and usually builds up very slowly. As a result, biological changes are also very gradual and are an integral part of the natural aging of such regions.

Man-made emissions of sulfur and nitrogen oxides move with major weather systems and are often transported many hundreds of kilometers. Transit time in the atmosphere increases the likelihood of chemical
transformation from oxides to acid-producing sulfates and nitrates. Acid deposition is the result of these acidifying compounds coming out of the air through rain, snow, or dry deposition.

Large areas of North America — in particular, eastern North America — are underlain by rocks and soils that make these areas vulnerable to acidification. In these areas, deposition of acidic pollutants over time acidifies streams, lakes, and soils.

As acid rain changes the chemistry of those ecosystems, it also alters their biology. Specifically, many important species that depend on the water become extinct as it turns acid. Some are of economic and cultural importance.

Over many years, deposition of man-made acids has increased the acid content of surface waters in vulnerable parts of industrialized countries. In some of those areas, highly acidified lakes can no longer support some species of fish and other life forms. There is a clear and direct relationship between increasing acidification and the deleterious changes in biological populations.

Acid rain also is acidifying some soils in these vulnerable regions. In the process, it may leach away nutrients and bring about changes to biological organisms that help maintain the productivity of the soil. In exceptional circumstances, acid rain can leach nutrients directly from tree foliage.

Recently, widespread damage to forests has been observed in eastern North America and in Europe (where it is much more advanced). This decline phenomenon is spreading rapidly. It is incompletely explained, but the damage is spatially linked with major pollution emission regions. The contribution of acidic pollutants to this problem has not been satisfactorily determined but is generally perceived in the scientific community to be a contributing factor, together with other pollutants, notably ozone. There is mounting evidence that this tree “dieback,” as well as serious growth retardation, are beginning to increase dramatically in some species.

Toxic heavy metals emitted and deposited more or less in conjunction with acidic pollutants, or mobilized from soils and rocks by the heightened acidity of circulating water, have a variety of toxic effects on plants and animal life. There is evidence of increased concentrations of certain heavy metals in acidifying water.
The pollutants that cause acid rain, while suspended in the atmosphere, reduce the amount of sunlight and so contribute to slower growth of crops and forests. They also reduce visibility, a fact of special importance in tourist regions.

Corrosion of materials is accelerated by fallout from the atmosphere of sulfur dioxide gas and other pollutants.

Because of day-to-day variability in weather patterns, atmospheric modelling and direct observation do not usually enable precise linkages to be made between individual emission sources and individual deposition-receptors. But on a broader scale, and over time, fairly accurate links can be made. Also, on a continental, multi-year scale, the relationship between total emissions and total deposition is almost linear. Thus a major, generalized reduction in emissions of sulfur and nitrogen oxides in eastern North America over several years would bring about a commensurate reduction in deposition of acidifying compounds.

At current rates of emission of acid-forming pollutants, acidification of sensitive environments will continue even if there is no increase in total emissions. Consequently, acid rain and its environmental, biological, and economic consequences will similarly continue. Indeed, damaging acidification of many ecosystems would continue even with some decreases in total emissions, although any significant reduction would slow the rate of acidification.

Observation of acid-sensitive surface waters offers guidance on acceptable levels of acid rain. By and large, moderately sensitive systems in eastern North America tend not to exhibit increased acidity if the total annual deposition of wet sulfate is below 20 kilograms per hectare. Thus, although the dry fraction of acid deposition is not yet being measured effectively, empirical data show that, in linking total acid loadings to acidification of sensitive waters, the wet sulfate fraction generally is an acceptable yardstick.

There is consensus in the international scientific community that the scientific data base is adequate to assess the immediate as well as the long-term implications of continuing, high-volume emissions of acid-causing pollutants and resulting acidification of sensitive ecosystems. The scientific data base is similarly adequate for the selection of effective emission reduction strategies to reduce substantially the effects of acid deposition.
2. Sources

The Special Envoys have been directed to examine the problem of acid rain in its international, transboundary context. A Canadian analysis of the sources of acid rain similarly must encompass the transboundary and the domestic components. After all, of the acid rain affecting eastern Canada, about one-half originates in the United States and one-half in Canada. In the regions of particular concern in Canada, such as the Muskoka-Haliburton tourist and recreation area in Ontario, two-thirds of the acid rain originates in the United States. Overall, the United States exports about four times as much \( \text{SO}_2 \) as it imports from Canada each year.

Air pollution became a major public concern in Canada, as it did in many industrialized countries, in the period of high industrial growth following the second world war. By the 1970s, many countries, Canada included, had passed clean air laws, which addressed in the main the most serious air pollution problem of the day: poor air quality, chiefly in urban centres, and its impact on human health. One of the ways of doing so, and often the cheapest, was the erection of tall smokestacks, to enable air currents to disperse pollutants more widely.

As a result, any progress in reducing acid precursor emissions has come almost entirely from attempts to meet local air quality standards. These attempts have met with a measure of success: in central and eastern Canada, for example, total \( \text{SO}_2 \) emissions dropped from 5,640 kilotonnes in 1970 to 4,516 kilotonnes in 1980. Fewer than one percent of Canadian regions currently fail to meet air quality objectives (including, in most acid-sensitive regions, a strict one-hour \( \text{SO}_2 \) standard).

But this downward trend may not continue. If additional steps are not taken, Canada estimates that the total of \( \text{SO}_2 \) emissions potentially affecting its acid-sensitive regions will rise by about 10 percent by the year 2000.

There are three main reasons for this:

1. Since local air quality is generally quite good in most localities, the principal legal imperative to bring down emissions has largely been satisfied;
2. Economic growth and other factors are resulting in expansion of some of the major sources of acid gas emissions; and
3. Some old and heavily polluting facilities, chiefly high-sulfur coal-burning power plants, are not being replaced as quickly as anticipated by new, cleaner facilities.
Another way of looking at the total loading of acidic pollutants in Canada is by industrial sector. Thus, about one-half of the acid rain falling on Canada results from emissions from coal-burning power plants, another quarter from smelters, and the remainder from other industrial sources and transportation.

Although in recent years there has been a reduction in total SO₂ emissions affecting Canada, what is significant is that they remain near their historical peak. The emissions of the other main acid-causing gas, NOₓ, are continuing to rise significantly. Total emissions will need to be cut sharply if the adverse effects of acid deposition are to be reversed.

Another factor in the increasing acidity of rainfall is a change in the way in which coal is burned. Although total usage of the coal that contributes to the Canadian acid rain problem has not increased significantly, seasonal use has changed dramatically. Summertime coal consumption is now much greater than it was several decades ago, due to increased use of air conditioning. Summertime heat and humidity hasten the transformation of SO₂ and NOₓ emissions into acid rain. And the construction of tall stacks means that the pollutants travel greater distances, damaging previously pristine regions.

Thus, even though overall coal consumption has not changed greatly, the sulfates and nitrates that cause acidity have increased significantly.

In summary, between 1940 and 1970, man-made emissions of SO₂ impacting on Canada rose by about two-thirds. Implementation of clean air laws produced a generalized reduction over the past 15 years. It is the Canadian perception that, unless additional measures such as the new Canadian reduction program are implemented, the total emissions of SO₂ affecting Canada will increase into the next century. NOₓ emissions will increase at an even higher rate.

3. Impacts
The various economic and ecological consequences of acid rain are discussed elsewhere in this report. What makes transported air pollutants, and especially acid rain, such a vexing issue in Canada is the fear of long-term, essentially irreversible, harm to sensitive environments, and consequent disruption of communities and lifestyles.
The long-term socio-economic impacts of acid rain in Canada should be viewed in the following terms:

- More than four-fifths of Canadians live in areas of high acid deposition. Many of them live, work, or spend leisure time in acid-sensitive regions.
- The fishery, tourism, and forestry resources potentially at risk due to acid rain sustain about eight percent of Canada's gross national product.
- Of the two million lakes in Quebec and Ontario, 43 percent are vulnerable to acidification.
- About 90,000 jobs are at risk in the eastern Canadian commercial fisheries.
- Of the 16,000 fishing camps and lodges in Ontario, 600 may be closed because of acid rain by the year 2000.
- More than 70 million hectares (or about one-half) of Canada's productive forests are in areas receiving high levels of acid rain. These forests generated 14 billion dollars' worth of forest products in 1982.

Such gross statistics do not begin to reflect adequately the current frustration and potential long-term harm in affected communities.

In general, acid-sensitive regions are relatively sparsely populated, not highly industrialized, and heavily dependent for their economy and lifestyles on a healthy and productive environment. Canadians living there perceive that their future is being put at risk because areas of high industrial activity are keeping their production costs down by exporting pollution. This perception of inequity and increasing long-term harm, especially when some of the pollution crosses the international border, is at the root of the Canadian view that emissions of acid gases impacting on Canadian territory must be reduced to levels that the environment can accommodate.

4. Co-operative Actions

Acid rain has become a politically sensitive issue in both the United States and Canada. Because of the large costs of substantially reducing the emission of pollutants that produce acid rain, the much less easily quantified, but also very large, economic, social, and aesthetic costs of inaction, and both the perception and the reality of incomplete scientific understanding, effective policy responses have not been easy to come by.

In Canada, for a number of reasons, it has been easier to move toward major reductions of the pollutants primarily responsible for excess acidity in precipitation. Canada has now embarked on such a program.
In the United States, many factors have combined to make a national response more difficult to achieve. Canada recognizes these difficulties, particularly when proposals involve legislative initiatives. At the same time, Canada believes the U.S. *Clean Air Act* affords opportunities, through implemented or as yet unused regulatory mechanisms, to take significant steps toward reducing emissions of acid gases.

5. Current Canadian Response

Air pollution control in Canada is a shared, concurrent responsibility of the federal and provincial governments. The provinces are primarily responsible for controlling emissions which impact within their borders, while the federal government is responsible for international air pollution. Both levels of government play a role in interprovincial air pollution.

Except for pollutants dangerous to human health, Canadian air pollution control programs are generally designed to achieve specified environmental quality objectives rather than prescribing the use of specific technologies. Air quality objectives for SO$_2$ have been published by the federal government for the guidance of the provinces. The Canadian acceptable levels result in air quality that is at least as healthy as that in most industrialized countries, while the Canadian desirable levels are among the most stringent anywhere. In addition, the one-hour (rather than 24-hour) standard helps deal with total loadings by reducing opportunities for excessively high emissions.

The following table summarizes Canadian SO$_2$ air quality objectives:

<table>
<thead>
<tr>
<th>Averaging Period</th>
<th>Canadian Objectives</th>
<th>Ontario Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Desirable</td>
<td>Acceptable</td>
</tr>
<tr>
<td>Annual</td>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>24-hour</td>
<td>150</td>
<td>300</td>
</tr>
<tr>
<td>1-hour</td>
<td>450</td>
<td>900</td>
</tr>
</tbody>
</table>

Most provinces base their control programs on the acceptable level; two use the desirable level.
Thus sulfur dioxide, as a local air quality problem, has been controlled successfully in Canada. This was achieved through a variety of actions including emission containment, use of tall smokestacks, use of low-sulfur fuels, intermittent control procedures, and fuel regulations.

Canadian non-ferrous smelters have used selective mining and mineral separation preparation practices, sulfur containment, and changes in process technology to reduce emissions. Regulations limiting the sulfur content of fuels have reduced non-utility fuel use emissions. Canadian utilities have used natural gas, low-sulfur coal, coal-blending, coal-washing, nuclear and hydraulic generation, and load management to limit increases in emissions.

The above summarizes the Canadian response to the problems of local air quality. While this is not a response to the problem of acid rain (and indeed exacerbated that problem by use of dispersion techniques), it serves as a foundation on which current acid rain mitigation programs are being erected.

The reductions of air pollutants that have occurred in Canada since 1970 have not alleviated the long-range transport and long-term loading problems of which acid rain is a part. Canada has therefore determined that substantial further emission reductions must take place to stem the damage being caused by acid rain. Accordingly, a Canadian acid rain abatement program is being put in place.

The scale of the Canadian program is based on the scientific evidence that most moderately sensitive regions can be adequately protected if annual loading of wet sulfate is kept below 20 kilograms per hectare. Reducing loadings to that level for most eastern Canadian acid-sensitive regions requires a reduction in impacting SO$_2$ emissions of close to 50 percent from 1980 levels. The scale of reductions agreed for central and eastern Canada has been set on that basis, and as the Canadian component of an adequate abatement program.

In March 1985, the Environment Ministers of the governments of Canada, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland agreed to reduce SO$_2$ emissions from the 1980 base by approximately 50 percent by 1994. At the same time, they agreed to an initial interprovincial allocation of reductions.
A tabular summary of past and projected changes in total central and eastern Canadian SO₂ emissions by sector follows:

**SULPHUR DIOXIDE EMISSIONS**

(thousands of metric tonnes per year)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Smelters</td>
<td>3,810</td>
<td>2,720</td>
<td>2,000</td>
<td>1,150</td>
</tr>
<tr>
<td>Utilities</td>
<td>470</td>
<td>730</td>
<td>450</td>
<td>450</td>
</tr>
<tr>
<td>Non-utility Fuel Use</td>
<td>950</td>
<td>580</td>
<td>400</td>
<td>300</td>
</tr>
<tr>
<td>Other</td>
<td>410</td>
<td>490</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>5,640</td>
<td>4,520</td>
<td>3,250</td>
<td>2,300</td>
</tr>
</tbody>
</table>

The provinces are in the process of enacting regulations to implement the new program. The two largest provincial emitters of acid gases, Quebec and Ontario, have now done so. Together they account for three-fourths of eastern Canadian SO₂ emissions.

The main elements of the Quebec and Ontario programs are summarized in the following tables.

**QUEBEC**

SO₂ Emission Controls
Legal Limits and Effective Dates

(thousands of metric tonnes per year)

<table>
<thead>
<tr>
<th>Sector</th>
<th>1980</th>
<th>1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noranda</td>
<td>552</td>
<td>275</td>
</tr>
<tr>
<td>Murdochville</td>
<td>91</td>
<td>65</td>
</tr>
<tr>
<td>Other Industrial Sources</td>
<td>135</td>
<td>116</td>
</tr>
<tr>
<td>Fuel Combustion</td>
<td>258</td>
<td>102</td>
</tr>
<tr>
<td>Transportation</td>
<td>49</td>
<td>39</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,085</td>
<td>597</td>
</tr>
</tbody>
</table>
ONTARIO
New Package of SO₂ Emission Controls
Legal Limits and Effective Dates

(Thousands of metric tonnes per year)

<table>
<thead>
<tr>
<th>Source</th>
<th>1980</th>
<th>1994</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ontario Hydro</td>
<td>452</td>
<td>175</td>
</tr>
<tr>
<td>Inco</td>
<td>1,155</td>
<td>265*</td>
</tr>
<tr>
<td>Falconbridge</td>
<td>154</td>
<td>100</td>
</tr>
<tr>
<td>Algoma (Wawa)</td>
<td>161</td>
<td>125</td>
</tr>
<tr>
<td>Other Sources</td>
<td>272</td>
<td>220</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2,194</td>
<td>885</td>
</tr>
</tbody>
</table>

* In addition, an even tighter objective has been set at 175 kilotonnes/year by 1994. Inco’s December 1988 report must describe in detail the technology and design which could be used to meet this lower objective and its cost.

In addition, the Ontario government is preparing a regulation to control new or modified boilers. It will place a one percent sulfur content constraint on the fuel or will require that an equivalent amount of SO₂ be removed from flue gas.

As part of this abatement program, the federal government is taking several steps in co-operation with provinces and the private sector:

- Limits have been set for new motor vehicle emissions to bring them to U.S. standards by September 1987.
- $25 million have been allocated to cost-share with industry the development and demonstration of new processes and pollution control techniques for non-ferrous smelters.
- $150 million have been allocated to cost-share, with provinces and industry, the implementation of these new techniques.
- A $30 million federal-provincial scientific research program is continuing, and is aimed in part at monitoring the efficacy of the Canadian abatement program.
These planned reductions are significant not only for their size, but also for the policy judgments on which they are based. They go beyond traditional concerns with improving local air quality, and address specifically the total pollution loading issue which is the cause of acid rain.
V. RECOMMENDATIONS

In preparing our recommendations to both governments, we have been conscious of the wide differences between our two countries on this issue, differences that are based not just on perception but also on certain underlying political, social, economic, and geographic realities. We have also kept in mind that our mandate was not to find a final solution to this bilateral problem, but to find ways in which our two countries can begin to move together to deal effectively with this vexing issue.

Both nations want to see progress on acid rain. For such progress to be possible, and if it is to result in part from the work of the Special Envoys, our recommendations must be realistic. They must not ask either country to make a sudden, revolutionary change in its position. They must not call for immediate abandonment of major policy stands. They must instead point the way to a resumption of fruitful bilateral dialogue and constructive action that will help us relieve the stress that this issue has created, and reduce the flow of airborne pollutants across our common border.

A. Innovative Control Technologies

A significant impediment to the development of a U.S. consensus on acid rain is the high cost of the available control options. Because the impacts of different options fall on different interest groups, political positions have become polarized, and it has become increasingly difficult to find a common ground for action. If the menu of control options were expanded, and if the new options were significantly cheaper yet highly efficient, it would be easier to formulate an acid rain control plan that would have broader public appeal.

Recommendation

Therefore, the U.S. government should implement a five-year, five-billion-dollar control technology commercial demonstration program. The federal government should provide half the funding — 2.5 billion dollars — for projects which industry recommends, and for which industry is prepared to contribute the other half of the funding.

Because this technology demonstration program is meant to be part of a long-term response to the transboundary acid rain problem, prospective projects should be evaluated according to several specific criteria. The federal government should co-fund projects that have the potential for the largest emission reductions, measured as a percentage of
SO\textsubscript{2} or NO\textsubscript{x} removed. Among projects with similar potential, government funding should go to those that reduce emissions at the cheapest cost per ton. More consideration should be given to projects that demonstrate retrofit technologies applicable to the largest number of existing sources, especially existing sources that, because of their size and location, contribute to transboundary air pollution. In short, although the primary purpose of this research program is to demonstrate the kinds of technologies that would be needed for any future acid rain control program, it should also result in some near-term reductions in U.S. air emissions that affect Canadian ecosystems.

Furthermore, special consideration should be given to technologies that can be applied to facilities currently dependent on the use of high-sulfur coal. Because the scrubbers currently available to clean high-sulfur coal are very expensive, there is an economic incentive for sources to switch to low-sulfur coal as a method of reducing emissions. However, coal-switching imposes significant socio-economic costs on high-sulfur coal miners, their families, and their communities. The commercial demonstration of innovative technologies that clean high-sulfur coal will help to reduce the economic consequences of any future acid rain control program.

We further recommend that a panel, headed by a senior U.S. cabinet official, be established to oversee this research demonstration program and select the projects to be co-funded by the federal government. The U.S. Environmental Protection Agency and Department of Energy should provide the technical expertise necessary to select demonstration projects. Other members of the panel should be drawn from the Department of State and state governments. Canada also should be invited to send a representative to sit on this panel.

In this connection, we note a somewhat similar approach being taken in Canada. There, the major industrial sources of acidic emissions are smelters. As part of the Canadian acid rain mitigation program, federal and provincial governments are co-operating financially with industry to develop and implement advanced technologies designed to improve smelter efficiency and reduce pollution.

**Recommendation**

The results of the Canadian technology development program should be shared with the United States.
B. Co-operative Activities

The Special Envoys have recognized the need to put in place mechanisms to help both governments deal with this issue in such a way that differences are not exaggerated and oppportunities for co-operation and agreement seized.

1. Domestic Legislation and Regulations

The U.S. and Canadian Clean Air Acts, and other legislation and regulations that delimit the emissions of airborne pollutants, were designed and are being implemented primarily to respond to air quality needs within each country. But both Acts recognize that special controls might be re- quired to deal with pollutants that cross the intenntional boundary.

Various scientific experiments, measurements, and observations demonstrate the reality of the transboundary flow of airborne pollutants. As a consequence, the interpretation by regulatory agencies of relevant domestic legislation can have an impact, albeit unintended, on the nature and quant- ity of pollutants that cross that border.

Recommendation

Both the United States and Canada should review their existing air pollution programs and legislation to identify opportunities, consistent with existing law, for addressing environmental concerns related to transboundary air pollution. The results of these reviews should be made available to the chief environmental officials of both countries for their consideration in the management of their respective programs.

In implementing air pollution legislation, agencies in both countries have tended to focus on local, domestic parameters. But clean air regulations obviously can have a transboundary effect. Therefore prior notice and consultation on such rulemaking is essential.

Recommendation

Agencies contemplating changes to laws or regulations that may alter the flow of transboundary pollutants should give timely notice of their intent to agencies of the other country through diplomatic channels.

2. Bilateral Consultation and Information Exchange

Acid rain, and other forms of long-range, transboundary air pollution, comprise a complex phenomenon with important political, economic, social, and environmental implications for both countries. Both domest- ically and as a bilateral issue, therefore, acid rain is not susceptible to
a quick-fix response. It must be assumed that it will remain on the bilateral agenda for some time, and that its intrinsic importance will dictate that it be handled at the highest levels.

Additionally, the Parliament of Canada and the U.S. Congress have maintained a keen interest in this issue. While their principal focus has been on legislation in response to perceived domestic problems, both bodies have shown an awareness of the transboundary flow of airborne pollutants and its political and diplomatic ramifications. Both bodies have passed amendments to the Clean Air Acts explicitly recognizing the potential for damage by pollutants crossing the international boundary and setting out means for reciprocal action designed to control pollutants deemed to cause such damage.

**Recommendation**

Acid rain should remain high on the agenda of meetings between the President and Prime Minister. They should be prepared to intercede personally from time to time to resolve difficulties and ensure progress. The U.S. cabinet official heading the technology development panel and a Canadian cabinet official would jointly advise the President and Prime Minister.

Heretofore preparations and briefings of Cabinet officers on acid rain have been separate and unilateral; henceforth, at least some of those briefings should be prepared on a co-operative basis. Moving in this way toward common perspectives for political-level discussions is a way to broaden the areas of accord.

**Recommendation**

Our two governments should establish a bilateral advisory and consultative group on transboundary air pollution. Such a group, comprising both diplomatic and environmental management officials, should provide the forum for discussions and first-level consultations on issues related to transboundary pollution. It should also provide advice to the directors of each country’s environmental programs and to the Secretary of State and Secretary of State for External Affairs.

**C. Research**

Scientific information provides a basis for determining the most effective actions to address the damage caused by acid rain and other long-range, transboundary air pollutants. There are several areas where research would be of special value to decision makers in guiding the development of environmental policies.
The following research recommendations are not listed in priority order. The decisions on which areas are of greatest concern are a matter of public policy to be determined by each nation. However, through the combined efforts of our two countries, active research efforts should be pursued in each of the areas listed.

1. **Deposition Monitoring**

   Although methods for monitoring wet deposition are well established and extensive standardized networks are in place across North America, total deposition is not being measured adequately. Dry deposition has been measured at specific sites using a variety of techniques, but no comprehensive monitoring network for dry deposition is currently in place. Measurements of dry deposition would permit more accurate evaluation of the total impact of acid deposition.

   **Recommendation**

   Standard, accurate methods to measure dry deposition should be developed and monitoring networks deployed. The networks should be of sufficient size and adequate statistical design, and implemented with adequate quality assurance and quality control procedures, in order to enable researchers to measure total acid deposition for sensitive areas across North America.

2. **Rates of Aquatic Change**

   Concern over the effects of acid deposition first began with the observation that atmospheric deposition is causing the acidification of surface waters and subsequent adverse effects on aquatic biota. Although much research has been conducted during the last decade, our understanding of what changes in water quality would result from a change in acid deposition in a variety of watershed types is still incomplete. The factors controlling watershed processes are also not well known. Information on dynamic watershed processes would improve our ability to predict changes in water quality from current and future deposition levels.

   **Recommendation**

   Process-level data from different watershed types would be of help for determining current and potential future effects of acid deposition on surface waters. Models for predicting watershed response to acid deposition should be developed and tested empirically. In addition, an adequate acid deposition data base on watershed characteristics should be developed to exercise the models for selected North American sensitive areas.
3. Aquatic Biology

Concern over the change in surface water chemistry due to acid rain stems from the subsequent potential for effects on aquatic biota, particularly fish. Effects of specific pH levels have been investigated, but the effects of chronic or slow acidification, and the relationships between trace metals and fish species, have not been adequately determined. The loss of fish in acidified surface waters may be one of the last effects to be observed. Effects on biota other than fish should also be considered.

Recommendation

The environmental damage of surface water acidification should be understood in terms of biological changes. This would help to quantify the relationship between changes in surface water chemistry and changes in aquatic biota more clearly. Special attention should be focused on both rates and types of biological change.

4. Forest Effects

Forest and tree declines in North America and in Europe have been documented in areas that receive high levels of atmospheric deposition. The concern about the possible effects of acid rain on forests is prompted by some provocative, albeit largely circumstantial, evidence. Despite the existence of observed changes in forest growth in certain areas, it is unknown to what degree, if any, current levels of acid rain are affecting the growth and productivity of forests in North America.

Recommendation

Research should be accelerated to investigate the potential link between forest and tree decline and acid rain as a causal or contributing factor.

5. Materials Damage

Materials damage is one of the few effects of air pollution that has the potential to be quantified economically. Fewer resources have been expended on this area of research than on the biological effects of atmospheric transport; estimates of damage have varied widely, but some have gone as high as several billion dollars annually. Equally of concern is the possibility that irreplaceable cultural resources may be damaged or destroyed.

Recommendation

The effects of acid rain on materials should receive increased attention so that the quantification of the extent of current damage, the resources at risk, and the prognosis for future damage can be improved.
6. Role of Heavy Metals

Heavy metals such as lead, mercury, cadmium, and arsenic become more soluble in solution at lower pH. All of these metals can be toxic to both aquatic biota and humans. The increased corrosivity of acidic water on water storage and distribution systems may also pose a potential health risk. The extreme toxicity of these metals warrants concern.

Recommendation

The mobilization, transport and flux of heavy metals in acidified surface waters should be investigated to determine their environmental toxicity. Special emphasis should be placed on potential effects on human health and on possible mitigation strategies. The role of these metals in aquatic and forest damages also needs more attention.