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Draft Proposal on Acid Rain

For seven years we have supported legislation to control acid rain. Three times in this decade the Committee on Environment and Public Works has reported such legislation, the latest being S. 1894, reported in November, 1987. But thus far the legislation has not been considered by the Senate.

Each of the bills reported by the Committee has been based on the principle already included in all of our major environmental laws: That he who causes the pollution should pay for its cleanup. We support that principle. But it has become clear to us that no acid rain control bill based entirely on that principle can be enacted. The costs are so great and the sources of emissions so concentrated that some form of cost-sharing is a practical necessity.

As reported, S. 1894 requires a reduction in emissions of sulfur dioxide of 12 million tons over 10 years. Although we firmly believe this to be the appropriate level of reduction over the right time period, we acknowledge the deeply-felt concerns of Senators from the states that will have to significantly reduce their emissions.

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Accordingly, we are prepared to support cost-sharing and a lesser amount of reduction over a longer period of time as compromises necessary for this legislation to be considered and approved.

The legislation pending before the Senate, S. 1894, has been before the members for over 6 months. That is sufficient time for interested parties to review its provisions and suggest amendments that may be needed. We are determined that clean air legislation be considered by the full Senate this year. If it is not placed on the Senate schedule, we will offer it as an amendment to other legislation.

This country -- and the world -- is in an air pollution crisis. There are daily headlines about the greenhouse effect and its possible impact on regional droughts that are devastating agricultural areas. Last week, ozone levels reached new peaks, placing the health of the American people, particularly that of children, at risk.

The problems are difficult, the resolution complex. But we must act. It has been 11 years since the Clean Air Act was last amended. Then, words like "acid rain", "greenhouse effect", "global warming", and "ozone depletion" were not in common use. Today they are daily reminders of the crisis we face.

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The policy shift we announce today is based on the compelling need to act now.

We therefore intend to modify S. 1894 to provide:

1. A national cost-sharing effort that will feature

(a) A 50% Federal share for capital costs associated with required reductions in sulfur dioxide and oxides of nitrogen.

The Federal share would be funded by a fee on electricity generation. The fee would be based on a State's annual average sulfur dioxide emissions rate. Those states with higher emissions rates would pay more than those who have already taken steps to control their emissions. Scrubbed capacity, nuclear and hydroelectric generation would be exempt from the fee.

(b) In applying the fee and the requirements of the reduction program, there will be a 10% cap on increases of residential electricity rates because of acid rain controls. So rate increases attributable to this program would be no more than 10% over the 12 year life of the program.

2. Funding for the Clean Coal technology program would be increased, with emphasis placed on developing retrofit technologies so existing plants may take advantage of new control technologies.

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3. An aggressive job protection program to mitigate any adverse effects caused by the legislation. This program, to be funded out of the Federal share, will include enhanced unemployment benefits, job retraining, relocation, reeducation, and transfer rights for those adversely affected.

4. This program would be used to share the costs required to achieve a 10 million ton reduction in sulfur dioxide by 2000. The reductions would be phased. By 1994, there would be a reduction of 4.5 million tons; the remaining reduction of 5.5 million tons would be achieved by 2000. After 2000, states would cap their emissions from existing sources.

We also agree to support the amendments proposed by the chairman of the Environment and Public Works Committee, Senator Burdick, to the extent those amendments remain necessary after these changes have been made. Similarly, states that have enacted 50% reduction requirements on their own and are in fact reducing their sulfur dioxide emissions would not be subject to additional reduction requirements.

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The evidence has never been more convincing; the need never greater. We are committed to move this legislation prior to the August recess. We hope that the significant modifications we announce today are sufficient to persuade those of our colleagues who until now have opposed this legislation to join us in taking this important step to protect the public health and the environment.

File

The Challenge of Acid Rain

Acid rain's effects in soil and water leave no doubt about the need to control its causes. Now advances in technology have yielded environmentally and economically attractive solutions

by Volker A. Mohnen

The atmosphere functions as a pool and chemical-reaction vessel for a host of substances. Many of the most important ones—oxygen, carbon dioxide and nitrogen and sulfur compounds, for example—are released by the activity of organisms. Often with the help of the water cycle, they pass through the atmosphere and are eventually taken up again into soil, surface water or organic matter. Through technology, human beings have added enormously to the atmospheric burden of some of these substances, with far-reaching consequences for life and the environment. The evidence is clearest in the case of acid rain: precipitation and particles that have been made acidic by air pollution.

The alarm over the increasing acidity of precipitation in Europe and eastern North America was first sounded in the 1960's. Since then the most attention has been focused on acid rain's effects, established and suspect-

ed, on lakes and streams, with their populations of aquatic life, and on forests, although the list of concerns is far broader: it includes contamination of groundwater, corrosion of manmade structures and, most recently, deterioration of coastal waters. Twenty years later, how much damage to the ecosystem, lakes and forests in particular, has been confirmed and measured? What has been learned about the processes that produce acid rain and underlie its effects? What does the knowledge imply for efforts to control the emissions—mainly sulfur dioxide from coal- and oil-burning power plants and oxides of nitrogen from motor vehicles and power plants—that cause acid rain?

The study of these questions has grown into a major scientific enterprise. Under the aegis of the National Acid Precipitation Assessment Program (NAPAP), enacted in 1980, many different agencies of the Federal Government sponsor research on the atmospheric processes that produce acid rain, its effects on the ecosystem and options for controlling it. In addition the Electric Power Research Institute, which is funded by the utility industry, supports studies of acid-rain effects and research on technologies for reducing power-plant emissions. The NAPAP will not issue a major report until 1990. Yet much evidence is already in hand—enough to make it clear that acid rain, or more correctly the pollutants that cause it, represents a large-scale interference in the biogeochemical cycles through which living things interact with their environment. Good global housekeeping

demand an effort to protect the integrity of these cycles, and economical means of doing so are at hand.

Acid rain is a direct consequence of the atmosphere's self-cleansing nature. The tiny droplets of water that make up clouds continuously capture suspended particles and soluble trace gases. When precipitation coalesces from cloud water, it washes the impurities out of the atmosphere. Not all trace gases can be removed by precipitation, but sulfur dioxide (SO_2) and oxides of nitrogen emitted into the atmosphere are chemically converted into forms that are readily incorporated into cloud droplets: sulfuric and nitric acids.

The processes that convert the gases into acid and wash them from the atmosphere began operating long before human beings started to burn large quantities of fossil fuels; sulfur and nitrogen compounds are also released by natural processes such as volcanism and the activity of soil bacteria. But human economic activity has made the reactions vastly more important. They are triggered by sunlight and depend on the atmosphere's abundant supply of oxygen and water.

The reaction cycle is played out in the troposphere, the lowest 10 or 12 kilometers of the atmosphere. It begins as a photon of sunlight strikes a molecule of ozone (O_3), which may have mixed downward from the ozone layer in the stratosphere or may have been formed in the troposphere by the action of nitrogen- and carbon-containing pollutants. The result is a molecule of oxygen (O_2) and a lone, high-

VOLKER A. MOHNEN is professor of atmospheric science at the State University of New York at Albany. He is a graduate of the University of Munich, which awarded him a Ph.D. in 1966, and a past director of SUNY Albany's Atmospheric Sciences Research Center. He has served on several commissions studying atmospheric chemistry and has testified before Congress on the subject of acid rain. In his role as project director of the U.S. Environmental Protection Agency's Mountain Cloud Chemistry Program, Mohnen is currently studying atmospheric processes that may affect the health of forests.

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ly reactive oxygen atom, which then combines with a water molecule (H_2O) to form two hydroxyl radicals ($HO\cdot$). This scarce but active species transforms nitrogen dioxide (NO_2) into nitric acid (HNO_3) and initiates the reactions that transform sulfur dioxide into sulfuric acid (H_2SO_4).

The concentration of the hydroxyl radical in the atmosphere is less than one part per trillion, but it is practically inexhaustible: several of the oxidation processes it triggers end up by regenerating it. For example, one by-product of the initial oxidation of sulfur dioxide is the hydroperoxyl radical ($HO_2\cdot$), which reacts with nitric oxide (NO) to produce nitrogen dioxide and a new hydroxyl radical. In effect each hydroxyl radical can oxidize thousands of sulfur-containing molecules. As a result only the amount of pollutant in the air determines how much acid is ultimately produced.

The sulfuric and nitric acids formed from gaseous pollutants can easily make their way into clouds. (Some sulfuric acid is also formed directly in cloud droplets, from dissolved sulfur dioxide and hydrogen peroxide.) Nitric acid gas readily dissolves in existing cloud droplets. Sulfuric acid formed through gas-phase reactions condenses to form microscopic droplets, from roughly .1 to two micrometers (millionths of a meter) in diameter, which are one component of the summertime haze in the eastern U.S. Some of these sulfate particles settle to the ground in a process known as dry deposition. (Dry deposition also refers to the capture of sulfur dioxide gas by vegetation.) Most of them, however, are incorporated in clouds. Moisture readily condenses on an existing surface—a condensation nucleus—and sulfate particles are ideal condensation nuclei. They grow into cloud droplets containing dilute sulfuric acid.

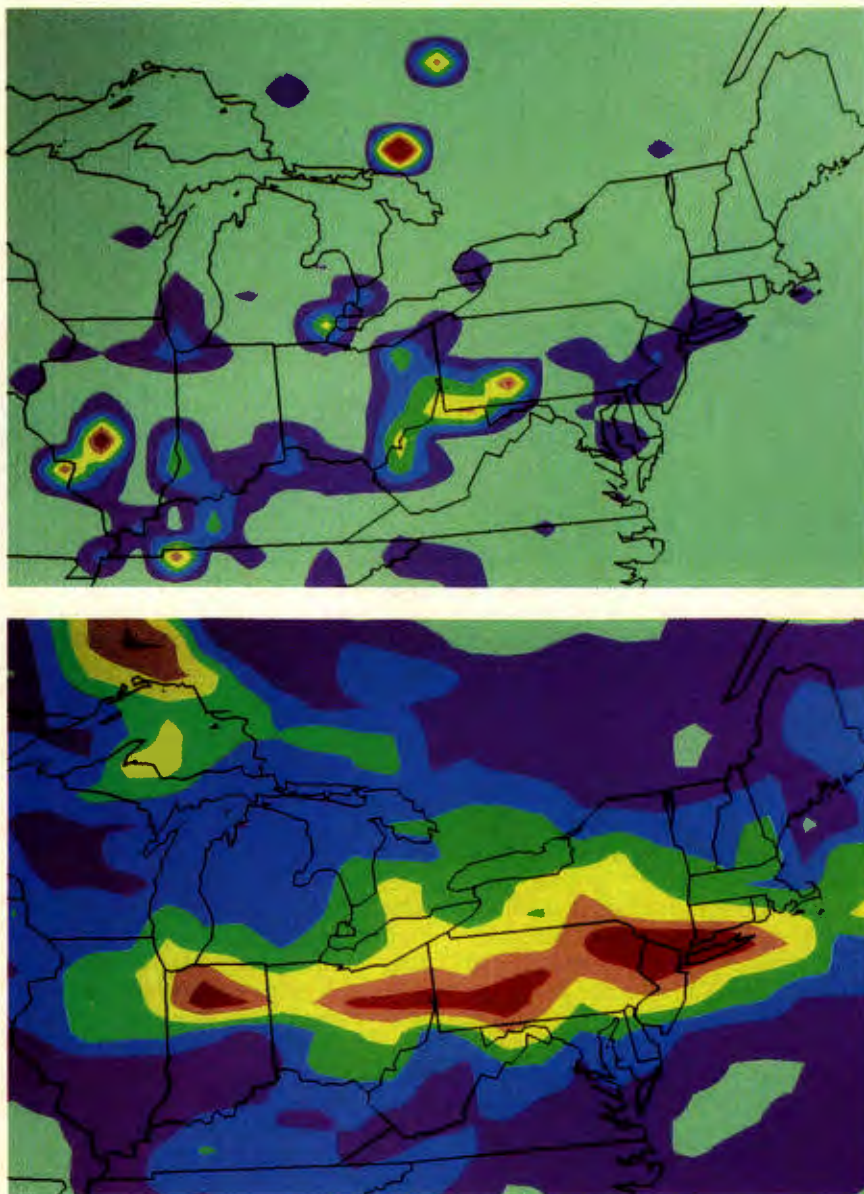
The sulfuric and nitric acids in cloud droplets can give them an extremely low pH. Water collected near the base of clouds in the eastern U.S. during the summer typically has a pH of about 3.6, but values as low as 2.6 have been recorded. (A pH of 7 is neutral; the lower the number, the stronger the acid it represents.) In the greater Los Angeles area the pH of fog has fallen as low as 2—about the acidity of lemon juice.

These very high acidities are found only near the base of clouds; the upper reaches are significantly cleaner. Soil and vegetation swathed in acidic clouds, as high-altitude forests can be, are directly exposed to the extremely acidic cloud base. Precipitation par-

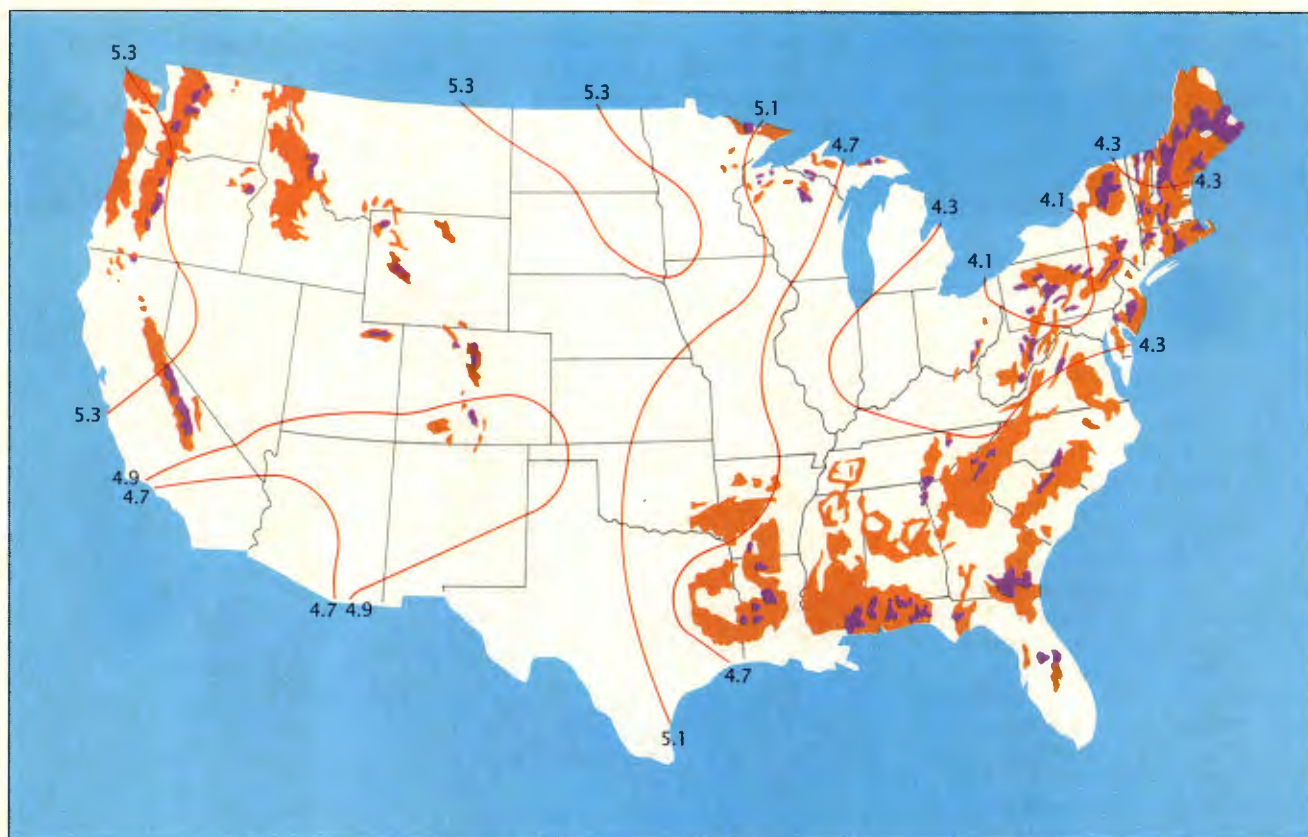
ticles, however, combine water from much of a cloud's thickness. The resulting dilution of the acid lowers the concentration of sulfur and nitrogen compounds in precipitation by a factor of between three and 30 and the acidity by between one-half and one

pH unit, to an average in the Northeast of about 4.2.

The acid rain may fall hundreds of miles from the pollution source. Wherever it lands, it undergoes a new round of physical and chemical



SULFURIC ACID DEPOSITION in three days' rain is modeled by computer. The top panel shows the pattern of sulfur emissions (mostly in the form of sulfur dioxide) in the northeastern U.S. and southern Canada, which served as input for the model. The pale background color represents the lowest emission levels and red represents the highest levels. Coal-fired power plants in the Middle West account for most of the U.S. sources; the copper-nickel smelter at Sudbury, Ontario, visible just north of Lake Huron, is the intensest Canadian source. Based on the weather conditions for April 22 through 24, 1981, the computer modeled the transport of the sulfur compounds and other relevant chemicals, their transformation to sulfuric acid and their deposition over the three-day period. The bottom panel shows how the sulfuric acid was deposited in rain; pale color indicates areas that received less than 10 grams of sulfur per hectare (about 2.5 acres) and red indicates areas receiving more than 260 grams per hectare. The computer model, known as the Regional Acid Deposition Model, was developed by Julius Chang of the State University of New York at Albany and his colleagues, with the support of the U.S. Environmental Protection Agency.



THREAT OF ACID RAIN to U.S. lakes and streams is mapped. Brown designates areas in which surface waters tend to have low alkalinity (a low content of ions such as bicarbonate, which can neutralize acid); purple areas have the lowest alkalinity. The contour lines chart the average pH of precipitation.

Where acidic (low pH) precipitation coincides with low surface-water alkalinity, lakes and streams are at risk of becoming acidified. (Alkalinity is not the only factor governing sensitivity to acid rain, however.) The data on water alkalinity were gathered by James M. Omernik of the EPA and his colleagues.

alterations, which can reduce the acidity and change the chemical characteristics of the water that eventually reaches lakes and streams. Alkaline soils, such as soils rich in limestone, can neutralize the acid directly. In the slightly acidic soils typical of the evergreen forests exposed to acid rain in the U.S., Canada and Europe two other processes can blunt the effects of acid deposition. The acid can be immobilized as the soil or vegetation retains sulfate and nitrate ions (from sulfuric and nitric acids respectively). It can also be buffered through a process that is known as cation (positive ion) exchange.

In cation exchange the ions of calcium, magnesium and other metals found in many soils take the place of the acid's hydrogen ions. The source of the metal ions is rock weathering: the dissolution of minerals by precipitation and groundwater containing dissolved carbon dioxide, which releases the positive metal ions into the soil together with anions, or negative ions, of bicarbonate (HCO_3^-). Then, when sulfuric acid is added to the soil, the sulfate (SO_4^{2-}) of the acid can displace the calcium or magnesium ions.

As the sulfate solution washes the metal cations from the soil, the hydrogen ions responsible for the acidity are left behind.

The extent to which retention and cation exchange take place in runoff or groundwater depends on the character of the watershed—its geology, vegetation and flow patterns, among other things. Soil processes cannot affect runoff from frozen or fully saturated ground or bare granite bedrock, and so the water that reaches the lake or stream remains about as acidic as the precipitation. Even when the rain does soak in, soil processes may be ineffective. Quartz, for example, is resistant to weathering and lacks the metals needed for cation exchange, and so percolation through quartz sand does little to buffer acid. In watersheds with deep soils capable of retaining large amounts of sulfate or nitrate, however, or soils rich in exchangeable cations, the release of acid to the lake or stream may be forestalled, at least until the retention or buffering capacity is used up.

What happens when acidified runoff or groundwater reaches a lake or a stream? A body of water may contain

bicarbonate and other basic ions derived from rock weathering, which can neutralize an influx of acid, preventing the pH of the water from falling below a value of about 5. The water's content of such neutralizing ions is known as its acid-neutralizing capacity (ANC), and the value of the ANC provides one measure of a lake's susceptibility to acidification. A lake with a very high ANC is protected against acid rain, at least for the moment; a lake with an ANC of zero may stay healthy if it lies far from acid rain. Otherwise any input of acid will acidify it directly.

An acidified lake is easy to spot. Its ANC is exhausted and its pH has fallen to well below 6; its waters are high in sulfate and other ions, such as aluminum, that are mobilized when acid percolates through soil, and it hosts an altered community of aquatic life (or no life at all). Forecasting the acidification of a lake with a low but still positive ANC is another matter. The retention or buffering of acid that is deposited in the watershed may slow the depletion of ANC for the time being. Moreover, a lake's budget of ANC is not fixed. Even as it is depleted by an influx of acid, it may be renewed

by the weathering of minerals in the lake's surroundings. To predict how a lake will respond to a steady input of acid one must know not only its ANC but also how fast its ANC is replenished and how long that rate can be maintained.

These interacting processes in the watershed and the lake, then, determine whether a given lake will acidify, and how fast. They are still not thoroughly understood, and learning enough about a system to predict its behavior is difficult. There is no doubt about the overall trend, however: in areas where the soil is poor in weatherable minerals and acid deposition is heavy, lakes have been acidifying. In 1986 a committee of the National Academy of Sciences compiled measurements of pH and alkalinity (a measure of buffering ability similar to ANC) made between the 1920's and the 1940's in several hundred lakes in Wisconsin, New Hampshire and New York and compared the data with recent measurements. In the interim, the committee found, pH and alkalinity have on the average increased in the Wisconsin lakes and stayed largely unchanged for those in New Hampshire. In New York, however, and in particular in the Adirondack Mountains, the data for some lakes show a trend of acidification.

The NAS committee got a more complete picture of the trend from microorganisms preserved in lake-bottom sediments. As the pH of a lake changes, the assemblage of diatoms and golden-brown algae it hosts changes as well. Species of these minute plants can be distinguished by the form of their skeletons, which makes it possible to reconstruct changes with time in the community of species, and hence in water pH. Of the 11 Adirondack lakes for which such data were available, six had increased in acidity since the 1930's, falling to a pH of below 5.2; the acidification was fastest during the period ending in 1970. The committee could identify no cause for the pH change other than acid rain.

Acidification of lakes in the Adirondacks is a function of the region's highly acidic precipitation (rain collected nearby, in western New York, has an average pH of about 4.1, the lowest in the country) and the poor buffering ability of its granite-floored soil and lakes. The recent National Surface Water Survey examined other areas around the country where the ANC of lakes and streams tends to be low, leaving them vulnerable to acid rain. The survey found high percent-

ages of acidic lakes in the Pocono Mountains of eastern Pennsylvania and on Michigan's Upper Peninsula—regions where rain is highly acidic. Acid rain is high on the list of suspected culprits for the relatively large number of acidic lakes found in central and southern New England. Florida showed a strikingly high proportion of acidic lakes, but they are believed to reflect other circumstances, such as organic acids produced by decaying vegetation in swampy regions and fertilizer-rich runoff from agricultural land.

Maine has the lowest percentage of acidic lakes in the Northeast in spite of its poorly buffered soil and waters. Poorly buffered lakes surveyed in the upper Great Lakes region, the southern Blue Ridge Mountains and the mountainous West also were mostly healthy, showing a pH of more than 6. What sets those regions apart is their relative freedom from acid rain.

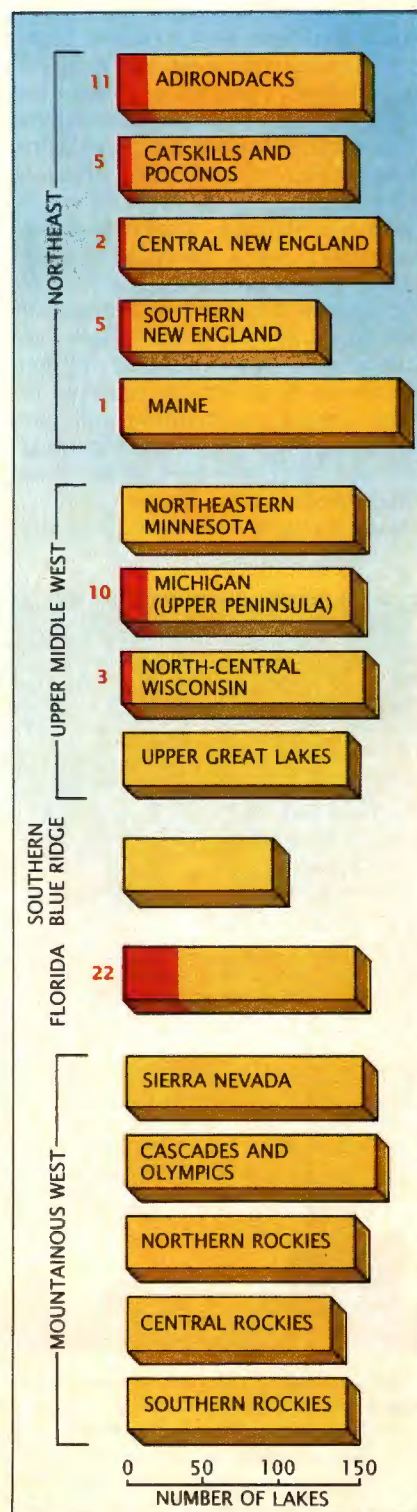
The evidence is not nearly as definitive for the other major environmental effect attributed to acid rain: forest decline. Since 1980 many forests in the eastern U.S. and parts of Europe have suffered a drastic loss of vitality—a loss that could not be linked to any of the familiar causes, such as insects, disease or direct poisoning by a specific air or water pollutant. The most dramatic reports have come from Germany, where scientists, stunned by the extent and speed of the decline, have called it *Waldsterben*, or forest death. Yet statistics for the U.S. are also unnerving.

The decline is most dramatic in high-elevation coniferous forests. For many sites lying above 850 meters in the Adirondacks, the Green Mountains in Vermont and the White Mountains in New Hampshire a comparison of historical records with current surveys shows that more than 50 percent of the red spruce have died in the past

ACIDIFIED LAKES are concentrated in the Northeast and the upper Middle West. The graph shows results of the National Surface Water Survey. The segment of each bar in dark color corresponds to the number of sampled lakes whose content of bicarbonate and other acid-neutralizing ions has been depleted; the number is also given as a percentage (color). Such lakes usually have a low pH and changed aquatic life. Sulfuric and nitric acids from pollutants are thought to account for most such lakes, except in Florida, where they are thought to reflect such factors as organic acids from decaying vegetation and fertilizer runoff.

25 years. At lower elevations injury to both softwoods and hardwoods has been documented.

In the forests at high elevations, at least, the dead timber is only the most dramatic evidence of a pervasive loss of tree vigor. Tree-ring records from high-elevation forests in the Northeast show sharply reduced annual growth



increments beginning in the early 1960's. The declines occur in stands of many different ages, with different histories of disturbance or disease. What common factor could underlie the growth reductions?

The role of acid rain and other forms of air pollution is under intensive investigation. In spite of the dimensions of the forest damage, however, a firm causal link has proved to be elusive. One can get some idea of the difficulties by contrasting the recent forest decline with clear-cut cases of fumigation: forest poisoning by air pollutants. Smelters and chemical plants that emit sulfur dioxide, oxides of nitrogen or fluoride compounds are often girdled by dead timber. In such cases there is a clear correlation between tree damage, a specific pollution source and a threshold concentration of the pollutant. The forests that are now dying, in contrast, are far from any source and are exposed to pollutants in concentrations well below the levels previously reported to injure trees. If air pollution, and specifically acid rain, plays a part in forest decline, it probably does so less as a lethal agent than as a stress.

Many stresses, both biotic and abi-

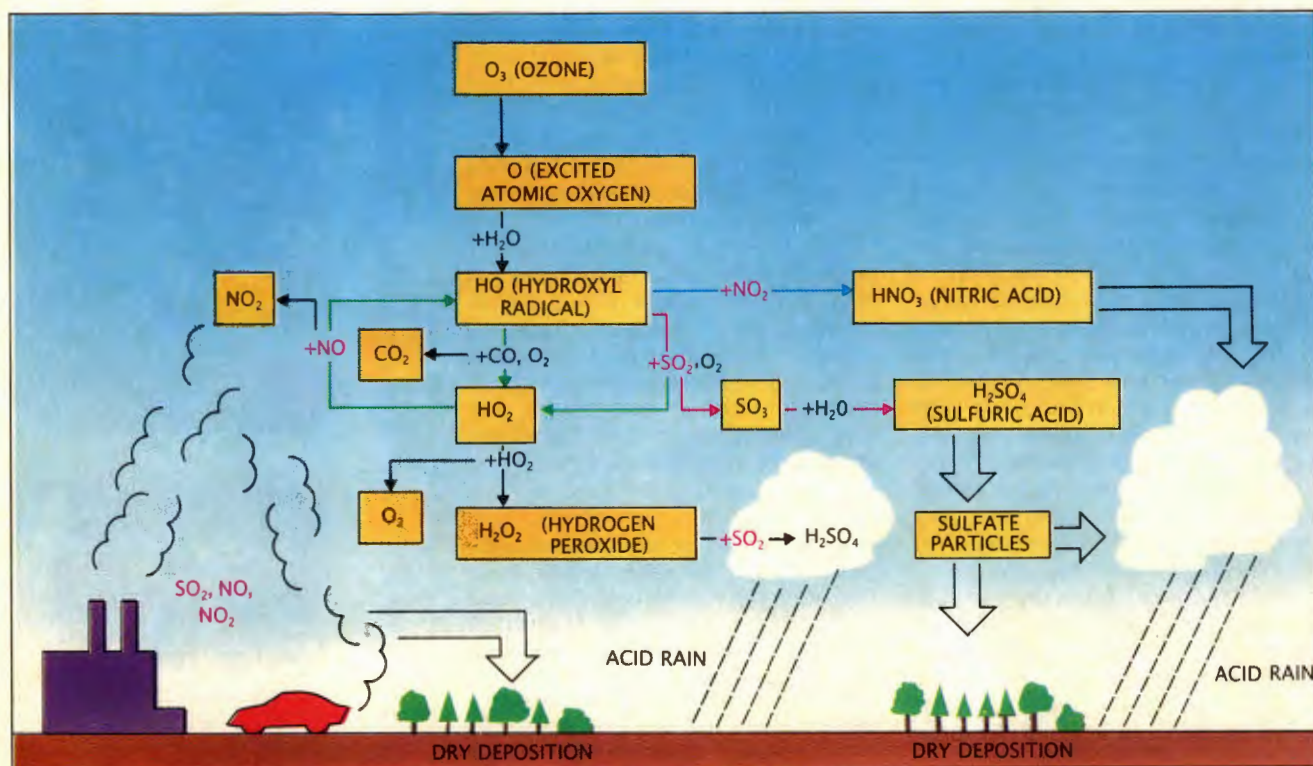
otic, combine to affect the vigor of a forest. The trees' genetic endowment or age can be a source of stress: a stand may be genetically weak or senescent. Other stresses may take such forms as diseases, insects, parasitic fungi and seed plants, a shortage of light, water or essential nutrients and sporadic injury from events such as floods, high winds and ice storms. Stresses easily withstood in isolation can combine with debilitating or fatal effects. A fatal sequence of stresses may begin with a "predisposing" stress, such as a shortage of nutrients. The tree may then be seriously weakened by an "inciting" stress, such as a severe winter. It is then defenseless against a final, "contributing" stress—the actual cause of death—such as disease or insect attack.

Acid and other pollutants could add to the high level of abiotic stresses, including thin soil, low temperatures and desiccating winds, present in a high-elevation forest. That is, the pollutants might handicap the trees with one more predisposing stress as they face subsequent stresses. But what is the nature of the added stress?

Investigators, most of them in Europe, have put forward a number of

hypothetical mechanisms, many of which would ultimately lead to nutrient deficiency in the tree. Several mechanisms would be played out in the soil. The aluminum released from soil minerals by acid might compete with calcium for binding sites on fine roots, reducing a tree's supply of calcium and slowing its growth. Alternatively, the soil itself might lose nutrients when vital elements such as calcium, magnesium and potassium are leached away by acid rain. The death of soil microorganisms is another possible source of nutrient stress. Low soil pH and high concentrations of aluminum can reduce populations of the bacteria that break down and release nutrients locked in decaying organic material. In addition, high levels of nitrate from nitric acid deposition can injure the mycorrhizae, symbiotic fungi that live on the roots of conifers and help the trees to ward off disease and extract water and nutrients.

In other scenarios the pollutants would work their effects aboveground. Acid rain or, more likely, acidic cloud droplets intercepted by the needles of a conifer could leach out nutrients—magnesium, calcium and potassium in particular—faster than the tree's roots



ATMOSPHERIC CHEMISTRY generates sulfuric and nitric acids from sulfur dioxide and oxides of nitrogen given off by industry and vehicles. The hydroxyl radical, formed when a molecule of ozone breaks apart and releases an oxygen atom that can react with water, is the major actor. It converts nitrogen dioxide (NO_2) into nitric acid (blue) and initiates the conver-

sion of gaseous sulfur dioxide (SO_2) into sulfuric acid (red). (A different reaction sequence forms sulfuric acid from sulfur dioxide and hydrogen peroxide dissolved in cloud water.) The hydroxyl radical is regenerated by reactions (green) involving nitric oxide (NO), and the acids come to the earth as dry particles and in rain and other forms of precipitation.

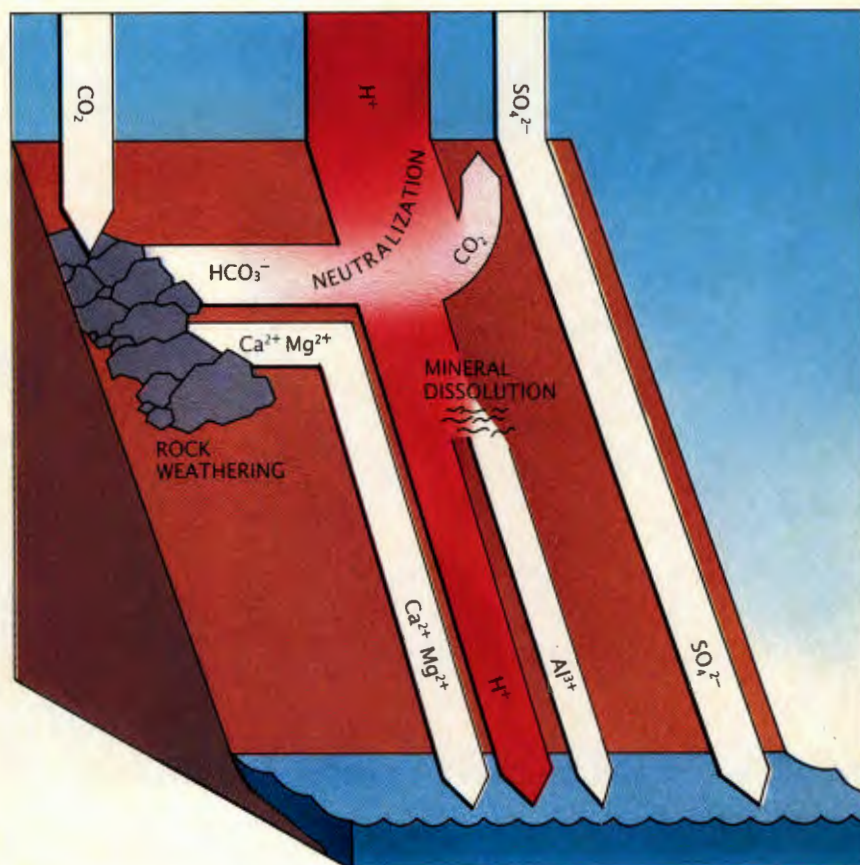
could replace them. An additional pollutant, ozone, might worsen nutrient leaching by degrading the water-resistant waxy coating of the needles. Still another hypothesis holds that ozone alone might lead to nutrient stress because it can damage chlorophyll, thereby impeding photosynthesis.

Finally, acid rain might augment the stress of low winter temperatures. In the fall a conifer ordinarily prepares for the freezing temperatures of winter by withdrawing water from its needles, a process known as cold hardening. The initiating signal for cold hardening ordinarily comes from the roots, in the form of a decreased supply of the nitrogen-bearing nutrients that are produced by soil microorganisms. As acid soaks into the needles, however, the nitrogen compounds it contains might in effect fertilize the tree. They might override the signal from the roots, delaying cold hardening and leaving the tree vulnerable to damage from ice formation in needle tissue. Ozone too might reduce a tree's resistance to freezing by damaging cell membranes in the foliage.

Laboratory tests are now under way to see which of these mechanisms (if any) might operate under the conditions of pollutant exposure in the afflicted forests. But only field studies, in the forests themselves, can show that a given mechanism is actually at work. The task is challenging: one is trying to track down what may be a relatively small increment of stress, superimposed on a complex set of natural stresses. That background of stresses may vary from stand to stand and even from tree to tree.

Whiteface Mountain in the Adirondacks provides a case in point. It displays some of the most dramatic forest decline in the U.S., but because of the dominance of several natural stresses only tentative conclusions about the role of pollutants can be drawn. The direct cause of forest decline, inferred from foresters' records and temperature data, seems to have been severe, repeated damage by desiccation or freezing during the winters in the early 1960's. Ozone may well have made the trees more vulnerable to frost damage: shielding tree limbs from the ambient ozone leads to changes in biochemistry that suggest ozone can indeed weaken the tree by attacking cell membranes in the foliage. The role of acid rain and acidic clouds has not yet been fully investigated, but it is conceivable that they also acted as a predisposing stress in some way.

Even though uncertainties surround



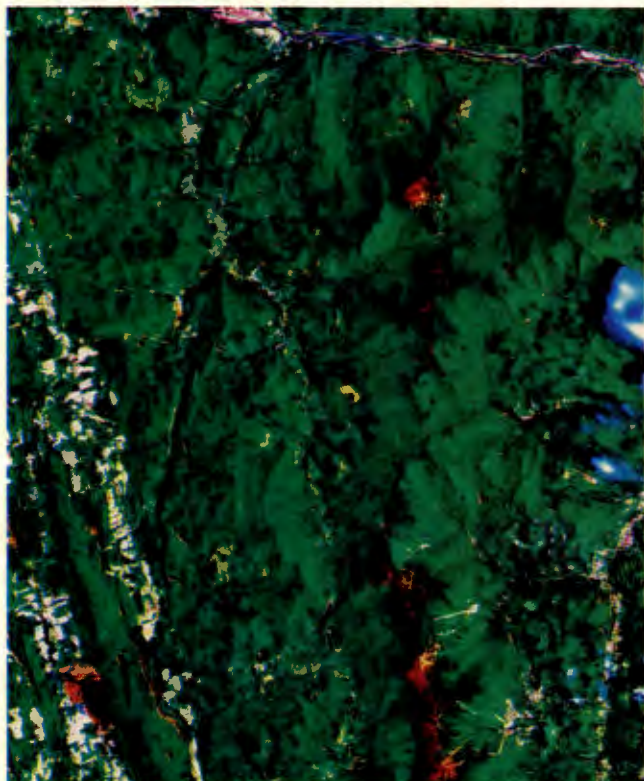
WATERSHED PROCESSES can alter the chemistry of acidic rainwater before it reaches a lake or stream. The illustration shows several processes that can act on sulfuric acid percolating through a hillside. So-called cation exchange can take place if the soil is rich in cations (positive ions) such as calcium and magnesium (Ca^{2+} and Mg^{2+}). Such ions are released from certain rocks by the weathering action of groundwater or precipitation containing dissolved carbon dioxide, a process that also generates bicarbonate ions (HCO_3^-). Some of the acid's hydrogen cations (*red*) then displace calcium and magnesium and are themselves retained in the soil, where bicarbonate ions can neutralize them. These processes reduce the hydrogen-ion concentration—the acidity—of water reaching the lake or stream. The acid can also dissolve clay minerals in the soil and release aluminum, which can harm plants and aquatic life.

acid rain's role in forest decline, its effects in the soil and water alone leave no question about the need to reduce the ambient burden of sulfur and nitrogen compounds and thereby lower the acidity of precipitation. Some progress has already been made. In the Northeast the sulfate content of rain and the concentration of airborne sulfur compounds have decreased in the past 15 years; the decreases reflect the pollution-control measures mandated by the Clean Air Act, enacted in 1975, and additional emission laws passed by individual states. The rate at which lakes in the Northeast are acidifying seems to have slowed as well. To actually reverse the trend, however, acid deposition will have to be reduced much further, and many policymakers and scientists are now asking: How quickly? By how much?

For precise answers to those ques-

tions we need to know how long soil processes can continue to buffer or retain acid in the threatened regions and how fast lakes can renew their acid-neutralizing capacity. We also need to understand the relation between acid rain and forest decline. Some answers should be forthcoming in the 1990 NAPAP report. Certain scientists have already speculated, however, that to protect lakes and streams in sensitive areas such as the Adirondacks it will be necessary to reduce acid deposition to less than 50 percent of its current level.

Where and by how much will emissions have to be reduced to achieve such reductions in deposition? Guidance will come from two massive computer models of acid production, transport and deposition that are now being tested: the Regional



DEAD OR DYING FOREST on high slopes of the Green Mountains in Vermont is apparent as areas of red in a false-color satellite image made at infrared wavelengths that are sensitive to chlorophyll (left). A photograph made on the ground at Whiteface Mountain in New York shows dead spruce (right). Many investigators think acid rain, perhaps in combination

with other pollutants, has caused the rapid decline of some alpine forests in the eastern U.S., although a causal link has not been established. The satellite image is from the Landsat Thematic Mapper and was provided by James E. Vogelmann of the University of New Hampshire; the photograph of the spruce was provided by Ann Carey of the U.S. Forest Service.

Acid Deposition Model (RADM), supported by the U.S. Environmental Protection Agency, and the Acid Deposition and Oxidant Model (ADOM), supported by agencies of the Canadian and West German governments. The models take into account all the atmospheric chemistry and meteorological processes known to act on molecules containing sulfur, nitrogen and carbon. (Carbon-containing molecules are included because of their role in producing the oxidants that convert sulfur and nitrogen emissions into acids.)

Given a set of source locations, emission levels and atmospheric conditions, these models can forecast weather and atmospheric chemistry in order to predict, with a geographic resolution of better than 50 miles square, the amount of acid deposited across an entire region in the course of up to four days. By averaging results calculated for a variety of atmospheric conditions, the models can also predict the long-term pattern of deposition for a given emission pattern, which should make them invaluable for designing a strategy of emission reductions.

How might the cuts be made? The most direct way of controlling the pollutants that cause acid rain would be to burn less fossil fuel for transportation and energy generation. Expanded mass transit and fuel-efficient cars can reduce oil consumption in the transportation sector, but energy generation is less tractable. In spite of worthy strategies for conserving energy, consumption is likely to increase in the long run, and current alternatives to fossil-fueled power plants do not look promising. Hydroelectric power is limited by a scarcity of appropriate sites, and nuclear power is beset by economic problems and a crisis of public confidence in its safety.

The key to controlling acid rain, then, must be the reduction of emissions from fossil-fueled power plants, coal-burning plants in particular. The approach that has already led to reductions in sulfur emissions in the U.S., West Germany and Japan combines the use of coal that is naturally low in sulfur, or has been washed to remove sulfur and other contaminants, with flue-gas desulfurization (FGD). In FGD wet limestone is sprayed

into the plant's hot exhaust gases, where it scavenges as much as 90 percent of the sulfur dioxide. The sulfur-containing waste can be difficult to dispose of, however, and FGD reduces the efficiency of a power plant, causing it to consume several percent more coal for a given output. Furthermore, the process does nothing to reduce nitrogen oxide emissions.

The new power-plant technologies developed jointly by the Government and industry under the Clean Coal Demonstration Program, enacted in 1984, offer a more comprehensive solution. Three clean-coal technologies are already being demonstrated in full-size plants [see "Coal-fired Power Plants for the Future," by Richard E. Balzhiser and Kurt E. Yeager; *SCIENTIFIC AMERICAN*, September, 1987]. In the system known as atmospheric fluidized-bed combustion, a turbulent bed of pulverized coal and limestone is suspended by an upward blast of air; the combustion region is threaded with boiler tubes, which supply steam to the plant's turbines. The turbulent mixing of the coal and the air allows combustion to take place at a lower and more even temperature than it

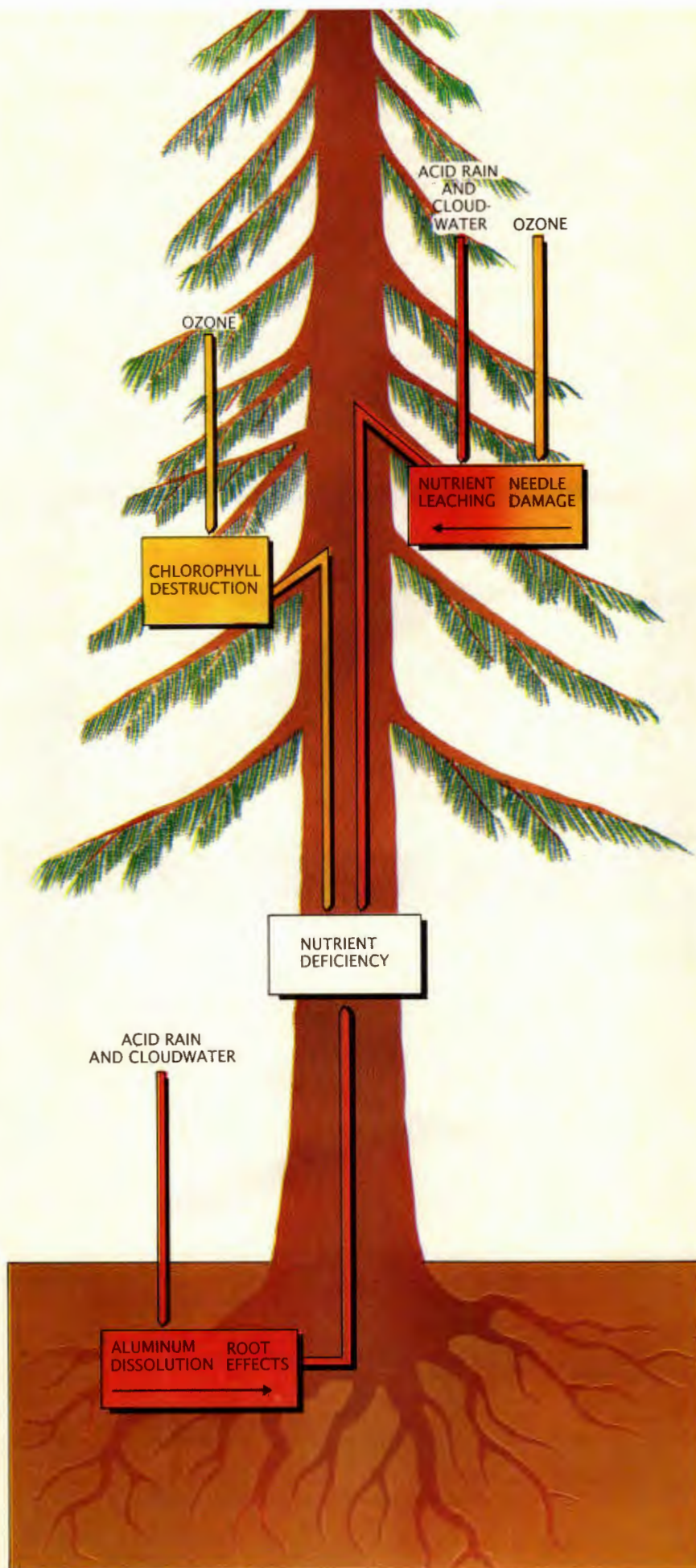
does in a conventional boiler, which reduces the formation of oxides of nitrogen. Meanwhile the limestone efficiently captures the sulfur dioxide. In a related technology known as pressurized fluidized-bed combustion the coal is burned in compressed air, which improves the plant's efficiency as well.

In the third technology, gasification/combined-cycle, coal is reacted with steam and air at high temperatures to produce a gas consisting mainly of hydrogen and carbon monoxide. The gas can then be burned, spinning a turbine; waste heat in the gas turbine's exhaust serves for generating steam, which drives a steam turbine to yield additional electricity. A gasification/combined-cycle plant operates much more efficiently than a conventional plant and gives off considerably less sulfur dioxide and nitrogen oxides.

Retrofitting existing plants with FGD offers the fastest way to reduce power-plant emissions. Almost half of the coal-fired plants in the U.S. were built before 1975 and have no controls for sulfur and nitrogen pollutants. Concentrated in the eastern half of the U.S., they account for most of the country's sulfur emissions. Adding conventional FGD to the plants could cut total emissions of sulfur dioxide from all power plants to less than half their present level, and the reduction could be accomplished within 15 years. Emissions of nitrogen oxides would not be affected, however. In addition, utilities object to the expense of installing and operating FGD equipment and the loss of plant efficiency it would cause.

Clean-coal technologies present an attractive alternative. Any effort to control acid rain must be focused on the aging plants, many of which will soon become candidates for retirement or refurbishment. Gradually re-

ACID RAIN AND OZONE together could lead to nutrient deficiency in a coniferous tree, according to a currently favored scenario for their possible role in forest decline. The ozone might act both by destroying chlorophyll (vital to photosynthesis) and by degrading the waxy coating of the needles. Acid rain or cloud water could then soak into needle tissue more readily and leach out nutrients. In the ground the acid might compound the nutrient deficiency by mobilizing aluminum, which could displace calcium from its binding sites on the tree's fine roots. Stressed by lack of nutrients, the tree would be vulnerable to destruction by insects, disease or some other process.



placing them with new conventional plants equipped with FGD would yield only modest reductions in emissions, and the cost of designing, building and getting regulatory approval for the new plants would be staggering. Instead most of the old plants—the 410 generating stations built between 1955 and 1975—could be “repowered”: refurbished with a new combustion section incorporating one of the clean-coal technologies.

A repowered plant could preserve much of its existing equipment for handling coal and ash and most of its steam-cycle and electricity-generating

hardware. The repowering of an existing plant would thus be quick and cheap compared with building a new one. The approach has an additional attraction for the utility industry: the new hardware could be added to a plant in modules, which would enable utilities to adjust generating capacity to the demand for power.

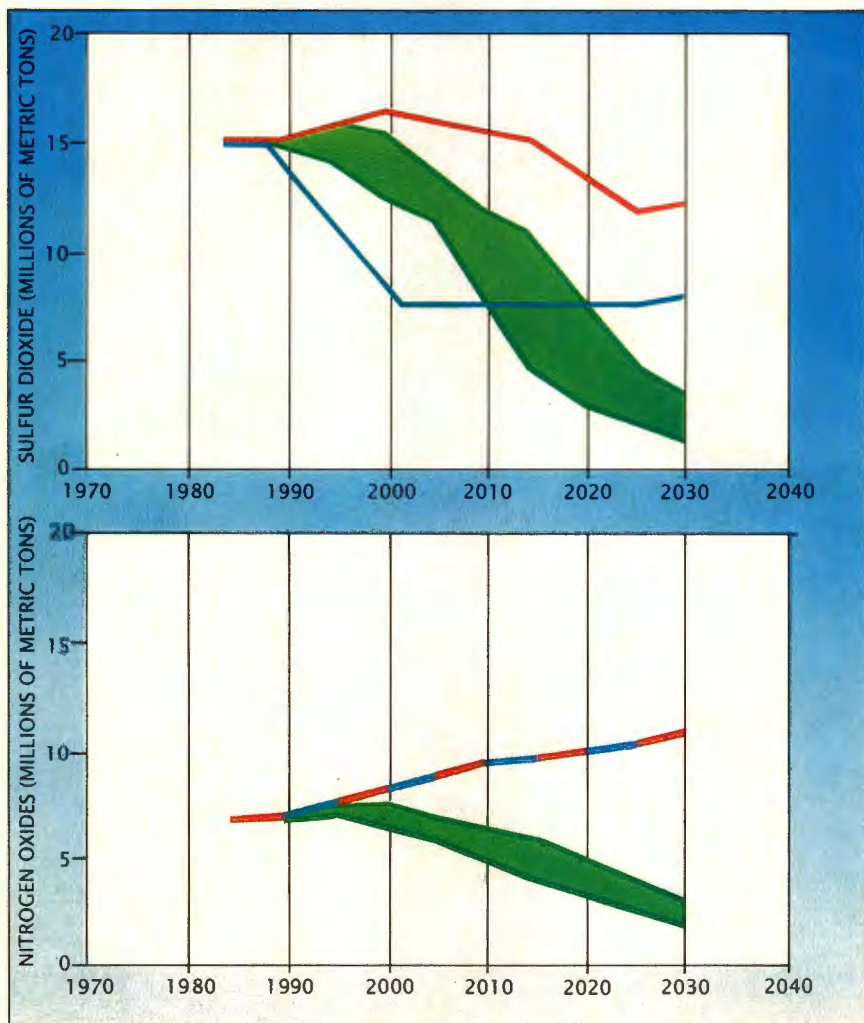
The repowering of aging plants promises ultimately the greatest emission reductions, affecting the full range of pollutants implicated in acid rain. The strategy could cut sulfur dioxide emissions by more than

80 percent and nitrogen oxide emissions by more than 50 percent; the emission of fewer nitrogen compounds would in turn reduce the formation of ozone in the troposphere.

We now know that the term acid rain covers a host of phenomena. Oxides of nitrogen, for example, affect the chemical cycle that converts sulfur dioxide into sulfuric acid, and the ozone they help to produce may work in concert with acid rain to destroy forests. The nitrate ion as well as the acidity that accompanies it may affect the ecosystem, not just on land but also, it now appears, in coastal waters. The emission reductions that are promised by repowering could lessen all these effects.

The drawback is that the reductions, dramatic as they are, would be slow in coming. The recent declines in the sulfate content of air and precipitation in the Northeast and the slowing of lake acidification suggest that some breathing space remains. The nation can probably forgo the short-term solution of retrofitting pollution controls on existing plants in favor of the gradual but more comprehensive and economical approach of repowering. Yet Government intervention, in the form of a timetable, may still be needed to speed the pace. If utilities simply repower plants as the need arises—as the plants reach an age of 50 years or so—the process would not be completed until well into the next century.

Technology has leapfrogged science and presented us with an option for addressing the problem of acid rain that is likely to be attractive whatever the resolution of the remaining scientific uncertainties. The urgent need to reduce human interference in the complex chemistry of the biosphere is already painfully clear.



EXPECTED REDUCTIONS in annual emissions of sulfur dioxide (*top*) and oxides of nitrogen (*bottom*) from power plants vary depending on the choice of technology. Replacing plants as they reached 50 years of age with new ones incorporating flue-gas desulfurization (FGD) would reduce only sulfur dioxide, and the reductions would come slowly (*red*). Retrofitting all existing power plants with FGD on a 15-year schedule would yield much sharper reductions, again in sulfur dioxide alone (*blue*). In both cases nitrogen oxide emissions would continue to climb as additional plants were built to satisfy growing demand for power. Refurbishing plants built between 1955 and 1975 with “clean coal” technologies such as fluidized-bed combustion (a strategy known as repowering) would eventually lead to the largest cuts in both kinds of pollutants. The green bands illustrate the range of reductions expected if the plants were refurbished when they reached an age of between 40 and 50 years.

FURTHER READING

ACID RAIN. Gene E. Likens, Richard F. Wright, James F. Galloway and Thomas J. Butler in *Scientific American*, Vol. 241, No. 4, pages 43–51; October, 1979.

SPECIAL ISSUE ON THE EXPERIMENTAL LAKES AREA. In *Canadian Journal of Fisheries and Aquatic Science/Journal canadien des sciences halieutiques et aquatiques*, Vol. 21, No. 37, pages 313–558; March, 1980.

ACID PRECIPITATION IN HISTORICAL PERSPECTIVE. Ellis B. Cowling in *Environmental Science and Technology*, Vol. 16, No. 2, pages 110a–123a; February, 1982.

AIRBORNE CHEMICALS AND FOREST HEALTH. James N. Woodman and Ellis B. Cowling in *Environmental Science and Technology*, Vol. 21, No. 2, pages 120–126; February, 1987.

THE WHITE HOUSE

WASHINGTON

April 25, 1988

DSA ✓

Amk _____

Send copies to
Larry + Chuck ~~SEA~~

MEMORANDUM FOR SENATOR BAKER
KEN DUBERSTEIN
MARLIN FITZWATER
TOM GRISCOM
ALAN KRANOWITZ ✓
COLIN POWELL

FROM: NANCY RISQUE *Nancy*
SUBJECT: EPA National Stream Survey -- HEADS UP

The Environmental Protection Agency has circulated a study on the acidification of streams for peer review by outside scientists. One of those scientists appears to have leaked the study to the Natural Resources Defense Council (NRDC.) EPA believes NRDC is planning a Tuesday press conference to talk about the report and Sen. Leahy also may be planning to make a statement.

The NRDC will try to use the report to argue that there is now concrete scientific evidence that emissions from U.S. industries are responsible for increased acid levels in rivers and streams in Canada and the northeastern United States. They say that 7.4% of upstream reaches of waterways in the middle Atlantic states are acidic and that this requires immediate action against acid rain.

EPA stresses two points in regard to the report:

- o The peer review process isn't complete. It is inappropriate to comment on something that hasn't received that review.
- o The report only discusses the condition of streams. This data cannot be used to establish a causal relationship between acid rain and how acid a stream is. Also, the data says nothing about trends or expected rates of change.

4/25/88

EPA NATIONAL STREAM SURVEY REPORT

Let to 4/25/88

Q. What is the National Stream Survey? Why hasn't it been released to the public?

A. The report completes the first phase of the National Surface Water Survey, a major project under the National Acid Precipitation Assessment Program. The document is being subjected to thorough scientific peer review, as well as technical review by affected states. It is on schedule to be released to the public in early June.

Q. What is the policy significance of the EPA National Stream Survey report that shows, e.g., 7.4% of the upstream reaches in the Middle Atlantic region are acidic? Does this report alter the Administration's view on the need for action to control acid rain?

A. The results of the National Stream Survey must be placed in context. As part of the acid rain research program being conducted by the federal government under the management of the National Acid Precipitation Assessment Program (NAPAP), EPA has been engaged in a National Surface Water Survey (NSWS). The first phase of this study was designed to determine the present chemical status of surface waters in regions of the United States containing the majority of streams and lakes considered to be at risk as a result of acid deposition. The Agency has already completed earlier studies in this phase of the NSWS: The Eastern and Western Lake Surveys. These surveys, along with the National Stream Survey, contribute to one of NAPAP's principal objectives: The quantification of the extent, location, and characteristics of sensitive and acidic streams and lakes in the United States.

From the time of the Report of the Joint Envoys in 1986, this Administration has recognized that acid rain is a serious environmental problem in this country. Since then, additional findings have shown some limited regional effects. The Eastern Lakes Survey established that various percentages of the lakes in the East were acidic depending on the subregion (e.g., 5% of the lakes in the Southern New England, the Catskills and Poconos regions were determined to be acidic, with 11% of the lakes in the Adirondacks acidic, i.e., $ANC < 0$). This latest survey found similar percentages of stream segments in the Middle Atlantic region.

Q. Why shouldn't the United States take action now?

A. This Administration has pursued a consistent policy toward acid rain. That policy consists of four components.

First, we continue to aggressively implement the Clean Air Act. This effort has led to measurable improvement in air quality. During the past 10 years, ambient levels of sulfur dioxide in the United States have declined by 37%.

Second, we have undertaken a clean coal technology program to demonstrate improved technology for coal combustion. The federal government will spend \$2.5 billion on this effort during the next five years.

Third, we are continuing major research into acid rain, in order to reduce the uncertainties over its causes and its effects, under a 10-year program mandated by Congress in 1980. This year, we will spend about \$85 million on acid rain research.

Fourth, as we move forward with our research, technology, and regulatory programs, we are committed to on-going policy analysis to determine if additional control measures are necessary.

DRAFT

Highlights from the National Stream Survey (NSS-I) Report

- The report provides quantitative regional and subregional estimates of the extent and characteristics of acidic and low ANC streams in areas of the Mid-Atlantic (MA) and Southeast (SE) United States. (See attached maps)
- Spring samples were drawn from about 500 stream reaches at upstream and downstream sampling points.
- 51% of the reaches in both the MA and the SE are estimated to have an Acid Neutralizing Capacity (ANC) less than 200 ueq/L. Many published works cite this as an ANC level below which waters are sensitive to acidification.
- In the MA, 7.4% of the reaches were acidic at their up-stream ends. In the MA, 3% of the reaches were acidic (ANC < 0 ueq/L) at their down-stream ends. These figures do not include the estimated 1300 reaches in Pennsylvania and West Virginia that were acidic due to acid mine drainage.
- In the SE, excluding Florida, less than 1% of the reaches were acidic at either the upstream or downstream ends. This does not include an estimated 120 reaches that were acidic due to acid mine drainage.
- In Florida a more restricted statistical design was used. Consequently, data for Florida are not strictly comparable with those for MA and SE. However, Florida stands out as a geographic area with a relatively high percentage of acidic, low ANC and low pH streams.
- A subpopulation of acidic streams was examined. After elimination of streams whose acidity could be due to sources other than acid deposition one is left with a "high interest" group of acidic streams for which acid deposition cannot be excluded as the source of the acidity. This high interest group has an estimated total length of 4250 km and comprises 4% of the total length of all reaches surveyed. These high-interest reaches are concentrated in forested upland drainages and coastal areas of the MA region that experience high levels of acid deposition.
- Stream water sulfate was significantly higher in the MA than in the SE.
- A plot of median stream sulfate vs. rates of sulfate deposition shows a strong positive linear relationship.

THE WHITE HOUSE
WASHINGTON

*acid
rain
file*

MEMORANDUM FOR THE DOMESTIC POLICY COUNCIL
THE SECRETARY OF STATE

SUBJECT: U.S. Acid Rain Policy

Pursuant to Domestic Policy Council meetings on this subject, the President has decided upon the following policy steps:

- o Continue present programs, including implementation of the Special Envoys' recommendations and the Innovative Control Technologies Program.
- o Implement the following recommendations of the President's Task Force on Regulatory Relief:
 - The Department of Energy, recognizing the risk inherent in demonstration of innovative technologies, should provide preferential treatment to ICTP projects.
 - The Federal Energy Regulatory Commission should implement a five year demonstration program allowing rate incentives for innovative technologies.
 - The Environmental Protection Agency should (1) encourage states to consider achieving greater ozone reduction through inter-pollutant trading and other measures that substitute less expensive nitrogen oxides emissions reductions for more expensive volatile organic compounds emissions reductions, (2) encourage the use of "bubbles" between recently built emissions sources, (3) expand commercial demonstration permits for innovative control technologies, and (4) encourage complementary use of emissions "bubbles" and waivers for innovative technology applications.
- o Specify that the U.S. is prepared to negotiate with Canada an accord designed to address air quality in our respective countries, as outlined in Option B (Expanded).
- o Deputy Secretary of State John Whitehead and EPA Administrator Lee Thomas should direct the efforts of the U.S. section of the Bilateral Advisory and Consultative Group on this project.


Edwin Meese III
Chairman Pro Tempore

read 10/31/11
clean air

THE WHITE HOUSE

Office of the Press Secretary

For Immediate Release

March 18, 1987

STATEMENT BY THE PRESIDENT

I am pleased to announce today several steps being taken to ensure that the United States continues to work closely with the Canadian government in determining and addressing the environmental effects of acid rain. These actions resulted from a review of this issue I directed my Domestic Policy Council to undertake and are consistent with the recommendations made by the Joint Envoys on Acid Rain, Drew Lewis of the United States and William Davis of Canada. Prime Minister Mulroney and I endorsed their recommendations in March 1986.

This past year, government-to-government coordination and research cooperation with Canada on acid rain problems have been substantially strengthened, as recommended by the Envoys. The Administration also has implemented the initial phase of the Department of Energy Clean Coal Technology Program, and has completed an inventory of federal, state and private clean coal research and demonstration projects, which are expected to expend more than \$6 billion by 1992.

To maintain the progress we are making, I am directing three major steps to continue to carry out the Envoys' proposals.

- o The first will be to seek the full amount of the government's share of funding recommended by the Joint Envoys -- \$2.5 billion -- for demonstration of innovative control technology over a five year period. Five hundred million dollars will be requested for fiscal years 1988 and 1989 to fund innovative emissions control projects. I will also encourage industry to invest an equal or greater amount over this period, and to stimulate development and deployment of innovative technologies for reduction of air pollution emissions. This builds on activities already underway in the Department of Energy Clean Coal Technology Program.
- o The second step I am taking is to direct the Secretary of Energy to establish an advisory panel. This panel, which will include participation by State governments and by the government of Canada, will advise the Secretary of Energy on funding and selection of innovative control technologies projects. Projects will be selected, as fully as practicable, using the criteria recommended by the Joint Envoys.
- o Third, I am asking the Vice President to have the Presidential Task Force on Regulatory Relief, which he chairs, review federal and state economic and regulatory programs to identify opportunities for addressing environmental concerns under existing laws. The Task Force will examine incentives and disincentives to the deployment of new emissions control technologies and other cost-effective, innovative emission reduction measures now inhibited by various federal, state and local regulations. The findings and results of the Task Force review will be reported in six months, along with any recommendations for changes to existing regulations.

I have advised Prime Minister Mulroney of these decisions. Next month, I will travel to Canada to discuss these and other issues with the Prime Minister. I feel these steps will help both countries to better understand and address this shared environmental problem, so that future specific actions that are taken will be cost-effective, and represent appropriate taxpayer expenditures.

#

file
ACID RAIN LIAISON

Agenda - February 26, 1987

Liaison Discussion

Background - purpose

Participants - how operate

CAWG activities - USA TODAY letter 2/11/87

US-Canadian April '87 Summit

Maintain current position - Special Envoy's Report

No additional US concessions -- at this time

What needs to be done?

NAPAP Interim Report

When issued - June '87?

Briefing by Larry Culp - US Chamber Hall of Flags?

How promote?

92 Group Briefing

CAWG will brief -- don't cosponsor - 1/7/87 letter

How handle Republicans in House (Lent, Tauke*,
Bilirakis, Rinaldo*)

Congressional Leadership

Byrd, Dole, Burdick, Stafford

Wright, Michel, Dingell, Lent

What can/needs to be done?

Legislation/Hearings

Health effects

Ozone

Acid Rain

Legislative strategies

ACID RAIN LIAISON

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USX Corporation
and Chairman,
Clean Air Working Group
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OPINION

The Debate: OUR CLEAN AIR

Today's debate includes our opinion that we've studied the problem of acid rain long enough and we must do something about it, an opposing view from Delaware, other views from Illinois, Maryland, and the District of Columbia, and voices from across the USA.

Act now to prevent an acid rain crisis

The evidence has been piling up for years. Lakes are being destroyed in New York, trees in the Great Smoky Mountains, and buildings in Southern California. Even the once-pristine lakes of the Rockies and the Pacific Northwest are threatened.

The culprit is polluted air — "acid rain."

Most of us don't know about it, don't want to talk about it, and don't want to hear or read about it. We're disinterested. We're wrong.

The government is disinterested, too. In spite of all the studies and all the evidence, little has been done. For years, Congress has wrangled over how to pay for expensive preventive measures. And the Reagan administration has urged still more study. The time has come for action.

While we dally, the problem worsens.

New evidence submitted at a congressional hearing last week shows that acid rain not only harms our lakes and forests and buildings — it harms our people.

Health experts testified that acid air pollution causes respiratory problems and aggravates existing conditions in healthy adults. It particularly affects the most vulnerable in our society — children, the elderly, pregnant women, asthmatics, and persons suffering from heart disease.

It also is increasing the acidity of our water. Acidic water delivered to home faucets can leach lead or copper out of water pipes and into the water glass.

If this continues, the cumulative effect can result in lead poisoning. The effects of that on children are well known — it can cause brain damage and even death. That's why we've concentrated on eliminating lead-based paint.

Researchers also suspect that acidic water, with higher levels of aluminum, may be linked to Alzheimer's disease.

Other researchers know that there is a danger of mercury poisoning from eating fish taken from acidic lakes.

We've studied enough. We know the sources of the pollutants that cause acid rain and acid fog — belching smokestacks from industrial plants, coal-fired utilities, and copper smelters, and emissions from the cars and trucks that clog so many of our highways.

These pollutants know no state or international boundaries. Industrialized areas spew their airborne garbage for hundreds of miles.

It's time to stop talking about this problem and act.

We must all share the cost of reducing this pollution. We must work with Canada and Mexico so acid rain is not exported or imported. We must persuade Mexico to put controls on two big smelters being constructed near the Arizona border. If not, western states will be gasping for breath.

Congress must pass comprehensive legislation that cuts noxious fumes. The administration must stop studying and start warning our citizens of the gravity of the problem, and work out agreements with our neighbors.

If we don't act together now, not only will we risk the health of our lakes, rivers, and forests, but the health of our children, too.



February 11, 1987

Mr. John C. Quinn
Editor
USA TODAY
1000 Wilson Boulevard
Arlington, VA 22209

Dear Mr. Quinn:

The rush to judgment on acid rain in the February 9, 1987, Opinion column ignores the scientific evidence that "has been piling up for years". It appears that USA TODAY did little research into the issue -- its causes, alleged effects, recent trends and confusion with other atmospheric phenomena.

Acid rain is a political issue and a topic of significant national concern. That is why Congress enacted the ten-year comprehensive research program on acid rain in 1980. The results of this effort are now beginning to be published and will continue to flow through 1989. Contrary to the conclusion of Opinion, the 100th Congress will most likely wait for science to guide public policy on acid rain. And they should.

Acid rain is the long-range transport of sulfur dioxide and nitrogen oxides which result in wet and dry acid deposition on resources of concern. It should not be confused with the cause and effects of other atmospheric phenomena such as the global warming or greenhouse effect, stratospheric ozone depletion, tropospheric ozone build-up or smog. Opinion managed to mix the effects of all of these phenomena (except the greenhouse effect) and concluded we have an acid rain crisis.

After years of debate, the case for acid rain controls has not been made. Under current requirements of the Clean Air Act, emission trends for nitrogen oxides are essentially level and there has been a significant reduction of sulfur dioxide emissions, yet the acidity of rainfall has not changed. We simply do not know if future emission reductions will measurably improve rain pH. We do know that trends established by recent research indicate the problem is stable and that we have time to let science guide the debate. There is no crisis.

Evolving scientific results are demonstrating that many allegations of adverse effects from acid rain were exaggerated, unsubstantiated or erroneous. The role of acid rain in the acidification of lakes has been exaggerated based on EPA's recent comprehensive lakes' survey. As one guest columnist noted, western high altitude lakes are sensitive bodies of water and no one would argue they should not be protected. Contrary to Opinion's statement, these lakes are still pristine and recent studies do not document a threat from acid rain. The original concern for forest damage may be erroneous in that other causes, not acid rain, appear to be the culprit. The effect on materials remains unsubstantiated and is thought to be from local sources of pollution -- not acid rain.

Marathon Oil Company,
USS
U.S. Diversified Group
Texas Oil & Gas Corp.

Mr. John C. Quinn

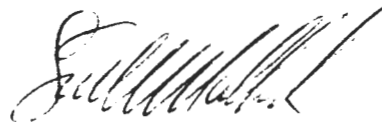
February 11, 1987

USXX

While research continues to document effects of acid rain, public health is not at issue. The National Ambient Air Quality Standards for acid rain precursors, sulfur dioxide and nitrogen oxide, have been set under the Clean Air Act to protect public health and are being met in virtually every part of the country. A careful reading of recent Senate testimony indicates the health effects mentioned do not relate to acid rain but rather to local pollution episodes, or to effects from exposure to sulfur dioxide well above the health-based standard. There is no basis to claim acid rain is a public health issue except for the potential problem of heavy metal release to the environment due to low pH, which is being studied.

The time to stop talking about acid rain is when we understand it, have determined its actual effects and know how to effectively control it to protect resources of concern. Before committing billions of dollars to acid rain controls, we have time to let good science answer these questions and guide public policy.

Sincerely,



Earl W. Mallick
Chairman
Clean Air Working Group

cc: John J. Curley

District of Columbia: No crisis

USA TODAY's rush to judgment on acid rain ignores the scientific evidence that "has been piling up for years." Acid rain is the long-range transport of sulfur dioxide and nitrogen oxides which result in wet and dry acid deposition on resources of concern. It should not be confused with the cause and effects of other atmospheric phenomena such as the global warming or greenhouse effect, stratospheric ozone depletion, tropospheric ozone buildup or smog. Your editorial managed to mix the effects of all of these phenomena (except the greenhouse effect) and concluded we have an acid rain crisis. After years of debate, the case for acid rain controls has not been made. Under current requirements of the Clean Air Act, emission trends for nitrogen oxides are essentially level and there has been significant reduction of sulfur dioxide emissions, yet the acidity of rainfall has not changed. We simply do not know if future emissions reductions will measurably improve rain pH. We do know that trends established by recent research indicate the problem is stable and that we have time to let science guide the debate. There is no crisis.

Earl W. Mallick
Clean Air Working Group
USX Corp.



January 7, 1987

The Honorable
Tom Ridge
U.S. House of Representatives
Washington, D.C. 20515

Dear Tom:

It is good to have you and the 100th Congress back in town. Confirming our phone conversation, several members of the Clean Air Working Group would like to meet with the 92 Group to discuss acid rain legislation in the 100th Congress.

The Clean Air Working Group (CAWG) is composed of over 100 representatives of the business and industrial community in Washington. In addition, most industry associations and key organizations representing business and industry in general are members of CAWG. We are concerned with amendments to the Clean Air Act, especially the enactment of any acid rain control legislation. The purpose of our group is to coordinate the business community's response to Clean Air Act legislative activities. CAWG seeks no amendments to the Clean Air Act in the 100th Congress and is in support of the Administration's current position on acid rain.

The time, place and format of the proposed meeting is completely open. I would expect a minimum of 6 and no more than 15 CAWG members to participate depending upon the number of 92 Group members that would plan to attend. We would like to meet as soon as possible on the Hill, in the Capitol Hill Club, or perhaps in one of the House office buildings. We could meet over breakfast, lunch or dinner or at any time during the day. I believe the format should be informal -- a discussion lasting perhaps one hour of our views and hopefully the 92 Group's perspective on acid rain. We, of course, would expect to cover any expenses that might be incurred as a result of the meeting.

I believe an exchange of views on acid rain is important even though we may not be in agreement. Hopefully, all participants will benefit -- at least know first hand why certain positions have been taken. Thanks for considering such a meeting and agreeing to discuss it with the 92 Group membership.

Sincerely,

A handwritten signature in black ink, appearing to be "Jim", written over a horizontal line.

92 GROUP MEMBERS

Doug Bereuter
2446 RHOB
5-4806

Sherwood Boehlert
1641 LHOB
5-3665

Rod Chandler
216 CHOB
5-7761

Bill Clinger
1122 LHOB
5-5121

Bob Davis
1124 LHOB
5-4735

Cooper Evans
127 CHOB
5-3301

Harris Fawell
511 CHOB
5-3515

Hamilton Fish
2227 RHOB
5-5441

Ben Gilman
2160 RHOB
5-3776

Bill Goodling
2263 RHOB
5-5836

Bill Green
1110 LHOB
5-2436

Steve Gunderson
227 CHOB
5-5506

Paul Henry
502 CHOB
5-3831

1/15/86

Jim Jeffords
2431 RHOB
5-4115

Nancy Johnson
119 CHOB
5-4476

Jim Leach
1514 LHOB
5-6576

Lynn Martin
1208 LHOB
5-5676

John McKernan
1208 LHOB
5-6116

Stewart McKinney
237 CHOB
5-5541

Jan Meyers
1407 LHOB
5-2865

John Miller
1723 LHOB
5-6311

Cid Morrison
1434 LHOB
5-5816

Tom Petri
1024 LHOB
5-2476

Carl Pursell
1414 LHOB
5-4401

Tom Ridge
1714 LHOB
5-5406

Matt Rinaldo
2338 RHOB
5-5361

Marge Roukema
303 CHOB
5-4465

John Rowland
512 CHOB
5-3822

Claudine Schneider
1512 LHOB
5-2735

Chris Smith
422 CHOB
5-3765

Olympia Snowe
133 CHOB
5-6306

Tom Tauke
2244 RHOB
5-2911

~~REDACTED~~



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

Wendi
Do we have an
acid rain file?

OFFICE OF
EXTERNAL AFFAIRS

March 6, 1987

Ben
3/9

MEMORANDUM

SUBJECT: Legislative Report for the Week of March 2-6, 1987

FROM: Jennifer Joy Wilson
Assistant Administrator
for External Affairs

TO: William L. Ball, III
Assistant to the President for Legislative Affairs

CONGRESSIONAL INITIATIVES

1. Issue. Clean Air Act

Acid Rain/Clean Coal Technology

On Wednesday, March 4, 1987, Senate Environment and Public Works Committee, Subcommittee on Environmental Protection, Mitchell (D-ME) Chairman, held a hearing on emerging and available technologies for the control of acid rain precursors. The purpose of the hearing was to review the status of advanced technology for acid rain control and its applicability to new or retrofitted plants. The witnesses, including Senator Byrd, felt that the technologies are close to commercialization and that any control ought to be focused on applying it to new sources rather than retrofitting. Some Committee Members and witnesses, specifically the Tennessee Valley Authority, questioned whether there will be substantial replacement of existing sources in the next 10 or 15 years, focusing on the need for retrofit on plants if acid rain is to be controlled.

2. Issue. Asbestos in Schools

On Tuesday, March 3, the Senate adopted H.J. Res. 153. The resolution requires funds be available for EPA issuance of grants and loans to ensure that local educational agencies can complete asbestos abatement work in schools during 1987 summer school recess. The legislation has been transmitted to the President.

SEPTEMBER 1987

*when
the fall*

ACID RAIN LEGISLATION AND THE ECONOMY

EXECUTIVE SUMMARY

A National Association of Manufacturers policy study
using the Data Resources (DRI) Model of the Economy

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This study was prepared under the direction of NAM by Data Resources Inc. The conclusions stated in this study reflect only the results of the econometric analysis presented here and do not necessarily represent the policy positions of the National Association of Manufacturers.

Additional copies of the summary can be purchased at a minimum charge. Bulk rate discounts are available. Copies of the full study, **Acid Rain Legislation and the Economy**, are \$100 for NAM members and \$200 for nonmembers. To order, write to NAM Publications Coordinator, 1331 Pennsylvania Avenue, NW, Suite 1500 North Lobby, Washington, DC 20004-1703.

SEPTEMBER 1987

ACID RAIN LEGISLATION AND THE ECONOMY

EXECUTIVE SUMMARY

A National Association of Manufacturers policy study
using the Data Resources (DRI) Model of the Economy

Acknowledgements

Executive summary and report prepared by Gordon Richards, Assistant Vice President of Taxation & Fiscal Policy, and Jana Oakley, Director of Energy & Natural Resources, with Jerry J. Jasinowski, Executive Vice President & Chief Economist, and Richard Seibert, Vice President of Resources & Technology (NAM).

Econometric Simulations: Joyce Yanchar, Donald Walls (DRI);
Model Inputs: Joyce Yanchar, Mary Smolenski (Macro Model),
Donald Walls, Alan Clayton-Matthews (Regional) (DRI).

A special acknowledgement is made to the Review Committee comprised of a select group of NAM members who contributed their expertise and time to the editing of this document.



National Association
of Manufacturers

ALEXANDER B. TROWBRIDGE
President

September 1987

Dear Reader:

Over the years, the acid rain issue has created a diverse constituency that has turned a meteorological event into a storm of political debates centered over Capitol Hill. But despite the marked lack of consensus as to the causes or consequences of acidic deposition, expensive legislative solutions have nevertheless been proposed in Congress, even in the absence of conclusive scientific evidence that would justify such measures.

By commissioning the Data Resources, Inc. economic study based on House and Senate versions of acid rain legislation, we have attempted to shed some light on the flip-side of the debate—what happens *economically* to industrial America should these measures be enacted.

However loosely one uses the word “control”, the legislative initiatives analyzed would not necessarily control acid rain, but would instead mandate new controls on emissions of compounds thought to be its precursors—sulfur dioxide (SO₂) and nitrogen oxides (NO_x). SO₂ and NO_x are by-products of the fossil fuel combustion process and have been identified as the compounds that allegedly cause acid rain.

Our study predicts there would be severe domestic economic disruptions should such proposed emission controls be enacted by Congress. The study systematically examines the impacts of this legislation on the economy as a whole, and what emerges is a startling economic picture. The effects include serious long-term losses in domestic output and employment, heavy cost burdens on manufacturing industries and a resultant gradual contraction of the entire industrial base. The irony of this bleak scenario is that these economic hardships are borne with no real assurance they would be balanced by a cleaner, healthier environment.

At a policy level, NAM opposes such measures from both an economic and environmental perspective. Such a “no win situation” cannot be the basis of a rational solution to the acid rain issue. Congress needs to start over, not by proposing more or different solutions, but by asking more and better questions. This will lead to an informed consensus that will correctly identify the sources of the problem and, within proper time frames, offer solutions that will improve the environment and deal fairly with the economy. We believe this study answers some questions, raises some new ones, breaks new conceptual ground, and will be of value in resolving the acid rain debate.

Sincerely,

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Acid Rain Legislation and the Economy: Executive Summary

Introduction

The following is an abstract of a study of acid rain legislation using the Data Resources Inc. (DRI) model of the U.S. economy. This abstract should be regarded as a summary only and should not be substituted in content for the full study. The complete study contains more detailed output tables from the simulations, and an extensive description of the model inputs, along with the rationale for their selection. For information on obtaining the full study, see the acknowledgements page. The econometric simulations were prepared by Data Resources under the direction of the NAM.

Acid rain legislation as presently conceived involves the mandating of controls over emissions of sulfur dioxide (SO_2) produced from fossil fuel electric generation by utilities and private industry, as well as nitrogen oxides (NO_x) produced by utilities, private industry and automobile engines. This study examines the macroeconomic costs of implementing acid rain control. The estimated costs of implementing acid rain legislation from the 99th Congress, as projected in a series of government studies, are used as inputs to the Data Resources Inc. model of the American economy.

The two acid rain bills from the 99th Congress that are analyzed here were sponsored by Representative Henry Waxman (D-CA-24) and Senator Robert Stafford (R-VT) (H.R. 4567 and S. 2203, respectively). These bills were used as the basis for the econometric simulations because both bills have been extensively analyzed by government researchers. The present analyses proceed from an 11-year simulation of the American economy using the DRI model, with the results of the government studies of H.R. 4567 and S. 2203 used as inputs. Each bill is simulated in its entirety. In addition, a partial implementation of the Waxman and Stafford bills incorporating the SO_2 controls alone is used as the basis for additional simulations with the DRI Regional model, in order to ascertain the effects on particular parts of the country. These bills define the lower and upper ranges of the economic costs associated with acid rain legislation. The simulations therefore delineate the lower and upper limits of the total costs to the economy. As discussed here, the regional simulations are limited to the effects of the SO_2 controls and therefore understate the aggregate economic costs. The principal features of the two bills are outlined below.

Waxman

Utilities would be required to meet a 10-million ton SO_2 reduction target in two stages. Starting in January 1993, the state average SO_2 emission limit for fossil fuel-fired electric utility boilers will be 2 pounds per million Btus (British thermal units). In 1997, the limit falls to 1.2 pounds per million Btus for both utility and industrial boilers. Utility and industrial fossil plants would also be required to meet a statewide NO_x emission limit of 0.6 pounds per million Btus by January

1997. Additionally, new plants would face more stringent requirements.

In some instances, the costs to consumers would be paid for in part by a subsidy financed by an electricity tax of $\frac{1}{2}$ mill per kilowatt hour. Utilities whose residential customers would otherwise face electric rate increases of more than 10 percent would in principle receive a subsidy in order to keep rate increases below this margin. However, a number of conditions would have to be satisfied before the subsidy would cushion the impact of the Waxman bill on residential customers.

Motor vehicles would be subject to changes in emission standards designed to reduce NO_x emissions.

Stafford

The Stafford bill is considerably more stringent than the Waxman bill, for several reasons. First, the requirements of the Stafford bill would not be phased in over time. Average SO_2 emissions from each industrial or utility fossil plant would be limited to 0.7 pounds per million Btus by 1991, although phase-out operations would be allowed for a short period at plants that were unable to meet this requirement.

Second, the Stafford bill would mandate that each plant meet the targets, rather than allowing compliance on a statewide average basis. The SO_2 emission reductions would be in the area of 14 million tons vis-à-vis 1980 levels.

Third, the corresponding NO_x emission standards would mandate the use of the best available emission control technology in use in the advanced industrial countries. The resulting reductions in NO_x emissions would be in the area of 6.8 million tons per year.

Overall Results

On a cumulative basis, acid rain legislation would cause serious and lasting damage to the economy. The causes of this damage have to do primarily with the effects of higher energy costs.

First, since energy is an important input to production and a major component of production costs, there are severe output losses and employment reductions in energy-intensive sectors. The most adverse impact is in durable manufacturing and metals industries.

Second, because energy prices feed through into final product prices, there are increases both in retail energy costs and in the overall inflation rate.

Third, because of higher inflation, interest rates increase. The rise in interest rates causes a major decline in housing starts. The result is a serious reduction in output and an increase in unemployment in housing-related industries such as construction materials. Thus, in the final analysis, a substantial share of the population will experience losses in employment opportunities, higher housing costs as reflected in higher

mortgage interest rates and higher utility bills.

With respect to the econometric simulations, the effects of this legislation are revealed to be asymmetric over time. In the near term (1990-1994), additional capital spending provides some transitory stimulus to the economy. By 1995, however, the temporary effects of higher investment spending are negated by higher energy costs, diminished profitability, higher inflation and higher interest rates. Thereafter, the economy diverges below its baseline trajectory. The output costs increase substantially in 1995-1996, and more gradually in subsequent years. Nevertheless, the general pattern to emerge in the final years of the simulation is for the output losses to cumulate.

The significance of this tendency for increasing divergence below the baseline is considerable. Normally, in econometric models, after the economy has gone through a cycle, it eventually converges back to the baseline. Here the divergence is permanent. The growth path diverges by progressively greater degrees below the current-law trajectory, implying permanent losses in production and jobs.

The effects on inflation are more immediate, if less lasting. By the second year of the simulation, wholesale prices diverge above their baseline. The peak differential in the price path is recorded in 1995. Thereafter, slower growth begins to depress inflation, and by the year 2000 prices are beginning to converge back toward their current-law trajectory. They do not, however, converge fully, with the result that the price level is permanently higher under the acid rain legislation.

It is primarily because of the higher rate of inflation that interest rates rise relative to trend. In turn, it is the rise in interest rates that causes the damage from acid rain legislation to spread throughout the economy into housing and other sectors, rather than be limited to energy-intensive industries.

Among the cyclical indicators, housing diverges below its baseline trajectory much more rapidly than other sectors. The major causes involve the rise in interest rates and the sensitivity of demand for housing to operation and maintenance costs, including energy prices, all of which affect the affordability of single-family homes. It should be noted here that since the baseline for housing is based on current (i.e., post tax reform) law, it is by no means robust. The performance of housing will be weakened in the 1990s by the reduction in the implicit tax subsidy for mortgage interest associated with lower personal tax rates. Consequently, the effects of acid rain control legislation on the housing sector will be to aggravate the weakness engendered by tax reform.

On a sector-by-sector basis, however, the most serious output and employment losses occur not in housing but in primary and fabricated metals industries. These sectors have one major element in common with housing: they have already been depressed by other factors. During the 1980s, metals industries have been subjected to losses in market share due to increased competition from imports and have experienced losses in profitability due to weak demand and depressed output prices. In this sense, acid rain control legislation is likely to exacerbate an already catastrophic situation in the metals industries.

The Full Waxman Bill

The effects of the Waxman bill are illustrated in Table 1.

Inflation. Wholesale prices for fuels, related products and

power diverge above their baseline path after two years, with a peak differential of 1.53 percent above the baseline in 1995. Consumer prices rise a total of 0.5 percent relative to the baseline by 1997. The increases in consumer energy and consumer electricity prices are 1.3 percent and 3.6 percent relative to the baseline.

Growth and Employment. Real GNP falls below the baseline starting in 1995. The output losses cumulate over time, with GNP some \$19 billion below the baseline by 2000. On a cumulative basis, real GNP is lowered by some \$99.3 billion (in constant 1982 dollars) relative to current law. Aggregate employment falls sharply: by the year 2000, some 213,000 jobs have been lost.

Investment. The effective cost of capital is raised 1.1 percent for equipment, 1.3 percent for utility structures, and 1.1 percent for other structures. Residential investment falls 1.0 percent by 1996, while aggregate business fixed investment falls by the same magnitude by the year 2000.

Interest Rates and Housing. The interest rate on three-month Treasury bills increases by up to 25 basis points in 1993. As interest rates rise, housing starts fall some 26,000 by 1995.

Industrial Production. Aggregate industrial production falls in 1995, decreasing 0.8 percent by the end of the simulation. Manufacturing production exhibits almost identical behavior. The sharpest declines come in energy-intensive industries. Production of primary metals falls below the baseline 2.2 percent, while fabricated metals falls 1.6 percent, electrical machinery falls 1.2 percent, non-electrical machinery falls 0.9 percent and transportation equipment declines 0.8 percent. Several other sectors, notably lumber, furniture and construction materials, are dragged down not so much by the rise in energy prices as by the ancillary effects on the housing sector. The sharpest declines occur in primary metals and fabricated metals products, with substantial losses also taking place in housing-related sectors. Real after-tax corporate profits fall 2.0 percent by the year 2000.

Trade Competitiveness. The effects on trade are negative. The acid rain controls raise industrial operating costs, which makes domestic goods less competitive relative to foreign substitutes, but some of this is offset by the fact that lower energy activity reduces demand for imports. By the end of the simulation, the trade balance has deteriorated by \$14.3 billion.

The Fiscal Deficit. The federal fiscal deficit increases by \$58.4 billion. Most of the increase in the nominal value of revenues and expenditures reflects inflation. However, real revenues are depressed by the weaker economy, while real expenditures are raised by higher debt service costs and lower employment, which raises outlays for income transfers.

The Full Stafford Bill

The effects of the Stafford bill are as much as three to four times greater than those of the Waxman bill, both in terms of higher inflation and lower production. The simulations of the Stafford bill are given in Table 2.

Inflation. There is a substantial rise in the price level relative to current law. The price index for wholesale fuels increases as much as 5.7 percent during the mid-1990s. The largest increase in wholesale prices are for electric power, which increases to more than 22 percent above the baseline starting in 1995.

Consumer prices increase as much as 2 percent above the baseline by the mid-to-late 1990s, with the most dramatic increases coming in retail electricity costs. Consumer electricity prices surge up to 13.4 percent while consumer energy prices increase 4.9 percent. On a cumulative basis, wholesale prices are 1.2 percent higher while consumer prices are 1.5 percent higher.

Capital Costs and Investment. The effective cost of capital is raised 4.6 percent for equipment, 5.9 percent for public utility structures and 5.2 percent for other structures. These increases take place both because the operation of industrial machinery is energy-intensive and because energy costs represent a major component of the cost of manufacturing machine tools. Further, these capital cost increases come in the wake of a 25 percent increase in the cost of capital caused by tax reform. In this sense, acid rain legislation will exacerbate the damage to the capital sector engendered by the repeal of the investment tax credit, the lengthening of depreciation schedules and changes in accounting provisions regarding capitalization of depreciable assets.

As a result of the increase in the cost of capital, residential investment falls starting in 1993, as much as 4.1 percent. Aggregate nonresidential fixed investment declines as much as 4.3 percent below current law from 1995 onward. On a cumulative basis, the capital stock is lowered 2 percent, while the stock of producer durables is lowered 2.4 percent.

Trade Competitiveness. During the later years of the simulation exports are lowered by higher domestic costs. Imports are also lowered in the long run following an initial surge, but by a lesser magnitude than the decline in exports. The result is that the balance of payments deteriorates drastically, by \$32 billion in the year 2000. On a cumulative basis, the trade balance is worsened by \$83.9 billion.

Growth. Real potential GNP is lowered up to 0.7 percent as a result of diminished energy inputs and diminished investment spending. On a cumulative basis, GNP is lowered by \$222.5 billion (constant 1982 dollars), while on a year-to-year basis, GNP diverges below the baseline by magnitudes of up to 7.6 billion.

Corporate Profits. Real after-tax profits, in constant inflation-adjusted dollars, are sharply reduced, falling more than 9.6 percent below the baseline starting in 1995.

Interest Rates and Housing. The Treasury bill rate is up sharply, as much as 109 basis points. As a result of the interest rate increases, housing starts plunge as early as 1993, with peak losses of 103,000 units.

Employment. The effects on employment are also adverse in the long run. During the early years of the simulation, employment is raised not only by faster economic activity but also by

the increasing labor intensity of production induced by the higher price of energy and capital inputs. However, this is reversed during the later years by diminished economic activity. By the latter part of the simulation, aggregate employment has diverged below the baseline by 862,000 jobs.

Industrial Production. The largest production and employment losses take place in energy-intensive manufacturing industries. Aggregate industrial production falls 3.1 percent below the baseline toward the end of the simulation interval, with manufacturing production 3.1 percent below current law. Production of primary metals falls 8.5 percent below the baseline while fabricated metal products are as much as 6.1 percent lower than current law. The other major losses take place in housing-related sectors, which are dragged down by lower residential investment. However, the direct impact of energy prices is more marked, with energy-intensive industries such as electrical and other machinery and transportation equipment falling 3 to 4 percent relative to the baseline.

Manufacturing Employment. To a significant extent, the same patterns are visible in manufacturing employment. Jobs in primary metal industries fall 8.9 percent below the baseline; the corresponding figure for fabricated metals is 5.3 percent.

The Fiscal Deficit. Because of revenue losses and higher expenditures, the federal fiscal deficit increases \$246.9 billion (in current dollars).

Regional Simulations

Background. In contrast to the analysis for the economy as a whole, the two regional simulations were run on the basis of the partial Waxman and partial Stafford bills (i.e., SO₂ controls alone). The reason for limiting the simulations to the SO₂ controls is lack of data from government agencies. The result, however, is that the regional impact of this legislation is understated by substantial magnitudes: the output and employment losses associated with the full Stafford bill are probably more than twice the results summarized here.

In order to put the following discussion in a more specific perspective, the nine census regions refer to the following states:

New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont.

Mid-Atlantic: New Jersey, New York, Pennsylvania.

South Atlantic: Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia.

East North Central: Illinois, Indiana, Michigan, Ohio, Wisconsin.

East South Central: Alabama, Kentucky, Mississippi, Tennessee.

West North Central: Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota.

West South Central: Arkansas, Louisiana, Oklahoma, Texas.

Pacific Northwest: Alaska, Idaho, Montana, Oregon, Washington, Wyoming.

Pacific Southwest: Arizona, California, Colorado, Hawaii, Nevada, New Mexico, Utah.

Results. The results of the regional simulations of the partial Waxman and partial Stafford bills involve losses of income, production and jobs in most of the country. The greatest damage occurs in states that specialize in capital- and energy-intensive manufacturing industries. As in the sectoral results of the national simulations, the baselines for some regions are significantly worse than others. The depressed oil-producing states of the Southwest are not expected to do well during the 1990s, and the industrial states of the Midwest will also achieve less growth than the national average. In the long run, the passage of acid rain control legislation will merely compound the existing economic damage to these regions and effectively prevent them from achieving any significant recovery from their current subnormal status.

Employment. Under the Stafford bill, the East North Central and South Atlantic states bear the brunt of the job losses, losing up to 144,000 and 131,000 jobs respectively. Smaller losses ranging from 52,000 to 35,000 jobs are visible in the Mid-Atlantic, East South Central and West North Central regions. Even New England undergoes some diminution in employment, losing just under 4,000 jobs. The overall job losses (in percents) are given in Table 3.

The total employment losses under the Waxman bill are less than half those under Stafford. As before, there are massive reductions in employment in the industrial states. The East North Central region loses 92,000 jobs by the year 2000, with the Mid-Atlantic losing 31,000, the East South Central losing 26,000 and the West North Central losing 15,285. New England actually gains jobs during the early years of the simulation, then undergoes very slight reductions toward the end. The employment gains in the West South Central states are just over 15,000. The Pacific Northwest gains 6,400 jobs, while the Pacific Southwest actually loses slightly.

About 40 to 50 percent of the job losses occur in manufacturing. The manufacturing employment losses occur primarily in the industrial states, but even in the regions that experience aggregate employment gains, manufacturing jobs fall. The manufacturing job losses under Stafford are given in Table 4.

Income and Output. Changes in output levels by state must be measured indirectly, since there is no aggregate measure of state product corresponding to GNP. Several alternative measures are possible, ranging from industrial production to personal disposable income.

Variations in real personal disposable income reflect both the overall decline in national income and the interregional distribution of economic activity. The losses in real income under Stafford are given in Table 5.

The situation with respect to housing starts is more complex, due to the fact that (as noted in the simulations for the entire country) housing declines more rapidly than the rest of the economy, but recovers toward the end of the simulation. In the Stafford simulation, in New England, housing starts decline approximately 4,000 units, troughing in 1999. Housing starts in the South Atlantic plunge 13,200 units by 1996, then recover. In the Mid-Atlantic, the cycle is less pronounced, with the downsizing in housing over time. The peak loss is 5,800 units. In the East North Central states, housing starts fall a maximum of 3,690 units in 1995. In the West North Central states, housing starts drop 2,600 units.

Manufacturing output falls throughout every part of the country. Under the Stafford bill, manufacturing production is 1.1 percent lower in New England by the year 2000, 1.0 percent lower in the Mid-Atlantic, 1.8 percent lower in the South Atlantic, 1.9 percent lower in the East North Central, 1.1 percent lower in the East South Central, 1.2 percent lower in the West North Central, 0.4 percent lower in the West South Central, 0.8 percent lower in the Pacific Northwest and 0.6 percent lower in the Pacific Southwest. The overall change in industrial production by region is as given in Table 6.

As before, the distribution of output losses by sector is a function of the energy intensity of particular industries or the extent to which they are dependent on residential construction. Further, the regional differences are a function of the degree to which states are specialized in particular industries. In other sectors (i.e., energy nonintensive and nonresidential industries) output losses occur only because of the pervasiveness of the economic weakness engendered by the acid rain legislation.

Conclusions

The significance of the acid rain legislation is revealed in the fact that it causes the economy to shift permanently below its equilibrium growth path. Moreover, the magnitudes by which certain sectors, primarily energy and capital-intensive manufacturing, undergo output losses relative to trend are considerable.

National Effects. At the national level, both the Stafford and the Waxman bills cause serious, long-term losses in output and employment, in conjunction with a similarly lasting increase in the price level.

In this sense, acid rain controls will only exacerbate the process of "selective deindustrialization" begun by some of the macroeconomic policies of the past decade, notably the successive recessions of 1980-1982 and the large trade deficits of 1982-1987. This threat is by no means negligible. By imposing heavy cost burdens on its manufacturing industries, the United States risks increased closing-down of productive facilities, relocation of factories to foreign countries and a gradual contraction of its industrial base. At a time when policies should be attempting to support industry in order to undo the damage wrought by the recessions and trade deficits of the early 1980s, acid rain legislation would clearly have the opposite effect: it would merely compound and accentuate the existing damage, thereby heightening the country's economic vulnerability. Initiatives such as acid rain legislation would, in this respect, achieve only the dubious distinction of moving the United States toward the status of a second-class industrial power by the end of the century.

In addition to the output and employment losses associated with acid rain legislation, it should be noted that the price effects are equally lasting.

The price increases are not limited to one-time increases in the relative price of energy. Although the largest increases are in energy-related sectors, as much as 80 percent of the initial price surge is eventually transmitted to wages and is thereby reflected in subsequent movements in the general price level. The rise in the price level in turn exerts a series of secondary effects through the economy, mainly by producing a rise in

interest rates, thereby lowering output in interest-sensitive sectors, such as housing. In the final analysis, when the secondary effects of acid rain legislation are taken into consideration, the economy will experience a significantly higher level of prices.

Regional Effects. Although the national effects of the acid rain legislation are quite serious, the aggregation of output and employment losses on a national scale tends to mask the damages sustained in individual regions. As the regional simulations demonstrate, the damage is concentrated in the nation's industrial heartland. The industrial states of the Northeast and Midwest, along with the industrialized regions along the southern part of the eastern seaboard and the south central parts of

the country, all sustain heavy damage. The production and job losses are concentrated in these states. Because of shifts in the regional locus of economic activity, these states will lose population.

It is to be emphasized in this context that the estimates here are conservative. They are based, as noted earlier, on government studies of the costs of this legislation. It is entirely conceivable that if the inputs to the DRI model had been based on estimates compiled by the private sector, the results would have emerged as even more deleterious. Consequently, the results of this study should not be viewed as unduly pessimistic. Rather, they represent minimum estimates of the costs of the economy. The true costs associated with acid rain legislation may well be significantly higher.

Table 1
Effects of Acid Rain Legislation
Waxman

	Changes Relative to Base Case										
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Retrofit Scrubber Equipment Expenditures (Billions of 1982 Dollars)...	1	2	3	3	1	0	0	0	0	0	0
Industrial Electricity Prices (Mills per KWH)	0	0	0	1	2	4	5	5	5	5	5
Price Effects	(Percentage Change)										
Producer Prices											
Fuels, Related Products & Power	0.0	0.0	0.1	0.4	0.8	1.5	1.4	1.3	1.2	1.1	0.9
Refined Petroleum Products	0.0	0.0	0.1	0.2	0.3	0.3	0.3	0.3	0.2	0.1	0.0
Crude Petroleum	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.4	0.5	0.5	0.4
Residual Fuels	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.4	0.4	0.4	0.4
Gas Fuels	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.3	0.3	0.3
Coal	0.0	0.0	0.1	0.2	0.3	0.4	0.5	0.5	0.4	0.3	0.2
Electric Power	0.0	0.0	0.1	1.3	3.1	6.0	5.9	5.6	5.3	5.0	4.6
Industrial Commodities	0.0	0.0	0.1	0.3	0.4	0.7	0.7	0.7	0.6	0.5	0.3
Textiles and Apparel	0.0	0.1	0.1	0.2	0.3	0.5	0.5	0.5	0.5	0.4	0.2
Chemicals	0.0	0.0	0.1	0.2	0.5	0.8	0.8	0.8	0.7	0.5	0.3
Rubber and Plastics	0.0	0.0	0.1	0.2	0.4	0.5	0.6	0.6	0.5	0.3	0.2
Lumber and Wood Products	0.0	0.1	0.2	0.2	0.1	-0.1	-0.1	0.0	0.1	0.1	0.0
Pulp and Paper	0.0	0.1	0.2	0.3	0.5	0.6	0.6	0.6	0.5	0.3	0.2
Metals	0.0	0.1	0.2	0.4	0.5	0.6	0.6	0.5	0.4	0.2	0.0
Machinery and Equipment	0.0	0.0	0.1	0.2	0.3	0.5	0.6	0.6	0.5	0.4	0.3
Transportation Equipment	0.0	0.0	0.1	0.1	0.3	0.4	0.6	0.6	0.6	0.5	0.3
Consumer Price Index	0.0	0.0	0.0	0.1	0.2	0.3	0.4	0.5	0.5	0.5	0.4
Residential Energy Prices	0.0	0.0	0.1	0.3	0.7	1.3	1.3	1.2	1.1	1.0	0.9
Residential Electricity Prices	0.0	0.0	0.0	0.8	1.9	3.6	3.6	3.4	3.3	3.0	2.8
Rental Price of Capital Equipment	0.0	0.0	0.1	0.3	0.5	0.7	0.9	1.0	1.1	1.0	0.8
Public Utility Structures	0.0	0.0	0.2	0.4	0.7	0.9	1.0	1.1	1.3	1.3	1.2
Other Structures	0.0	0.0	0.1	0.4	0.6	0.8	0.8	1.0	1.1	1.1	0.9
Macroeconomic Impacts											
Real GNP (Billions of 1982 Dollars)	1	4	8	8	2	-7	-11	-13	-14	-17	-19
	(Percentage Change)										
Real GNP	0.0	0.1	0.2	0.2	0.0	-0.1	-0.2	-0.3	-0.3	-0.3	-0.4
Consumption	0.0	0.0	0.1	0.1	0.1	0.0	-0.1	-0.1	-0.2	-0.2	-0.2
Energy	0.0	0.0	0.0	0.1	0.1	0.5	-0.1	-0.2	-0.2	-0.2	-0.2
Residential Investment	0.0	0.1	0.1	-0.1	-0.5	-0.9	-1.0	-0.9	-0.5	-0.4	-0.2
Business Fixed Investment	0.1	0.5	0.9	0.9	0.3	-0.5	-0.8	-0.9	-0.9	-1.0	-1.0
Exports	0.0	0.1	0.2	0.2	0.2	0.0	-0.1	-0.2	-0.4	-0.6	-0.6
Imports	0.0	0.1	0.3	0.4	0.3	0.0	-0.2	-0.2	-0.2	-0.1	-0.1
Real Potential GNP	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.2
Real Disposable Income	0.0	0.0	0.1	0.1	0.1	0.0	-0.1	-0.1	-0.1	-0.1	-0.2
Real After-Tax Profits	0.2	0.7	1.1	0.7	-0.8	-1.6	-1.6	-1.6	-1.6	-1.9	-2.0
Industrial Production	0.0	0.2	0.4	0.3	0.0	-0.4	-0.6	-0.6	-0.7	-0.9	-0.8
Treasury Bill Rate (Basis points)	0	2	7	14	20	25	25	24	22	19	12
Mortgage Rate (Basis points)	0	2	7	14	20	22	22	22	22	20	16
Housing Starts (Thousands of units)	0	2	2	-5	-17	-28	-21	-13	-6	-1	4
Productivity	0.0	0.1	0.1	0.1	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2
Employment	0.0	0.0	0.1	0.1	0.1	0.0	-0.1	-0.1	-0.2	-0.2	-0.2
(Thousands of Persons)	10	46	104	141	89	-14	-109	-161	-188	-207	-213
Unemployment Rate (Percent)	0.0	0.0	-0.1	-0.1	-0.1	0.0	0.0	0.1	0.1	0.1	0.1
Current Account Balance (Billions of Dollars)	0	0	-1	-1	-1	0	0	1	-1	-4	-7

Effects of Acid Rain Legislation
Waxman (Continued)

	Changes Relative to Base Case												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000		
Industrial Production													
	(Percentage Change)												
Manufacturing.....	0.1	0.2	0.4	0.4	0.0	-0.4	-0.6	-0.6	-0.7	-0.7	-0.8		
Mining.....	0.0	0.1	0.1	0.1	0.0	-0.2	-0.3	-0.4	-0.4	-0.5	-0.5		
Tobacco.....	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.3		
Textiles.....	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	-0.1	-0.1		
Apparel.....	0.0	0.1	0.2	0.2	0.0	-0.2	-0.3	-0.3	-0.3	-0.4	-0.4		
Lumber and Wood Products.....	0.0	0.1	0.2	0.1	0.2	-0.1	-0.1	0.1	0.0	-0.1	-0.1		
Furniture and Fixtures.....	0.0	0.1	0.2	0.3	0.0	-0.4	-0.7	-0.8	-0.8	-0.8	-0.7		
Paper and Products.....	0.0	0.2	0.3	0.3	0.0	-0.3	-0.4	-0.4	-0.4	-0.4	-0.3		
Printing and Publishing.....	0.0	0.3	0.3	0.3	0.0	-0.4	-0.6	-0.5	-0.4	-0.4	-0.3		
Chemicals and Products.....	0.0	0.2	0.3	0.3	0.0	-0.3	-0.5	-0.5	-0.5	-0.5	-0.5		
Petroleum and Products.....	0.0	0.0	0.0	0.1	0.1	0.0	-0.0	-0.1	-0.1	-0.1	-0.1		
Rubber and Plastic Products.....	0.1	0.2	0.4	0.4	0.0	-0.5	-0.7	-0.7	-0.7	-0.7	-0.8		
Leather and Products.....	0.0	0.1	0.2	0.2	0.3	0.4	0.4	0.3	0.1	-0.3	-0.3		
Clay, Glass and Stone Products.....	0.1	0.5	0.8	0.7	0.0	-0.7	-1.0	-1.0	-1.0	-1.0	-0.9		
Primary Metals.....	0.2	0.7	1.4	1.3	0.2	-1.0	-1.5	-1.8	-1.9	-2.1	-2.2		
Fabricated Metal Products.....	0.2	0.8	1.4	1.4	0.4	-0.5	-1.0	-1.3	-1.4	-1.6	-1.6		
Non-electrical Machinery.....	0.0	0.2	0.3	0.3	0.0	-0.3	-0.5	-0.6	-0.7	-0.8	-0.9		
Electrical Machinery.....	0.0	0.2	0.3	0.3	0.0	-0.1	-0.5	-0.7	-0.8	-0.9	-1.1		
Transportation Equipment.....	0.0	0.2	0.3	0.3	0.1	-0.5	-0.6	-0.6	-0.6	-0.7	-0.8		
Instruments.....	0.0	0.1	0.3	0.3	0.1	-0.3	-0.5	-0.6	-0.6	-0.7	-0.8		
Miscellaneous Manufactures.....	0.0	0.2	0.3	0.4	0.1	-0.2	-0.3	-0.3	-0.4	-0.6	-0.9		
Employment													
	(Percentage Change)												
Manufacturing.....	0.0	0.1	0.2	0.3	0.1	-0.2	-0.4	-0.4	-0.5	-0.5	-0.6		
Food and Products.....	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1		
Tobacco.....	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Textiles.....	0.0	0.1	0.1	0.1	0.0	-0.1	-0.2	-0.2	-0.2	-0.2	-0.3		
Apparel and Other Textiles.....	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.1		
Lumber and Wood Products.....	0.0	0.2	0.3	0.3	-0.1	-0.6	-0.7	-0.7	-0.6	-0.4	-0.3		
Furniture and Fixtures.....	0.0	0.1	0.2	0.2	0.0	-0.2	-0.5	-0.6	-0.6	-0.5	-0.5		
Paper and Products.....	0.0	0.1	0.2	0.2	0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2		
Printing and Publishing.....	0.0	0.0	0.1	0.1	0.0	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2		
Chemicals and Products.....	0.0	0.0	0.1	0.1	0.0	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2		
Petroleum and Products.....	0.0	0.0	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1		
Rubber and Misc. Plastics.....	0.0	0.1	0.3	0.3	0.0	-0.3	-0.5	-0.5	-0.5	-0.6	-0.6		
Leather and Products.....	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.4	0.3	0.2	-0.1		
Stone, Clay, and Glass.....	0.1	0.5	0.6	0.5	0.3	-0.3	-0.7	-0.9	-0.9	-0.8	-0.8		
Primary Metal Industries.....	0.1	0.4	1.0	1.0	0.6	-0.2	-1.1	-1.6	-1.9	-2.1	-2.3		
Fabricated Metal Products.....	0.1	0.5	1.0	1.2	0.7	0.0	-0.6	-0.9	-1.2	-1.3	-1.4		
Non-electrical Machinery.....	0.0	0.1	0.2	0.2	0.1	-0.2	-0.3	-0.4	-0.4	-0.5	-0.6		
Electrical Machinery.....	0.0	0.1	0.2	0.2	0.0	-0.1	-0.3	-0.3	-0.4	-0.4	-0.5		
Transportation Equipment.....	0.0	0.1	0.2	0.2	0.0	-0.3	-0.4	-0.4	-0.4	-0.4	-0.5		
Instruments.....	0.0	0.1	0.2	0.2	0.1	-0.1	-0.3	-0.4	-0.4	-0.5	-0.5		
Miscellaneous.....	0.0	0.1	0.2	0.2	0.1	-0.1	-0.2	-0.2	-0.2	-0.4	-0.6		
Federal Budget Impacts													
	(Billions of Dollars)												
Revenues.....	0.5	1.9	4.0	5.3	4.2	3.5	3.4	4.2	4.1	3.3	-0.4		
Expenditures.....	0.0	0.0	0.4	1.9	4.8	8.9	12.4	14.7	16.3	16.4	15.4		
Deficit.....	-0.5	-1.9	-3.6	-3.6	0.6	5.5	9.0	10.9	12.2	14.2	15.8		

Table 2
Effects of Acid Rain Legislation
Stafford

	Changes Relative to Base Case												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000		
Retrofit Scrubber Equipment Expenditures (Billions of 1982 Dollars)...	3	9	17	17	7	0	0	0	0	0	0		
Industrial Electricity Prices (Mills per kWh)	0	0	0	3	8	17	17	17	17	16	16		
Price Effects													
	(Percentage Change)												
Producer Prices													
Fuels, Related Products & Power.....	0.0	0.1	0.3	1.6	3.3	5.7	5.4	5.0	4.5	3.9	3.2		
Refined Petroleum Products.....	0.0	0.2	0.5	0.9	1.3	1.5	1.3	1.3	1.0	0.6	0.1		
Crude Petroleum.....	0.0	0.0	0.0	0.2	0.5	1.0	1.5	1.9	2.0	1.9	1.6		
Residual Fuels.....	0.0	0.0	0.0	0.2	0.6	0.9	1.4	1.7	1.7	1.4	1.1		
Gas Fuels.....	0.0	0.0	0.0	0.1	0.3	0.6	0.9	1.1	1.2	1.2	1.0		
Coal.....	0.0	0.2	0.4	0.8	1.2	1.6	1.8	1.9	1.7	1.3	0.8		
Electric Power.....	0.0	0.1	0.3	5.0	11.8	22.6	21.6	20.1	19.0	17.5	15.5		
Industrial Commodities.....	0.0	0.2	0.5	1.1	1.8	2.6	2.7	2.6	2.2	1.7	1.1		
Textiles and Apparel.....	0.1	0.2	0.5	0.9	1.3	1.8	2.1	2.1	1.8	1.3	0.9		
Chemicals.....	0.0	0.1	0.5	1.2	2.1	3.0	3.3	3.0	2.4	1.6	0.7		
Rubber and Plastics.....	0.0	0.2	0.4	0.9	1.5	2.2	2.4	2.3	1.8	1.2	0.6		
Lumber and Wood Products.....	0.1	0.4	1.0	1.3	0.8	-0.1	-0.3	0.2	0.7	0.6	0.4		
Pulp and Paper.....	0.0	0.2	0.6	1.3	2.0	2.4	2.5	2.2	1.7	1.0	0.4		
Metal.....	0.1	0.4	1.0	1.0	2.0	2.1	2.1	1.7	1.1	0.4	-0.2		
Machinery and Equipment.....	0.0	0.1	0.3	0.7	1.3	1.9	2.4	2.4	2.1	1.5	1.0		
Transportation Equipment.....	0.0	0.1	0.2	0.5	1.0	1.6	2.3	2.5	2.3	1.7	1.1		
Consumer Price Index.....	0.0	0.0	0.2	0.4	0.9	1.4	1.8	2.0	2.0	1.8	1.5		
Residential Energy Prices.....	0.0	0.1	0.3	1.4	3.0	5.1	4.9	4.6	4.2	3.4	3.3		
Residential Electricity Prices.....	0.0	0.1	0.2	3.1	7.2	13.4	13.1	12.5	11.7	10.7	9.6		
Rental Price of Capital Equipment.....	0.0	0.0	0.3	1.1	2.2	3.2	3.8	4.4	4.6	4.2	3.2		
Public Utility Structures.....	0.0	0.2	0.7	1.8	3.1	3.9	4.2	4.9	5.7	5.9	5.2		
Other Structures.....	0.0	0.1	0.5	1.7	3.0	3.7	3.7	4.4	5.1	5.1	4.2		
Macroeconomic Impacts													
Real GNP (Billions of 1982 Dollars).....	5	20	39	42	12	-27	-48	-56	-62	-70	-76		
	(Percentage Change)												
Real GNP.....	0.1	0.5	0.9	1.0	0.3	-0.6	-1.0	-1.2	-1.3	-1.4	-1.5		
Consumption.....	0.0	0.2	0.4	0.6	0.4	0.0	-0.3	-0.5	-0.6	-0.6	-0.6		
Energy.....	0.0	0.1	0.2	0.3	0.3	0.1	-0.3	-0.4	-0.4	-0.7	-0.7		
Residential Investment.....	0.1	0.3	0.5	-0.2	-2.1	-4.1	-4.3	-3.3	-2.2	-1.3	-0.5		
Business Fixed Investment.....	0.7	2.5	4.7	4.9	1.6	-1.9	-3.5	-4.0	-4.1	-4.1	-4.0		
Exports.....	0.1	0.3	0.8	1.2	1.0	0.2	-0.8	-0.8	-0.7	-0.5	-0.3		
Imports.....	0.1	0.6	1.4	2.4	1.5	-0.2	-0.6	-0.9	-0.7	-0.5	-0.3		
Real Potential GNP.....	0.0	0.0	0.0	0.1	0.1	0.0	-0.1	-0.2	-0.4	-0.6	-0.7		
Real Disposable Income.....	0.0	0.2	0.5	0.7	0.6	0.1	-0.2	-0.4	-0.5	-0.5	-0.6		
Real After-Tax Profits.....	1.1	3.3	9.7	3.3	-4.6	-9.1	-9.6	-8.3	-8.0	-8.6	-9.1		
Industrial Production.....	0.3	1.0	1.8	1.8	0.2	-1.6	-2.3	-2.7	-2.8	-3.0	-3.1		
Treasury Bill Rate (Basis points).....	1	66	82	159	106	101	89	70	81	70	81		
Mortgage Rate (Basis points).....	-1	2	9	31	63	89	97	97	91	81	66		
Housing Starts (Thousands of units).....	3	8	10	-16	-71	-113	-93	-54	-24	-1	22		
Productivity.....	0.1	0.3	1.4	-0.4	-0.1	-0.4	-0.4	-0.4	-0.4	-0.5	-0.7		
Employment.....	0.0	0.2	0.5	0.6	0.4	0.0	-0.4	-0.6	-0.7	-0.7	-0.7		
[Thousands of Persons].....	53	232	520	728	511	13	-634	-681	-687	-682	-680		
Unemployment Rate (Percent).....	0.0	-0.1	-0.3	-0.4	-0.2	0.2	0.3	0.4	0.3	0.3	0.3		
Current Account Balance (Billions of Dollars)	0	-2	-5	-7	-7	-2	-1	-1	-1	-1	-32		

Effects of Acid Rain Legislation
Stafford (Continued)

Changes Relative to Base Case
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000

Industrial Production

(Percentage Change)

Manufacturing.....	0.3	1.1	2.0	2.0	0.3	-1.6	-2.5	-2.7	-2.8	-3.0	-3.1
Mining.....	0.1	0.3	0.5	0.5	0.0	-0.7	-1.2	-1.5	-1.6	-1.6	-1.6
Food.....	0.0	0.2	0.4	0.6	0.5	0.1	-0.3	-0.5	-0.7	-0.9	-1.0
Tobacco.....	0.0	0.0	0.1	0.3	0.4	0.4	0.2	0.1	0.0	-0.2	-0.4
Textiles.....	0.2	0.6	1.1	1.1	0.1	-0.9	-1.2	-1.3	-1.4	-1.6	-1.6
Apparel.....	0.1	0.5	1.0	1.3	0.8	0.1	0.0	0.0	-0.1	-0.5	-1.0
Lumber and Products.....	0.3	1.2	2.2	1.7	-0.8	-3.2	-3.6	-3.1	-2.4	-1.9	-1.3
Furniture and Fixtures.....	0.1	0.5	1.2	1.4	0.4	-1.5	-3.1	-3.8	-3.8	-3.5	-3.0
Paper and Products.....	0.2	0.8	1.6	1.6	0.3	-1.2	-1.8	-1.7	-1.6	-1.5	-1.4
Printing and Publishing.....	0.2	0.8	1.6	1.6	0.1	-1.8	-2.5	-2.2	-1.7	-1.4	-1.1
Chemicals and Products.....	0.2	0.8	1.5	1.5	0.2	-1.3	-1.9	-2.0	-2.0	-2.0	-1.9
Petroleum and Products.....	0.0	0.1	0.2	0.4	0.4	0.1	-0.1	-0.3	-0.3	-0.4	-0.4
Rubber and Plastic Products.....	0.3	1.2	2.3	2.2	0.1	-2.2	-3.0	-3.0	-3.0	-3.0	-3.0
Leather and Products.....	0.1	0.3	0.6	0.9	1.0	1.1	1.3	1.4	0.9	-0.1	-1.4
Clay, Glass and Stone Products.....	0.7	2.3	4.1	3.8	0.1	-3.1	-4.3	-4.4	-4.2	-4.0	-3.5
Primary Metals.....	1.1	3.8	6.8	6.8	1.4	-4.1	-6.5	-7.3	-7.9	-8.4	-8.5
Fabricated Metal Products.....	1.3	4.3	7.3	7.3	2.5	-2.1	-4.0	-5.1	-5.7	-6.1	-6.1
Non-electrical Machinery.....	0.2	0.8	1.6	1.6	0.2	-1.5	-2.5	-2.8	-3.1	-3.5	-3.8
Electrical Machinery.....	0.2	0.9	1.5	1.3	-0.4	-2.2	-3.3	-3.6	-3.9	-4.3	-4.5
Transportation Equipment.....	0.2	0.9	1.5	1.5	-0.2	-2.1	-2.8	-2.8	-2.9	-3.1	-3.3
Instruments.....	0.2	0.8	1.6	1.6	0.6	-1.2	-2.4	-2.8	-3.0	-3.2	-3.5
Miscellaneous Manufactures.....	0.2	0.9	1.7	1.9	0.6	-1.0	-1.6	-1.6	-1.9	-2.7	-3.6

Employment

(Percentage Change)

Manufacturing.....	0.1	0.6	1.3	1.5	0.6	-0.7	-1.6	-1.9	-2.0	-2.2	-2.2
Food and Products.....	0.0	0.0	-0.1	0.0	0.1	0.2	0.1	0.0	-0.1	-0.2	-0.3
Tobacco.....	0.0	-0.1	-0.2	-0.2	-0.1	0.1	0.2	0.2	0.2	0.1	0.1
Textiles.....	0.1	0.3	0.6	0.7	0.2	-0.5	-0.8	-0.8	-0.9	-1.0	-1.1
Apparel and Other Textiles.....	0.0	0.2	0.5	0.7	0.5	0.2	0.1	0.1	0.1	-0.2	-0.5
Lumber and Wood Products.....	0.2	0.8	1.6	1.5	-0.2	-2.3	-3.2	-2.9	-2.3	-1.8	-1.2
Furniture and Fixtures.....	0.1	0.3	0.6	0.9	0.3	-0.9	-2.0	-2.5	-2.6	-2.4	-2.0
Paper and Products.....	0.1	0.3	0.7	0.8	0.3	-0.5	-0.9	-1.0	-0.9	-0.8	-0.7
Printing and Publishing.....	0.2	0.8	1.6	1.6	0.2	-0.5	-1.0	-1.1	-0.9	-0.6	-0.4
Chemicals and Products.....	0.0	0.2	0.4	0.5	0.2	-0.3	-0.7	-0.8	-0.8	-0.8	-0.7
Petroleum and Products.....	0.0	-0.2	-0.4	-0.4	-0.3	0.1	0.3	0.4	0.4	0.4	0.5
Rubber and Misc. Plastics.....	0.2	0.8	1.5	1.6	0.3	-1.4	-2.3	-2.4	-2.3	-2.3	-2.3
Leather and Products.....	0.0	0.1	0.2	0.4	0.6	0.8	1.0	1.2	1.0	0.4	-0.5
Stone, Clay, and Glass.....	0.3	1.3	2.6	3.2	1.5	-1.3	-3.0	-3.7	-3.8	-3.7	-3.4
Primary Metal Industries.....	0.5	2.3	4.9	6.5	4.2	-0.6	-4.5	-6.6	-7.8	-8.6	-8.9
Fabricated Metal Products.....	0.7	2.6	5.2	6.3	4.0	-0.2	-3.3	-5.6	-6.7	-7.5	-7.3
Non-electrical Machinery.....	0.1	0.4	0.9	1.1	0.4	-0.8	-1.6	-1.9	-2.1	-2.4	-2.6
Electrical Machinery.....	0.1	0.5	0.9	0.9	-0.1	-1.4	-2.2	-2.5	-2.7	-2.9	-3.1
Transportation Equipment.....	0.1	0.5	0.9	0.8	-0.1	-1.3	-1.7	-1.7	-1.8	-1.9	-2.0
Instruments.....	0.1	0.3	0.8	1.1	0.7	-0.4	-1.4	-1.9	-2.1	-2.7	-2.4
Miscellaneous.....	0.1	0.4	0.9	1.2	0.7	-0.4	-1.0	-1.1	-1.2	-1.7	-1.3

Federal Budget Impacts

(Billions of Dollars)

Revenues.....	2.3	9.2	19.7	25.7	19.0	13.0	11.9	14.6	13.5	6.4	-3.9
Expenditures.....	-0.2	0.9	0.9	1.5	7.6	20.2	37.9	53.0	62.9	67.5	68.9
Deficit.....	-2.5	-9.2	-18.2	-18.1	1.2	24.9	41.0	48.4	54.0	60.4	64.4

Table 3

Difference Between the Partial Stafford and Base Scenario,
Percent Difference, and Trough Year (If Before 2000), for:

Non-Agricultural Employment (thousands)

	Difference	Percent Difference	Trough Year
U.S. Total	-360.163	-0.298	1999
New England	-3.983	-0.053	1999
Middle Atlantic	-52.029	-0.272	
South Atlantic	-131.652	-0.601	1999
East North Central	-144.560	-0.742	
East South Central	-50.608	-0.791	1999
West North Central	-35.300	-0.417	1999
West South Central	1.188	0.011	1990
Pacific Northwest	0.751	0.018	1990
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Table 4

Difference Between the Partial Stafford and Base Scenario,
Percent Difference, and Trough Year (If Before 2000), for:

Manufacturing Employment (thousands)

	Difference	Percent Difference	Trough Year
U.S. Total	-189.093	-0.969	1999
New England	-11.070	-0.739	1999
Middle Atlantic	-23.214	-0.787	1999
South Atlantic	-44.061	-1.404	1999
East North Central	-64.661	-1.585	1999
East South Central	-11.497	-0.871	1999
West North Central	-13.444	-1.017	1999
West South Central	-5.900	-0.372	1998
Pacific Northwest	-4.448	-0.715	1997
Pacific Southwest	-12.508	-0.426	1997

Effects of Acid Rain Legislation
Stafford (Continued)

	Changes Relative to Base Case											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	
Industrial Production												
	(Percentage Change)											
Manufacturing.....	0.3	1.1	2.0	2.0	0.3	-1.6	-2.5	-2.7	-2.8	-3.0	-3.1	
Mining.....	0.1	0.3	0.5	0.5	0.0	-0.7	-1.2	-1.5	-1.6	-1.6	-1.6	
Food.....	0.0	0.2	0.4	0.6	0.5	0.1	-0.3	-0.5	-0.7	-0.9	-1.0	
Tobacco.....	0.0	0.0	0.1	0.3	0.4	0.4	0.2	0.1	0.0	-0.2	-0.4	
Textiles.....	0.2	0.6	1.1	1.1	0.1	-0.9	-1.2	-1.3	-1.4	-1.6	-1.6	
Apparel.....	0.1	0.5	1.0	1.3	0.8	0.1	0.0	0.0	-0.1	-0.5	-1.0	
Rubber and Plastics.....	0.3	1.2	2.2	2.7	0.9	-1.8	-2.5	-2.7	-2.7	-3.4	-3.1	
Furniture and Fixtures.....	0.1	0.5	1.2	1.4	0.4	-1.6	-3.1	-3.8	-3.5	-3.0		
Paper and Products.....	0.2	0.8	1.6	1.6	0.3	-1.2	-1.8	-1.7	-1.6	-1.5	-1.4	
Printing and Publishing.....	0.2	0.8	1.6	1.6	0.1	-1.8	-2.5	-2.7	-2.7	-3.4	-3.1	
Chemicals and Products.....	0.2	0.8	1.5	1.5	0.2	-1.3	-1.9	-2.0	-2.0	-2.0	-1.9	
Petroleum and Products.....	0.0	0.1	0.2	0.4	0.4	0.1	-0.1	-0.3	-0.3	-0.4	-0.4	
Rubber and Plastic Products.....	0.3	1.2	2.3	2.2	0.1	-2.2	-3.0	-3.0	-3.0	-3.0	-3.0	
Leather and Products.....	0.1	0.3	0.6	0.9	1.0	1.1	1.3	1.4	0.9	-0.1	-1.4	
Clay, Glass and Stone Products.....	0.7	2.3	4.1	3.8	0.1	-3.1	-4.3	-4.4	-4.2	-4.0	-3.5	
Primary Metals.....	1.1	3.8	6.8	6.8	1.4	-4.1	-6.5	-7.3	-7.9	-8.4	-8.5	
Fabricated Metal Products.....	1.3	4.3	7.3	7.3	2.5	-2.1	-4.0	-5.1	-5.7	-6.1	-6.1	
Non-electrical Machinery.....	0.2	0.8	1.6	1.6	0.2	-1.5	-2.5	-2.8	-3.1	-3.5	-3.8	
Electrical Machinery.....	0.2	0.9	1.5	1.3	-0.4	-2.2	-3.3	-3.6	-3.9	-4.3	-4.5	
Transportation Equipment.....	0.2	0.9	1.5	1.5	-0.2	-2.1	-2.8	-2.8	-2.9	-3.1	-3.3	
Instruments.....	0.2	0.8	1.5	1.8	0.6	-1.2	-2.4	-2.8	-3.0	-3.2	-3.5	
Miscellaneous Manufactures.....	0.2	0.9	1.7	1.9	0.6	-1.0	-1.6	-1.6	-1.9	-2.7	-3.6	
Employment												
	(Percentage Change)											
Manufacturing.....	0.1	0.6	1.3	1.5	0.6	-0.7	-1.6	-1.9	-2.0	-2.2	-2.2	
Food and Products.....	0.0	0.0	-0.1	0.0	0.1	0.2	0.1	0.0	-0.1	-0.2	-0.3	
Tobacco.....	0.0	-0.1	-0.2	-0.2	-0.1	0.1	0.2	0.2	0.2	0.1	0.1	
Textiles.....	0.1	0.3	0.6	0.7	0.2	-0.5	-0.8	-0.8	-0.9	-1.0	-1.1	
Apparel and Other Textiles.....	0.0	0.2	0.5	0.7	0.5	0.2	0.1	0.1	0.1	-0.2	-0.5	
Rubber and Plastics.....	0.2	0.8	1.6	1.5	-0.2	-2.3	-3.2	-2.9	-2.3	-1.8	-1.2	
Furniture and Fixtures.....	0.1	0.3	0.6	0.9	0.3	-0.9	-2.0	-2.5	-2.6	-2.4	-2.0	
Paper and Products.....	0.1	0.3	0.7	0.8	0.3	-0.5	-0.9	-1.0	-0.9	-0.8	-0.7	
Printing and Publishing.....	0.2	0.8	1.6	1.6	0.2	-0.5	-1.0	-1.1	-0.9	-0.6	-0.4	
Chemicals and Products.....	0.0	0.2	0.4	0.5	0.2	-0.3	-0.7	-0.8	-0.8	-0.8	-0.7	
Petroleum and Products.....	0.0	-0.2	-0.4	-0.4	-0.3	0.1	0.3	0.4	0.4	0.4	0.5	
Rubber and Misc. Plastics.....	0.2	0.8	1.5	1.6	0.3	-1.4	-2.3	-2.4	-2.3	-2.3	-2.3	
Leather and Products.....	0.0	0.1	0.2	0.4	0.6	0.8	1.0	1.2	1.0	0.4	-0.5	
Stone, Clay, and Glass.....	0.3	1.3	2.6	3.2	1.5	-1.3	-3.0	-3.7	-3.8	-3.7	-3.4	
Primary Metal Industries.....	0.5	2.3	4.9	6.5	4.2	-0.8	-4.5	-6.6	-7.8	-8.6	-8.9	
Fabricated Metal Products.....	0.7	2.6	5.2	6.3	4.0	-0.2	-3.3	-5.6	-6.7	-7.5	-7.3	
Non-electrical Machinery.....	0.1	0.4	0.9	1.1	0.4	-0.8	-1.6	-1.9	-2.1	-2.4	-2.6	
Electrical Machinery.....	0.1	0.5	0.9	0.9	-0.1	-1.4	-2.2	-2.5	-2.7	-2.9	-3.1	
Transportation Equipment.....	0.1	0.5	0.9	0.8	-0.1	-1.3	-1.7	-1.7	-1.8	-1.9	-2.0	
Instruments.....	0.1	0.3	0.8	1.1	0.7	-0.4	-1.4	-1.9	-2.1	-2.7	-2.4	
Miscellaneous.....	0.1	0.4	0.9	1.2	0.7	-0.4	-1.0	-1.1	-1.2	-1.7	-1.3	
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Pacific Northwest	-4.448	-0.715	1999
Pacific Southwest	-12.508	-0.426	1997

Table 5

Difference Between the Partial Stafford and Base Scenario,
Percent Difference, and Trough Year (If Before 2000), for:

Real Disposable Income (billions of 1972 dollars)

	Difference	Percent Difference	Trough Year
U.S. Total	-4.759	-0.280	
New England	-0.023	-0.021	
Middle Atlantic	-0.695	-0.250	
South Atlantic	-1.981	-0.666	
East North Central	-2.257	-0.874	
East South Central	-0.662	-0.825	
West North Central	-0.379	-0.335	
West South Central	0.017	0.014	1990
Pacific Northwest	0.008	0.016	1990
Pacific Southwest	0.040	0.016	1990

Table 6

Difference Between the Partial Stafford and Base Scenario,
Percent Difference, and Trough Year (If Before 2000), for:

Manufacturing Production Index (1973:1 = 1)

	Difference	Percent Difference	Trough Year
U.S. Total	-0.025	-1.286	1999
New England	-0.030	-1.178	1999
Middle Atlantic	-0.017	-1.112	1999
South Atlantic	-0.044	-1.859	1999
East North Central	-0.027	-1.956	1999
East South Central	-0.025	-1.201	1999
West North Central	-0.025	-1.256	1999
West South Central	-0.011	-0.519	1997
Pacific Northwest	-0.023	-1.013	1997
Pacific Southwest	-0.023	-0.766	1997



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