U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

Assistant Administrator
For Air and Radiation

Christina -

Per our discussion, I have enclosed some introductory information on the Grand Canyon Regulation that will be signed on the President's Sept 18 trip.

Let's talk as your writers start the drafting as to what other info. is useful.

Tom Kiernan
382-7400 - Chief of Staff Air Office.

ENVIRONMENTAL CONSENSUS IN THE 90'S

President George Bush:
"This bill balances economic growth with environmental protection."

REFORMULATED GASOLINE:

- Presidential leadership in Clean Fuels implementation.
- Proposed agreement maximizes environmental benefit (full 15% VOC reduction in all states) and achieves President Bush's regulatory reform agenda by increasing flexibility and reducing cost.
- Petroleum industry (API), auto industry, environmental community (NRDC & Sierra Club), states, EPA staff and others are ready to endorse.

GRAND CANYON VISIBILITY

- Resolved 15 year legal battle to cut Navajo Power Plant emissions which impair visibility at the Grand Canyon.
- Achieves 46% greater benefits at 20% lower cost than EPA's original proposal through providing utility with greater flexibility in achieving environmental goal.
- Utility owners, environmentalists, and Governor Symington want to stand with the President to sign the regulation.

ACID RAIN

- Over 7 meetings of 100's of utility, state, environmental and other representatives have provided the Administration with a regulatory outline that resolves most of the issues -- while achieving a 10 million ton SO2 reduction and establishing a market-based trading system.

RESULT

- Implementation of the Clean Air Act that:
  - Cleans the Air,
  - Establishes the President's Regulatory Reform, and
  - Builds consensus among industry, environmental community and the Administration

NAVAJO GENERATING STATION
Status of Discussions

1. **Series of Discussions have Produced Unprecedented Agreement.**

2. **Utilities and Environmentalists are Recommending to Their Board of Directors:**

   - o 90% control
   - o 1997, 98, 99
   - o Annual Average
   - o Winter maintenance

3. **30% Lower Cost than NPRM.**

	Capital	Annualized	Annual W/ A.R. Credits
NPRM:	$510	$106	$78
Agreement:	$430	$90	$53
Savings:	18%	18%	32%

	Approx % of Savings
o More efficient technology:	20%
o Annual Average:	40%
o Additional Time:	40%

4. **46% Additional Increase in Visual Range.**

	Emissions	Visual Range
NPRM:	.3 lbs/MMBTU	8%
Agreement:	.1 lbs/MMBTU	11.7%
Benefits:	66%	46%

   - o Peak episodes even more significantly improved

5. **SUMMARY: EPA Regulation that achieves:**
   - **o More Environmental Protection**
   - **o At Lower Cost**
   - **o With Endorsement Among Constituents**
   - **o Minimal Precedent Impact**

NAVAJO GENERATING STATION

Principal Elements of Agreement Among SRP, EDF and GCT

Emission Limitation:	.1 lbs/MMBTU plant-wide average
Averaging Time:	Rolling Annual Average
Compliance Phase-in Schedule:	Unit #1: Nov. 19, 1997 Unit #2: Nov. 19, 1998 Unit #3: Aug. 19, 1999 (Interim dates before unit compliance)
Maintenance:	Schedule unit maintenance in the winter (subject to load demand and premium on replacement costs)
Reheat:	No
Design SO2 Removal Rate:	92%
Forced Outages Reporting:	Best efforts to avoid outages; Reports to EPA on expected repair time and explanation of expeditious return.
Other Pollutants:	No NOx or PM limitations if FGD installed.
Management Commitments:	The utilities will make best efforts to secure the approval of their management; the environmental groups will make best efforts to secure the agreement of other major environmental organizations.

REFORMULATE GASOLINE
Status of Agreement

1. **CONSENSUS:** Regulatory Negotiation was an unprecedented success. Tentative agreement was reached among the oil refiners (major and minor), auto industry, environmentalists, and others.

2. **REGULATORY REFORM** Agreement assures market-based implementation. Would have been impossible without concurrence from states and environmentalists, e.g.:

   - o Toxics Averaging
   - o Annual Averaging Periods

3. **LOWER COST:** Regulatory flexibility will lower the cost of implementing reformulated gasoline:

   - o Simplified Anti-Dumping
   - o Simplified Fuel Certification

4. **CHEAPER BENEFITS:** 15% reduction in all cities achieves cost-effective reductions that will replace other extremely expensive options.

5. **NEXT STEPS:** Signature by Friday.

"ALL ABOARD THE CLEAN AIR BUS"

Remarks by

William G. Rosenberg

Assistant Administrator

United States Environmental Protection Agency

at

American Bar Association

Annual Meeting

Atlanta, Georgia

August 12, 1991

I'm happy to be here today, and I appreciate this opportunity to talk about EPA's efforts to implement the new Clean Air Act. Your presence at this luncheon shows that you take an interest in matters that affect the environment -- either on your own behalf or on behalf of your clients. I think that's very commendable. It shows that you have keen minds, discerning taste, and a highly evolved social conscience.

Now you may think I'm trying to flatter you. Actually, I'm an attorney myself, and with all the abuse we lawyers take from the public, I try to build up our self esteem whenever I can!

But besides being keen of mind, you may not know that our interest in the environment puts us right in step with the hottest trend in American society. According to a recent Roper Poll, when Americans were asked, "What's 'In' in the 90's," the environment was listed first -- followed by patriotism and safe sex.

These results tell me two things: that Americans care about their environment as never before -- and that the time may be right for a best seller on the mating habits of the bald eagle!

Quite seriously, the Roper Poll showed that 85% of all Americans are seriously concerned about the environment. They told the pollsters that improving the quality of our environment is as important to them as solving the problems of crime and drugs and finding a cure for AIDS.

A Wall Street Journal/NBC News Poll, released just a week ago, told the same story. Eight out of ten Americans identified themselves as "environmentalists."

How do we respond to these concerns?

As luck would have it, the United States government has just the product for these Americans. It's called the Clean Air Act Amendments of 1990. It's designed to address -- and to solve -- air pollution problems nationwide -- and at a price all Americans can afford.

The new Act will remove 56 billion pounds of pollution each year from the air we breathe. That's 224 pounds for every man, woman, and child. Sulfur dioxide and nitrogen oxide emissions that cause acid rain will be cut virtually in half.

Every part of the country finally will have realistic means to attain healthy air. The risk from toxic air emissions will be cut by three-fourths. And the Clean Air Act is also designed to finally reconcile the automobile and the environment.

It was President Bush who provided the impetus that made these new laws a reality. Without his commitment to the environment, this landmark clean air legislation, which languished for thirteen years in the Congress, would never have had a "breath" of a chance. At the White House last November, as he signed this bill into law, our President reaffirmed his commitment, calling the Clean Air Act of 1990 "the most significant air pollution legislation in our nation's history."

Nor would there be a Clean Air Act without the leaders in the U.S. Congress: Senators Mitchell, Baucus, Chafee and Dole, and Congressmen Dingell, Waxman and Lent -- not to mention their tireless staffs, who rarely get the credit they deserve.

The Clean Air Bill passed in the Senate by a vote of 89-11, and in the House by a vote of 401-25. You don't have to be a mathematician or an economist to understand what these numbers mean -- an overwhelming mandate from the American public and a clear national agenda for action.

Perhaps most remarkably, the Clean Air Act also reflects the needs and interests of both American industry and the environmental community. Up until now, these two groups have worked together about as closely as General Custer and Sitting Bull!

But both played an important role in shaping these laws, after 13 years of deadlocked debate. Today, industry leaders and environmentalists are advising EPA -- in an unparalleled collaborative process -- in the writing of new clean air regulations. In the process, they are showing a willingness to compromise, and increasingly, even to trust each other.

Where did this consensus come from? I believe the Act itself is the foundation -- because it accomplishes sweeping environmental reforms that clean the air -- while allowing the marketplace to function. It also achieves the nation's energy policy objectives.

There's something for everyone. The Act is truly market-based. Several of its programs actually promote competitiveness and stimulate the free enterprise system. We call it E to the power of three. Achieving environmental objectives, stimulating the economy and saving energy. Today, EPA is moving with incredible speed -- especially by federal regulatory standards -- to implement 55 major rules by November of next year. It's an awesome task -- or as my children would say -- totally awesome!

But so far we are on schedule and on target -- in large part because we are getting a great deal of support -- and a minimum of resistance -- from business.

That's a big change. But I see an even bigger and broader change -- and it's happening right before our eyes:

In matters affecting Clean Air, I believe that the national agenda, the state agenda, the consumer agenda, and the corporate agenda -- all are in tune with the environmental agenda. It's an "alignment of forces" that is completely without precedent.

Let me give you a three quick examples of how this new clean air alignment is working:

Last Thursday, just four days ago, I was in Governor Fife Symington's office in Phoenix, Arizona to announce an agreement that will reduce -- by 90 percent -- the sulfur dioxide emissions from the Navajo Generating Station, which sits on the rim of the Grand Canyon.

As EPA Administrator Bill Reilly said recently, "the Grand Canyon is to the United States what the grand cathedrals are to Europe. It's a symbol worldwide of the American landscape."

For years, pollution from the Navajo power plant has impaired visibility in the Grand Canyon. But in the flurry of conflicting claims and accusations, and the protracted litigation that followed, nothing was done about the problem.

Now I realize that for many in this room, the phrase "protracted litigation" may have a very nice ring to it. As I said, I'm a lawyer myself so I can appreciate that. But in this case -- after a twenty-year dispute -- we were able to forge a compromise without litigation, in a way that served the public interest -- and in a form that all parties could live with.

Several months ago, EPA Administrator Bill Reilly and I went to Arizona and met with Mark DeMichele, chief executive of the Arizona Public Service Company and with the Governor. These meetings set the stage for five months of negotiations. And on Thursday,

Governor Symington, the owners of Navajo -- including the Salt River Project, the environmentalists -- including Grand Canyon Trust and the Environmental Defense Fund -- all gave their endorsement to this agreement.

Now that's what I call an alignment of forces! Thursday's Wall Street Journal carried the banner: "Accord Is Reached To Clean The Air Of Grand Canyon." The front page of Friday's New York Times heralded the pact with the following headline: "Utilities Take Steps To Cut Haze At Grand Canyon -- Companies and Environmental Groups Reach Agreement."

Even old Sitting Bull would have been impressed!

Example Two: In the next week we hope to publish a negotiated regulatory agreement on reformulated gasoline and oxygenated fuels. Clean fuels alone will move us a very long way toward solving the nation's number one cause of air pollution: automotive tailpipe emissions and evaporating fuel.

This agreement was the product of a unique regulatory negotiation process called "Reg-Neg," which brought all of the players to the table: The American Petroleum Institute, the Motor Vehicles Manufacturers Association, the Natural Resources Defense Council, the Sierra Club, the methanol and ethanol industries.

Talk about an eclectic group! But do you know what? We involved them in the regulatory process -- and they quickly became an alignment of forces. Unlikely as it may seem, these folks worked together and helped us to hammer out details of rules that will take giant steps toward cleaner air -- and that also give industry a maximum degree of flexibility. Their proposals were environmentally progressive, economically sound and even

energy efficient. Together with the RVP rule, these programs will save an estimated 6 billion gallons of gasoline per year. Another example of E to the power of three!

Perhaps the most dramatic example of this new alignment can be seen in the work of our Acid Rain Advisory Committee (ARAC) -- 44 members who at the outset had only two things in common: they all disagreed with each other and they all disliked EPA!

Utilities, state regulators, environmental and consumer groups, the coal and gas industry, pollution control manufacturers -- we even let in a few lawyers -- if they promised to behave! We discovered, much to our surprise and delight, that if you put a group of adversaries in a hot stuffy room, and let them talk -- long enough and loudly enough -- they will agree to almost anything!

In fact, the ARAC Committee has been extraordinarily helpful to our work. They have met seven times in the past eight months -- addressing hundreds of issues -- and they have helped EPA to write a thousand pages of Acid Rain regulations. (I said they were helpful. I didn't say they were succinct!)

Their biggest contribution was to structure the Allowance Trading Program, which enables utilities to buy and sell sulfur dioxide emissions allowances. This unique program was in the national news just recently, when the Chicago Board of Trade announced it had voted to create a market for buying and selling emission credits.

The details still need to be worked out, but for anyone who still doubts EPA's commitment to market-based principles, I ask you, "What could be more enterprising than the Commodities Market? Perhaps Bill Reilly should consider a new motto: "EPA is bullish on the environment!"

So who is providing the impetus for this new clean air alignment? I believe it's coming from an environmentally awakened American public -- from a more sophisticated, better focused, and better financed environmental movement -- from the President and Congress -- from Bill Reilly, who is taking the message to the American people, and from the states, who are raising their own environmental standards.

But the impetus is also coming from within American industry. To cite a few examples:

-- Detroit Diesel Corporation: maker of heavy duty diesel engines for trucks and buses. Just last Tuesday, I was with company president Roger Penske when he announced the development of a methanol engine for buses -- to replace outmoded and heavily polluting diesel bus engines. Nothing represents air pollution to the public like a dirty, smoking urban bus. Penske, as you may know, has been a champion race car driver -- but he is also an environmentalist. (That proves, of course, that "real men" do care about clean air.) Penske is also a good businessman. Since he took over in 1988, Detroit Diesel has upped its market share from three percent to 22 percent. I'm sure Roger sees another market opportunity with clean air bus engines.

-- Monsanto Company: just reported on its progress in reducing toxic air emissions company wide by 90 percent.

-- Dow Chemical also has pledged to cut substantially its toxic emissions. The reason, says company president Frank Popoff: "It's good business."

-- Dupont has developed a new coolant with dramatically reduced CFC content. Dupont's chief executive said that, in his case, CEO not only stands for chief executive officer -- it also stands for chief environmental officer.

-- Arco has developed a reformulated gasoline product, and the other oil companies are following suit -- to meet the new challenge from methanol, ethanol and natural gas. (That sounds like healthy competition to me!)

-- The Big three automakers -- GM, Ford, and Chrysler are climbing aboard the clean air bus -- and they're hoping to build that bus at a profit. They're also developing electric cars, methanol cars, and reformulated gas vehicles.

-- Their foreign competitors are moving at least as swiftly. Volvo's new preheated, catalyst M-85 car is being tested in California.

-- Nissan has developed new air conditioning systems with no CFCs.

The list of green companies just keeps growing:

-- McDonalds has dropped styrofoam packaging -- and is cutting 80 percent of its waste.

-- UPS and Federal Express are converting trucks to natural gas in ozone non-attainment areas.

-- Finally, 3M Company -- whose 3P Program -- Pollution Prevention Pays -- has been a major success. Today 3M is developing filter traps in buses to reduce particulates; chemical substitutes to replace CFCs; and solventless adhesives to cut air toxics.

Progressive companies like these have the foresight to recognize that this new spirit of environmentalism is no passing fancy -- but instead represents a fundamental change in the American culture. They see that clean air and pollution prevention are the wave of the future -- not only for government regulators, but for their customers. These companies are "catching the environmental wave," and riding its crest, instead of waiting for it to wash over them.

At EPA, we are tailoring these new clean air regulations to fit the agendas of the most progressive companies in each industry. Our programs are market-based, performance-based, and non-prescriptive. We are encouraging -- and rewarding -- the industry leaders who meet their own, their customer's, and EPA's environmental objectives. And we are challenging their competitors to catch up!

By building consensus with industry, the environmental community, and EPA staff -- we are strengthening the clean air alignment. And, finally, we are achieving the President's goal of balancing environmental progress, economic growth, and sound energy policy. E to the power of three.

The clean air forces are aligned and moving together. The environmental leaders in American industry are joining the alignment and adding to the momentum.

When our work is done, the beneficiaries of our efforts will be our children and grandchildren. They will reap the rewards of cleaner cars and fuels -- cleaner power plants, chemical plants, and steel mills -- cleaner refineries, cleaner refrigerators and even cleaner dry cleaners!

Best of all, we will endow them with a rich legacy of fresh, clean air.

We invite you to join this new alignment -- and we welcome you aboard the clean air bus!

Thank you.

AUG 14 '91 10:40AM AT&T FAX 9015PF

Post 8-14-91

Post-it™ brand fax transmittal memo 7671 | # of pages »

To Ed Norton et al | From Knuffke | Co. | Co. TWS | Dept. | Phone # | Fax # | Fax #

THE DENVER POST

SINGLETON, Chairman
F. HUNT, Publisher
N McKIBBEN, President and General Manager
IARD JACOBS, Administration and Operations
FRANK DIXON, VP Operations
STEVE HESSE, VP Circulation
KEN CALHOUN, VP Marketing

F. GILMAN SPENCER, Editor
CHUCK GREEN, Editor of the Editorial Page
NEIL WESTERGAARD, Executive Editor
GAY COOK, Managing Editor
WILLIAM H. HORNBY, Senior Editor

Cleaning up the canyon

DAYBREAK AT the Grand Canyon is an excursion into spiritual silence. On a clear morning, a visitor can peer over the precipice and seemingly see into infinity. Every rock ridge, every color-splashed stone, every rugged wave on the Colorado River far, far below is etched perfectly in the crystalline light of a southwestern dawn.

But on certain days the gray tentacles of civilization seep into this cherished national treasure in the form of a terrible smog. There are times that the air pollution at the Grand Canyon is so bad that it's impossible to see the opposite rim. What's more, the same pollution appears to have fouled the air in Mesa Verde National Park in Colorado and several national playgrounds in Utah, such as Capitol Reef and Bryce Canyon. Americans who have witnessed this deterioration have been outraged.

Yet they now ought to be cheered by an agreement announced last week between a coalition of environmental groups and the operators of the giant Navajo power plant near Page, Ariz., that has created most of the air pollution fouling the Grand Canyon and surrounding national lands. The pact ends two decades of bickering and represents a complete change in how industry and environmentalists solve problems: instead of litigating, they negotiated.

The two sides didn't dream up this plan on their own, however. It was a shotgun marriage forcefully arranged by the U.S. Environmental Protection Agency, which previously had proposed a cleanup plan that neither the environmentalists nor the power company found tolerable.

The marriage appears to have produced a healthy baby — a new plan that will create cleaner air for fewer dollars than the EPA's initial proposal.

The EPA's original plan would have reduced air pollution by only 70 percent and would have required the power plant to spend $106 million annually to install redundant pollution-control equipment. Under the new plan, which the EPA still must approve, the power plant will have to cut its emissions by 90 percent, but won't have to install as many back-up "scrubbers," so the total cost of the cleanup will be only $89 million a year.

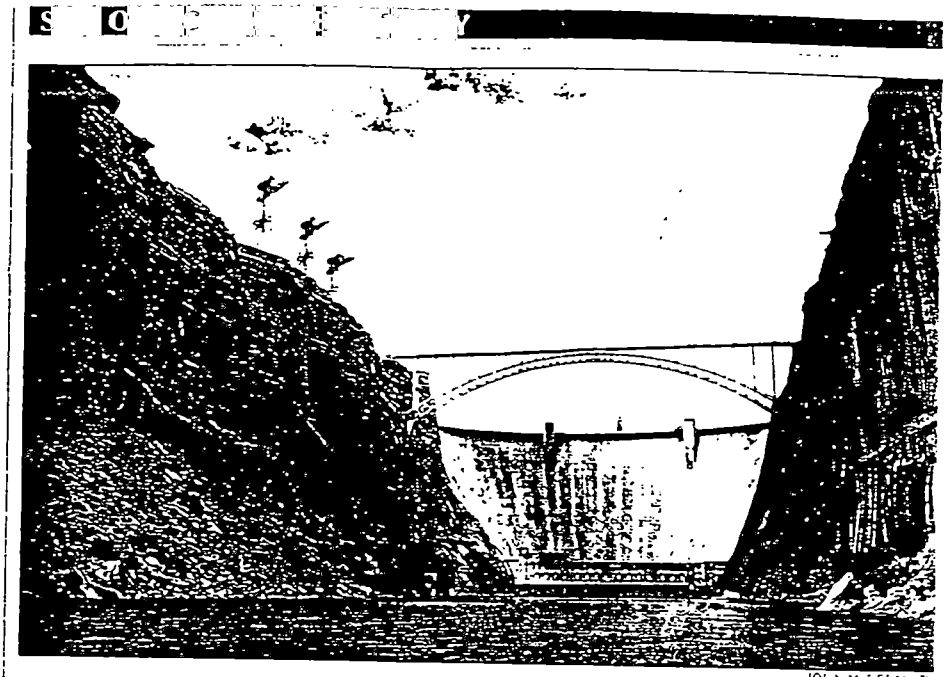
The agreement won't clean the skies over the Grand Canyon and surrounding national playgrounds until the turn of the 21st century. But that's a quicker improvement than would have been accomplished if the environmentalists and the power company continued with their endless lawsuits.

The EPA still must find solutions to regional haze and visibility problems affecting national parks in other parts of the country, where once-great vistas have vanished in the smog. But the recent agreement is so reasonable that it ought to serve as a model for future cleanup proposals.

It is, in effect, a grand plan for the Grand Canyon.

RE

Colo crat, have d to do s pass a Rep. I Wirth/ of Rep of pris nated tions o But Club a groups dernes Wirth Campb Dan behalf "the th give a people lar, is wilder Colora States to clai portion year's suits:



JOHN M. GERNERT

Surging current: *Water from the Glen Canyon Dam has damaged the Grand Canyon*

ENVIRONMENT

Lifting the Canyon's Veil

On a clear day at the Grand Canyon, you can see ... scratch that. There have been so few clear days that many of the 4 million tourists flocking to the rim each year can't pick out the bas-relief of rock formations, or the brick and ocher veins marbling the canyon walls. "They just don't see the beauty of the place," says superintendent Jack Davis. Since 1976, much of the haze, especially in winter, has come from coal burned in the Navajo Generating Station, 15 miles to the northeast, whose owners never made good on a 1973 promise to install scrubbers. The pall violates the Clean Air Act, so in 1982 environmental groups sued. The case bogged down—until last week, when the Environmental Protection Agency's new resolve to encourage opponents to negotiate, not litigate, broke the logjam.

Led by the Grand Canyon Trust, environmentalists had pushed for a 90 percent reduction in sulfur emissions. The plant's owners, including the federal Bureau of Reclamation, thought zero percent sounded about right. EPA was about to side with the environmentalists but, under pressure from the White House, recommended a 70 percent cut this February. But neither side was happy. That's when EPA Assistant Administrator William Rosenberg got both parties together. The trust proposed allowing the Navajo's owners to average sulfur emissions over a year, rather than monthly. This strategy would let the plant get by without costly backup scrubbers but still cut emissions more than 90 percent for $90 million—$18 million *less* than EPA's proposed 70 percent cut would have. The owners were convinced. President Bush called the accord "a milestone in our implementation of the Clean Air Act and in our efforts to protect one of America's crown-jewel national parks." He will visit the canyon next month to celebrate the accord.

The canyon faces one more threat. For years the Glen Canyon Dam has released wildly fluctuating amounts of water into the Colorado River to meet peak power demands. The surging current—which sometimes raises the river by 13 feet—has eroded the Grand Canyon's beaches, destroyed habitats of its fauna and flora, and begun to eat away at about 300 of the 400 Indian archeological sites and sacred places. Last week Interior Secretary Manuel Lujan announced that he would order the flow stabilized. That should have little impact on electricity supply—utilities can buy power from the grid—but will limit destruction downstream. To make the policy stick, the Senate is weighing a bill that requires Glen Canyon to be operated in a way that protects downstream sites. The House passed the measure in June, and Sen. Bill Bradley of New Jersey, a sponsor of the bill, thinks its chances are excellent. "When it passes," says Ed Norton of the Grand Canyon Trust, "the idea that power has primacy will be dead meat forever." And the water that carved the Grand Canyon eons ago will no longer destroy it.

SHARON BEGLEY with MARY HAGER in the Grand Canyon

The New York Times

Founded in 1851

ADOLPH S. OCHS, *Publisher 1896-1935*
ARTHUR HAYS SULZBERGER, *Publisher 1935-1961*
ORVIL E. DRYFOOS, *Publisher 1961-1963*

ARTHUR OCHS SULZBERGER, *Publisher*
ARTHUR OCHS SULZBERGER JR., *Deputy Publisher*

MAX FRANKEL, *Executive Editor*
JOSEPH LELYVELD, *Managing Editor*
WARREN HOGE, *Assistant Managing Editor*
DAVID R. JONES, *Assistant Managing Editor*
CAROLYN LEE, *Assistant Managing Editor*
JOHN M. LEE, *Assistant Managing Editor*
ALLAN M. SIEGAL, *Assistant Managing Editor*

JACK ROSENTHAL, *Editorial Page Editor*
PHILIP M. BOFFEY, *Deputy Editorial Page Editor*

LANCE R. PRIMIS, *President and General Manager*
RUSSELL T. LEWIS, *Sr.V.P., Deputy General Manager*
JOHN M. O'BRIEN, *Sr.V.P., Deputy General Manager*
ERICH G. LINKER JR., *Sr.V.P., Advertising*
WILLIAM L. POLLAK, *Sr.V.P., Circulation*
ELISE J. ROSS, *Sr.V.P., Systems*
JAMES A. CUTIE, *V.P., Marketing*

Cleaner Air, by Consensus

The biggest question left by the Clean Air Act of 1990 — President Bush's grandest legislative achievement so far — was whether its promise would be thwarted by bureaucratic infighting, regulatory paralysis and endless litigation. That's been the sad fate of other ambitious laws, including the original Clean Air Act of 1970.

Although the jury is still out on the new act, legislators already complain that the President's Council on Competitiveness, headed by Vice President Quayle, is becoming a haven for businesses seeking to avoid costly investment in anti-pollution equipment. In one case, the council pressured the Environmental Protection Agency to ease regulations on old coal-fired power plants.

But there's promising news as well. In the last two weeks the E.P.A. has announced two major agreements aimed at cleaning the air in America's dirtiest cities and above the Grand Canyon. In both cases, agreement was reached only after the agency gathered traditionally hostile interests in one room and invited a consensus — using a process called regulatory negotiation or, in Washington-speak, "reg-neg."

By whatever name, it's an immensely valuable procedure that ought to be used far more often than it is. For one thing, the parties to a consensus are less likely to challenge government regulations at some later date, not least because they helped write them. That means fewer lawsuits and fewer attempts to subvert the purposes of the act through backdoor intervention with the Office of Management and Budget — or Mr. Quayle.

One agreement involved a crucial provision of the 1990 act requiring oil refiners to produce a cleaner-burning gasoline to reduce smog in the nation's nine dirtiest cities, including Los Angeles and New York. The act was far from clear on how that goal was to be reached, so the E.P.A. summoned representatives from 30 different interest groups, including environmentalists and oil company executives, for two months of negotiations.

The result was a compromise under which gasoline sold in 1995 will be 15 percent cleaner than it is now. Industry will be allowed to average the 15 percent reduction in ozone-forming hydrocarbons so that some gallons come in higher, some lower. That gives the companies flexibility to accommodate differences among refineries. But it's wholly consistent with the intent of the act.

The second set of negotiations involved the haze that fouls the Grand Canyon. The haze comes from sulfur dioxide emissions from the Navajo Generating Station, a giant coal-burning plant 15 miles northeast of the canyon. Environmentalists and the E.P.A. wanted a 90 percent reduction; the plant's owners, though clearly in violation of the law, wanted none. Mr. Quayle's council recommended a 70 percent cut.

The owners eventually agreed to the original 90 percent target — but only after the environmentalists proved to the company that, by using a complex averaging scheme, the company could meet the target at lower cost than it thought possible.

Nobody said that carrying out the act would be easy. And regulations have yet to be written for controversial sections of the law covering toxic chemicals and acid rain. Yet the odds of success went up when the E.P.A. established a simple principle: Negotiation now beats litigation later.

San Francisco Chronicle
THE VOICE OF THE WEST

8-12-91

EDITORIALS

Clean Skies At Grand Canyon

A NATIONALLY significant agreement reached by environmentalists and the owners of a power plant in northern Arizona promises to control the air pollution that envelops the Grand Canyon and sometimes blocks the world-famous view from rim to rim.

Industrial pollution from the huge coal-burning Navajo Generating Station 12 miles from the canyon has also raised concern about haze that could threaten seven other national parks and monuments in Utah, Arizona and Colorado.

Bright white haze can block views from rim to rim

The plan announced last week is the culmination of one of the most bitter environmental battles in the West and it marks the first time that a 1977 federal law will be used solely to improve visibility at a national park. Hence, the agreement can be used as an effective precedent for other national parks with problems stemming from haze.

ACCORDING TO the deal, the owners of the Navajo utility will install $430 million of control devices on their smokestacks and hopefully achieve a 90 percent reduction in sulfur dioxide emissions by the end of the decade.

Cleaning the skies over the Grand Canyon, a national landmark and a worldwide symbol of the American West, is of such political importance that the agreement could be the catalyst for a possible trip to the park by President

THE ARIZONA REPUBLIC
Founded in 1890 Published since 1946 by
Phoenix Newspapers, Inc., 120 E. Van Buren, Phoenix, Ariz. 85004

EUGENE C. PULLIAM 1889-1975 Publisher, 1946-1975
EUGENE S. PULLIAM President
WILLIAM P. CHESHIRE Editor of the Editorial Pages
JOHN F. OPPEDAHL Managing Editor
CONRAD KLOH Director of Sales and Marketing
BILL SHOVER Director of Public Affairs

Where The Spirit Of The Lord Is, There Is Liberty — II Corinthians 3:17

EDITORIALS

GRAND CANYON HAZE

Compromise in the works

FOR the past several weeks the various factions in the effort to clean up the winter haze at Grand Canyon National Park have been negotiating a plan to reduce sulfur dioxide emissions from the Navajo Generating Station at Page. Lately the signs are that a compromise is in the works.

The clearest indication of a pending accord was the decision to prolong the talks beyond the July 4 deadline set by William Rosenberg, assistant administrator of the Environmental Protection Agency. A recent EPA statement suggested that enough progress was being made on the issue of anti-pollution controls at the Page power plant to justify more negotiations.

Moreover, the agency's optimism underscores the importance that the Bush administration has attached to resolving this dispute. The Bureau of Reclamation owns the largest share of the power plant. Given Mr. Bush's desire to be known as "the environmental president," the idea of the feds contributing to canyon air pollution would hardly be welcome.

Should the talks between the EPA, the Salt River Project and the non-profit Grand Canyon Trust collapse, it would be up to the EPA to impose a cleanup plan on the coal-fired power plant. Depending on what action the EPA took, SRP and the other utilities that own the power plant or the environmental community could take the matter to court, and that would further delay emission controls at Navajo.

This point should not be lost in the wrangling over the technical arcana on reaching an agreement on emission limits. To be sure, the issue of the canyon's haze has been studied to death. It remains only to apportion the power plant's contribution to the problem. Is Navajo a "major contributor" (as the National Park Service insists), has it "contributed significantly" (as the National Research Council concludes), or is the plant's contribution less than 10 percent (as SRP, the plant's operator, alleges)?

The Interior Department has been conspicuously absent from the talks and appears content to sit on the fence. It has refused to back either the NPS call for a 90 percent emission reduction or the Bureau of Reclamation's desire to do nothing at all. Nevertheless, Secretary Manuel Lujan is obliged to protect the national parks and he should take a position. Furthermore, the power plant's operators agreed in their original environmental impact statement to install anti-pollution equipment, a promise that remains unfulfilled.

At least Interior's wishy-washiness has not deterred the EPA from pushing hard for a satisfactory resolution of the issue. All the parties to the dispute should keep working to achieve the best possible reduction of emissions from the Navajo plant.

The Washington Post

AN INDEPENDENT NEWSPAPER

Creeping Reg-Neg

ONE OF the places where government tends to break down is at the busy intersection of politics and science. Congress is simply not equipped to make the technical judgments that many of the laws it passes require, particularly in the health and safety and environmental fields. The technical issues are hotly contested besides; the typical legislative response is to take refuge in a fuzzy formulation and toss the matter to the regulators who have become the modern government's fourth branch. Too often the regulators' handiwork will then be taken to the courts by the very parties who were fighting over the wording in Congress in the first place. The business of giving effect to the laws tends to be more circular than quick.

Now comes a new process intended as a kind of shortcut through this laborious older pattern. It is called reg-neg, which stands not for negation but for regulatory negotiation. The negotiations process may already have helped to crack two of the harder issues from last year's copious amendments to the Clean Air Act, including an almost impenetrable set of questions relating to alternative fuels on which tentative agreement was announced last week.

The Administrative Conference of the United States, having commissioned a study, approved regulatory negotiation for use by federal agencies in 1982. Last year Congress gave its official blessing as well. Normally an agency with a regulatory task assembles what information it can and writes the rule on its own. The rule is published for comment, then fine-tuned or not as the agency and Office of Management and Budget, representing the president, see fit, and made final. That's when one side or the other and sometimes both will take it to court, and while the courts can only overturn regulatory decisions on rather limited grounds, the litigation tends to eat up a lot of money and time.

The negotiating process is in part an effort to do the fighting up front. A committee is formed—the law requires that it be broadly representative of the parties at interest—and tries to work out a compromise acceptable to the parties and the agency in advance. The compromise will often include a promise to refrain from future litigation. The negotiating sessions are required to be public; in that sense the process is even more open than normal rule writing. Once agreement is reached, the proposed rule is still published in the Federal Register for comment as under normal procedures. Thus no group forfeits any right, including the right to go to court, that it already has.

The process has been tried about 20 times, mostly though not always with success. Federal officials note that not all disputes are amenable to it; sometimes the span of disagreement is so great that the agency can only cut through on its own as in the past. But where it works, as apparently with alternative fuels, it's plainly a good idea. Regulatory government on the present scale is recent enough that the country is still feeling its way. This seems to be a sensible step along the path.

Accord Is Reached To Clean the Air Of Grand Canyon

By BARBARA ROSEWICZ
Staff Reporter of THE WALL STREET JOURNAL

WASHINGTON—Ending years of opposition, owners of a huge Western power plant struck a deal with environmentalists to slash air pollution blamed for obscuring views of the Grand Canyon.

The accord is to be announced today in Arizona. But a spokesman for the Phoenix-based Salt River Project, operator and part-owner of the Navajo Generating Station, confirmed the agreement, which has been secretly negotiated for months.

Under the agreement, owners of the Navajo power plant in Page, Ariz., would install $430 million of air-pollution-control devices on its three giant smokestacks to clean the air and improve visibility at the canyon, a national landmark 12 miles away.

The agreement marks the first time that a 1977 federal law would be enforced to improve visibility at national parks, a growing concern around the country and the subject of lawsuits by environmental groups. The plume of sulfur dioxide from the coal-fired Navajo plant is blamed for contributing, particularly in winter, to a bright white haze that on the worst days can keep visitors from seeing across the canyon.

Pushed by environmental lawsuits, the federal government had begun taking steps to force cutbacks in pollution by the plant. But utility owners were contesting such steps. The deal is unusual because it voluntarily brings together factions that have been warring over pollution in the Grand Canyon for more than a decade. Plus, under the agreement, owners of the power plant—five utility companies and the U.S. Interior Department—would make even steeper cuts in sulfur-dioxide emissions than proposed by federal regulators, though at a reduced overall cost than under the federal plan.

The federal government is expected to approve the deal and write it into a new regulation. The White House already is embracing the accord as an example of how cost-effective solutions can be found for environmental problems, and the agreement could spur a trip by President Bush to the Grand Canyon later this year, an administration official said.

According to people close to the negotiations, environmental groups led by the Grand Canyon Trust won a 90% cutback in sulfur-dioxide emissions by 1999, more than the 70% proposed by the Environmental Protection Agency earlier this year. The incentive for the plant's owners, who originally had contested even the 70% cutback, was that they could adjust some of the technical requirements to lower their costs.

The agreement lowers the costs of compliance to an estimated $89 million a year, from $106 million annually as proposed under the EPA's plan. The cost savings would result from giving the plant additional years to begin installing its first "scrubbing" devices, and from removing a requirement that a costly back-up scrubber be installed for each boiler.

Still, the costs represent a significant expense for a plant that already burns low-polluting, low-sulfur coal and already is cleaner than the scores of power plants targeted by new acid-rain requirements. Taxpayers will share in the costs because the U.S. Bureau of Reclamation, in the Interior Department, owns the largest share of the plant, 24.3%. Other owners are: the Salt River Project, 21.7%; Los Angeles Department of Water and Power, 21.2%; Arizona Public Service Co. unit of Pinnacle West Capital Corp., 14%; Nevada Power Co., 11.3%, and Tucson Electric Power Co., 7.5%.

Ed Norton, head of Grand Canyon Trust in Washington, which negotiated for environmental groups, called the deal "a very good agreement" that will benefit not only the canyon but a circle of nearby national parks. However, he said it won't eliminate haze in the canyon because it's also caused by smog from Los Angeles and other nearby urban areas.

The Navajo plant is one of the largest coal-fired plants in the Western U.S. Its owners entered negotiations, which were informally initiated by the EPA, after contesting for years studies linking the plant to haze in the canyon.

LOS ANGELES TIMES THURSDAY, AUGUST 8, 1991 A13

Power Plant Agrees to Stiffer Smog Curbs

■ Pollution: Accord calls for 90% reduction in sulfur dioxide emissions at Grand Canyon by 1999. EPA had sought a 70% cut.

By LARRY B. STAMMER
TIMES ENVIRONMENTAL WRITER

The Los Angeles Department of Water and Power and other owners of a huge Arizona power plant whose emissions obscure scenic vistas at the Grand Canyon have agreed to tougher smog controls than proposed by the U.S. Environmental Protection Agency.

The agreement, to be announced today in Phoenix in Gov. Fife Symington's office, follows months of intensive negotiations with environmentalists.

The accord calls for a 90% reduction in visibility-impairing sulfur dioxide emissions by August, 1999, at a cost of $89.6 million.

In February, the EPA—reportedly under pressure from the White House to hold down costs—said it would insist on no more than a 70% cut in emissions from the Navajo Generating Station, situated 80 miles northeast of the Grand Canyon's South Rim.

But environmentalists, led by the Grand Canyon Trust, and operators of the 2,250-megawatt plant in Page, Ariz., said that the EPA has backed the compromise.

Owners of the plant agreed because the new controls, although stricter in the long run, will have a lower cost because of less restrictive interim compliance deadlines.

The agreement was hailed Wednesday as a forerunner of future efforts to protect the pristine air of the nation's national parks and wilderness areas, many of which are under a growing smog siege.

If the controls are accepted by the EPA, as expected, it will mark the first time since Congress enacted the Clean Air Act in 1977 that the law has been invoked to specifically protect air quality in national parks and wilderness areas.

"I do not think that it abuses the word to call this agreement truly historic," said Ed Norton, president of the Grand Canyon Trust, which was one of the principal environmental negotiators of the pact.

"If the EPA adopts the . . . recommendation, it will be the first time that the agency has acted solely to protect visibility and the paramount aesthetic values of a national park," Norton said.

Barring unforeseen developments, the EPA regulations enforcing the agreement will become final sometime after a 30-day public comment period.

Despite the agreement, operators of the plant remained at odds with environmentalists over how much cleaner the Grand Canyon's air would be with the tougher controls.

Whatever the improvement, both sides agreed that it would be substantial. One study said that 40% of the man-made haze over the park could be blamed on the plant, which is said to be the largest source of sulfur dioxide emissions in the Southwest.

Under terms of the agreement, owners of the plant will be given until August, 1999, to complete the installation of pollution controls—two months earlier than the EPA proposed last February.

However, plant owners will be given two additional years to start fitting the controls on the power plant. Moreover, by averaging pollution on a yearly basis instead of a monthly basis, as first proposed, operators will have more flexibility in meeting the goal. It will also save them money.

Under the old proposal, operators estimated that it would cost them $106 million to comply. Under the new approach, the costs were placed at $89.6 million.

The DWP said that the controls will cost the average homeowner, who pays $40 a month for power, another 20 cents.

The plant is operated jointly by the DWP, Salt River Project, Arizona Public Service Co., Tucson Electric Power, Nevada Power Co. and the U.S. Bureau of Reclamation.

UTILITIES TO TAKE STEPS TO CUT HAZE AT GRAND CANYON

BIG POWER UNIT AFFECTED

Companies and Environmental Groups Reach Agreement—Impact Is Years Away

By KEITH SCHNEIDER
Special to The New York Times

WASHINGTON, Aug. 8 — After two decades of court battles and regulatory skirmishes, the owners of a giant coal-burning power plant in northern Arizona agreed today to a series of expensive measures to control air pollution and reduce haze in the Grand Canyon by the end of the decade.

The agreement, between the owners and two environmental groups, is almost certain to end one of the angriest and most visible environmental struggles in the American West. In recent years, thick haze had turned the Grand Canyon from a breath-taking natural wonder to a sad tableau of spreading industrial pollution and Government inaction. On many days, particularly in the winter, the haze is so thick that visitors standing on one rim can barely see the other side.

The power plant blamed for much of the haze had also become a symbol for environmentalists of industrial excess: every bit as visible as the towering brownish-yellow plume of soot and smoke that poured from its 770-foot smokestack across the fragile desert landscape.

Open to Public Comment

Under the agreement, which will be open for public comment and is likely to be adopted as law this fall by the Environmental Protection Agency, which assisted in negotiations, six owners would spend roughly $430 million to install pollution control equipment on the power plant's three boilers, with the first boiler-scrubbing system to be installed by 1997 and the last by 1999.

The equipment will be designed to capture sulfur dioxide, a gas produced from the burning of coal that is chemically transformed into particles when it reacts with sunlight and other chemicals. If the equipment works properly, it will reduce the amount of sulfur dioxide pouring from the plant's smokestacks to 6,000 to 7,000 tons a year, a 90 percent reduction from the 65,000 to 70,000 tons now produced each year.

The plant generates power for four million people and businesses in Arizona, Nevada and California and to the Central Arizona Project, a manmade canal and pump system that provides water from the Colorado River for Phoenix and Tucson.

"The Grand Canyon is to the United States what the grand cathederals are to Europe," said William K. Reilly, the Administrator of the Environmental Protection Agency. "It's part of our heritage, a symbol worldwide of the American landscape."

Suit Brought in 1984

The pact reached today after months of negotiations settles a Federal lawsuit brought in 1984 against the power plant's owners by the Environmental Defense Fund, a national environmental group and the National Parks and Conservation Association, a Washington-based group.

It also ends a ticklish internal battle between two units at the Department of the Interior. The National Park Service, which owns and operates Grand Canyon National Park, has fought for the controls for years. The Bureau of Reclamation, which owns 24 percent of the power plant, the largest share, has fought the controls, saying that the cause of haze had not been proven and that controlling sulfur dioxide would cost too much.

And the agreement represents a small victory for the Environmental Protection Agency.

After reviewing studies of the haze and its causes, Mr. Reilly was prepared late last year to require the plant, the Navajo Generating Station, to reduce sulfur dioxide emissions 90 percent. But in February, the E.P.A. proposed a reduction of just 70 percent after the Office of Management and Budget and the White House objected, saying that the costs of a 90 percent reduction were too high.

An E.P.A. Eye on Costs

Within the February proposal, though, was a provision that the E.P.A. knew would make a 70 percent reduction so expensive that the owners of the power station were likely to negotiate a less costly solution. The proposed rule in February would have required the Navajo power plant to be able to cut sulfur dioxide emissions 70 percent over each month, allowing the plant less flexibility than if the emissions were measured over a year, allowing for good months and bad months.

The restrictions in the February pro- have had to install three pollution control systems on each boiler instead of two because if one system failed, a backup was necessary to meet the regulation. The owners and the E.P.A. estimated the cost of installing the systems under the February proposal at $510 million.

The agreement reached today calls for the plant to cut emissions 90 percent on an annual average, thus allowing it more flexibility. The effect of the longer time frame is that the plant will need to install two pollution control systems on each boiler instead of three. If one fails, the plant has more time to repair it and still make the 90 percent limit. The estimated cost of the new strategy is $430 million.

The E.P.A. played a pivotal part in providing technical specialists and data to help the negotiators, a role that was discouraged by the White House when the talks opened in April, according to E.P.A. officials who asked to remain unidentified. The White House later relented after the Bush Administration recognized the symbolic political importance of a deal to scrub the skies in the Grand Canyon.

Costs to Be Apportioned

The owners will share the cost of the pollution control equipment in percentages equal to their share of ownership, with the Bureau of Reclamation responsible for roughly $103 million of the total. Other owners are the Salt River Project, a Phoenix-based utility that also operates the plant; the Los Angeles Department of Water and Power, the Arizona Public Service Company, Tucson Electric, and Nevada Power.

The Navajo Generating Station, completed in 1976 and located 15 miles north of the Grand Canyon in Page, Ariz., has raised concern about its potential to pollute the skies of the Southwest from the day it was first proposed in 1970 by the Bureau of Reclamation. The bureau, the Government's powerful western dam-building agency, had wanted to build two dams in the Grand Canyon to provide hydroelectric power for the pumps that would divert Colorado River water into a canal to slake the thirst of Phoenix and Tucson hundreds of miles south.

The Sierra Club fought the dams, and when the Bureau of Reclamation relented in the 1960's it was the first time an environmental group had stopped a major Government dam in the West.

The alternative, though, proved just as troublesome to environmental groups, said Robert E. Yuhnke, a senior lawyer at the Environmental Defense Fund in Boulder, Colo. The bureau proposed the Navajo Generating Station, a 2,250 megawatt power plant fueled by 24,000 tons of coal a day, a plant so big — it covers 1,800 acres — and so polluting its trail of uncontrolled smoke could be seen miles away.

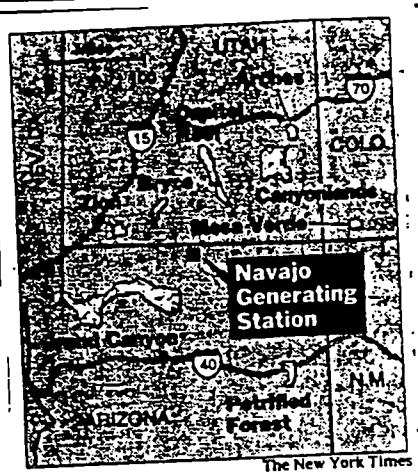
Other Parks Affected

Mr. Yuhnke said environmental

Cont'd

groups warned that the soot would cause haze in the Grand Canyon, and they worried about the seven other national parks and monuments on the Colorado Plateau in Utah, Arizona and Colorado. A study completed this year by the Environmental Defense Fund showed that the plant's soot was a factor in the haze that obscured those parks as well.

In 1973, the Department of Interior signed an agreement with the other owners that said that as soon as technology was available to control sulfur dioxide, it would be bought and installed at the plant. Mr. Yuhnke said such equipment was ready in 1976 when the $659 million plant was finished, but never installed.



The Navajo Generating Station is blamed for haze at eight parks.

end

A FRIDAY, AUGUST 9, 1991 USA TODAY

Grand Canyon to get clearer

By Rae Tyson
USA TODAY

The skies over Arizona's haze-shrouded Grand Canyon could be clearer by decade's end under a landmark agreement disclosed Thursday.

Sulfur-dioxide emissions from the coal-fired Navajo Generating Station will be cut 90% before August 1999.

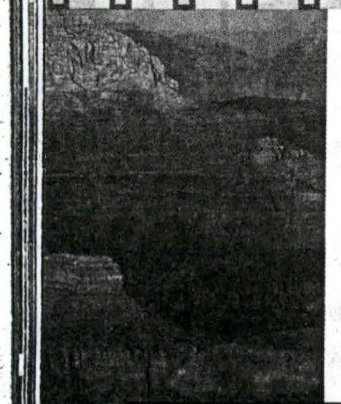
The settlement is the first under a Clean Air Act provision designed to improve visibility at national parks.

It will cost $2 billion to install pollution equipment on the plant's three smokestacks.

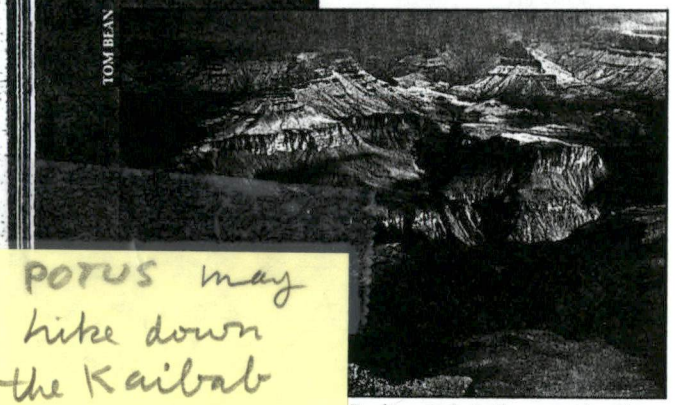
The plant is 12 miles from the northern end of the Grand Canyon. Environmentalists have considered it a big reason for the area's poor visibility.

"I do not think it abuses the word to call this agreement truly historic," says Ed Norton of Grand Canyon Trust, an environmental group.

The agreement won't completely eliminate haze there. Another major source: drifting Los Angeles smog.



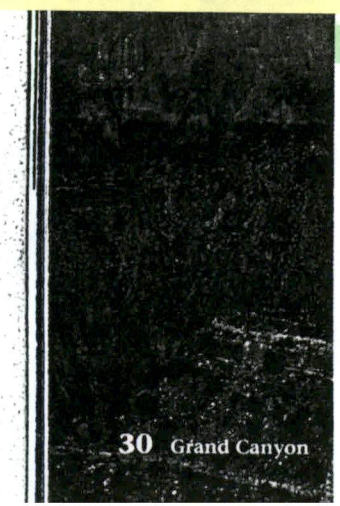
The forces of nature can carve wondrous formations out of the earth given enough time and the right confluence of erosion and upheaval. The Grand Canyon, nature's masterpiece of sculpted earth, provides our most awe-inspiring and informative example.



TOM BEAN

Fresh snow dusts the upper elevations of the South Rim. Snow rarely falls on the lower elevations of the canyon floor.

POTUS may hike down the Kaibab Trail.



The Land and Time

The Grand Canyon is a chasm cutting deeply into a mountainous region called the Kaibab Plateau. "Kaibab" is a Paiute Indian word for "mountain lying down." Scientists, considering the wealth of geologic evidence, have developed different theories for detailed geologic histories of the canyon's formation. However, most agree that a series of mountain-building upheavals starting 65 million years ago created the Kaibab Plateau. In fact, on the South Rim you stand above a canyon within a canyon. Over the course of two billion years the inner canyon rocks were formed from a succession of upheavals and erosion as tremendous forces within the earth caused mountains five to six miles high to rise. Then the erosive forces of wind and water erased these mountains grain by grain.

As the earth continued to rise and ripple, physical and chemical processes of erosion began to rip a chasm in the earth. Ever so slowly, over the next 50 million years or more, streams were rerouted and lakes began to drain, connecting with other water sources in a common search for the sea. Finally, four to five million years ago, a great river, what we now call the Colorado, found its way to the Gulf of California and began to erode the canyon as it cut down into the Kaibab Plateau to create the Inner canyon. Over time, the Colorado River has carved a vertical mile-high chasm into the earth.

Native Americans

Archaeologists speculate that Paleo Indians were the first to settle in the region about 11,000 years ago. As time ➤

CEQ annual report 1991

Table 39.--U.S. emissions of criteria air pollutants, by source, 1940-1989.

(million metric tons)

Year	Sulfur dioxide					
	Transportation	Fuel combustion	Industrial processes	Solid waste	Miscellaneous	Total
1940	2.9	11.0	3.7	0.0	0.5	17.6
1950	2.3	12.9	4.6	0.0	0.5	19.8
1960	0.4	14.0	5.3	0.0	0.5	19.7
1970	0.6	21.3	6.4	0.0	0.1	28.3
1975	0.6	20.3	4.7	0.0	0.0	25.6
1976	0.7	20.9	4.6	0.0	0.0	26.2
1977	0.8	21.5	4.7	0.0	0.0	26.9
1978	0.8	19.9	4.3	0.0	0.0	25.0
1979	0.9	19.5	4.4	0.0	0.0	24.8
1980	0.9	18.7	3.8	0.0	0.0	23.4
1981	0.9	17.8	3.9	0.0	0.0	22.6
1982	0.8	17.3	3.3	0.0	0.0	21.4
1983	0.8	16.7	3.3	0.0	0.0	20.7
1984	0.8	17.4	3.3	0.0	0.0	21.5
1985	0.9	17.0	3.2	0.0	0.0	21.1
1986	0.9	16.9	3.2	0.0	0.0	20.9
1987	0.9	16.6	3.2	0.0	0.0	20.7
1988	0.9	16.6	3.4	0.0	0.0	20.9
1989	1.0	16.8	3.3	0.0	0.0	21.1

Year	Nitrogen oxides					
	Transportation	Fuel combustion	Industrial processes	Solid waste	Miscellaneous	Total
1940	2.2	3.4	0.2	0.1	0.9	6.8
1950	3.5	4.7	0.3	0.2	0.6	9.3
1960	4.9	6.7	0.5	0.3	0.4	12.8
1970	7.6	9.1	0.7	0.4	0.3	18.1
1975	8.9	9.4	0.7	0.1	0.1	19.2
1976	9.3	10.0	0.7	0.1	0.2	20.3
1977	9.5	10.4	0.7	0.1	0.2	20.9
1978	10.3	10.3	0.7	0.1	0.2	21.7
1979	10.1	10.5	0.7	0.1	0.2	21.6
1980	9.8	10.1	0.7	0.1	0.2	20.9
1981	10.0	10.0	0.6	0.1	0.2	20.9
1982	9.4	9.8	0.5	0.1	0.1	20.0
1983	8.9	9.6	0.5	0.1	0.2	19.3
1984	8.8	10.2	0.6	0.1	0.2	19.8
1985	8.9	10.2	0.6	0.1	0.1	19.8
1986	8.3	10.0	0.6	0.1	0.1	19.1
1987	8.1	10.5	0.6	0.1	0.2	19.4
1988	8.1	10.9	0.6	0.1	0.3	20.0
1989	7.9	11.1	0.6	0.1	0.2	19.9

continued

Table 39 (continued).--U.S. emissions of criteria air pollutants, by source, 1940-1989.

(million metric tons)

Year	Reactive volatile organic compounds					
	Transportation	Fuel combustion	Industrial processes	Solid waste	Miscellaneous	Total
1940	5.2	4.7	3.3	0.9	4.6	18.6
1950	7.9	3.1	5.4	1.0	3.6	21.0
1960	11.1	1.9	6.3	1.4	3.1	23.8
1970	12.4	1.1	8.9	1.8	3.3	27.5
1975	10.3	1.0	8.1	0.9	2.5	22.8
1976	10.4	1.2	8.7	0.8	2.9	24.0
1977	10.0	1.4	9.0	0.8	2.8	24.2
1978	8.6	0.8	9.9	0.8	2.7	22.8
1979	8.0	0.9	9.9	0.7	2.9	22.4
1980	9.0	0.9	9.2	0.6	2.9	22.7
1981	8.9	0.9	8.3	0.6	2.5	21.3
1982	8.3	1.0	7.5	0.6	2.2	19.5
1983	8.2	1.0	7.9	0.6	2.7	20.3
1984	8.1	1.0	8.8	0.6	2.7	21.1
1985	7.6	0.9	8.5	0.6	2.6	20.2
1986	7.2	0.9	8.1	0.6	2.3	19.1
1987	7.1	0.9	8.3	0.6	2.5	19.4
1988	6.9	0.9	8.1	0.6	2.9	19.5
1989	6.4	0.9	8.1	0.6	2.5	18.5

Year	Total suspended particulates					
	Transportation	Fuel combustion	Industrial processes	Solid waste	Miscellaneous	Total
1940	2.7	7.5	8.7	0.5	3.7	23.1
1950	2.1	7.0	12.7	0.6	2.5	24.9
1960	0.7	5.7	12.5	0.9	1.8	21.6
1970	1.2	4.6	10.5	1.1	1.1	18.5
1975	1.4	2.7	5.0	0.6	0.7	10.6
1976	1.4	2.5	4.4	0.4	1.0	9.7
1977	1.4	2.5	4.0	0.4	0.8	9.1
1978	1.4	2.5	4.0	0.4	0.8	9.1
1979	1.4	2.5	3.8	0.4	0.9	8.9
1980	1.3	2.4	3.3	0.4	1.1	8.5
1981	1.3	2.3	3.0	0.4	0.9	8.0
1982	1.3	2.2	2.6	0.3	0.7	7.1
1983	1.3	2.0	2.4	0.3	1.1	7.1
1984	1.3	2.1	2.8	0.3	0.9	7.4
1985	1.4	1.8	2.8	0.3	1.1	7.3
1986	1.4	1.8	2.5	0.3	0.9	6.8
1987	1.4	1.8	2.5	0.3	1.0	7.0
1988	1.5	1.7	2.7	0.3	1.3	7.5
1989	1.5	1.8	2.7	0.3	1.0	7.2

continued

Table 39 (continued).--U.S. emissions of criteria air pollutants, by source, 1940-1989.

(million metric tons)

	Carbon monoxide					
Year	Transportation	Fuel combustion	Industrial processes	Solid waste	Miscellaneous	Total
1940	29.3	15.9	6.6	3.3	26.5	81.6
1950	43.6	11.4	10.5	4.3	16.5	86.3
1960	57.0	7.0	9.3	5.1	10.0	88.4
1970	74.4	4.5	8.9	6.4	7.2	101.4
1975	65.0	4.3	6.9	3.1	4.8	84.1
1976	64.3	4.7	7.1	2.7	7.1	85.9
1977	61.0	5.1	7.3	2.6	5.8	81.8
1978	63.1	5.9	7.2	2.5	5.7	84.4
1979	59.1	6.7	7.1	2.3	6.5	81.7
1980	56.1	7.4	6.3	2.2	7.6	79.6
1981	55.4	7.7	5.9	2.1	6.4	77.4
1982	52.9	8.2	4.3	2.0	4.9	72.4
1983	52.4	8.2	4.3	1.9	7.7	74.5
1984	50.6	8.3	4.7	1.9	6.3	71.8
1985	47.9	7.5	4.4	1.9	7.9	69.5
1986	44.6	7.5	4.2	1.8	5.9	64.0
1987	43.3	7.6	4.3	1.8	7.2	64.2
1988	41.2	7.6	4.6	1.7	9.9	65.0
1989	40.0	7.8	4.6	1.7	6.7	60.9

(thousand metric tons)

	Lead					
Year	Transportation	Fuel combustion	Industrial processes	Solid waste	Miscellaneous	Total
1970	163.6	9.6	23.9	6.7	0.0	203.8
1975	122.6	9.3	10.3	4.8	0.0	147.0
1976	132.4	8.3	8.1	4.3	0.0	153.1
1977	124.2	7.2	5.7	4.1	0.0	141.2
1978	112.4	6.1	5.4	4.0	0.0	127.9
1979	94.6	4.9	5.2	4.0	0.0	108.7
1980	59.4	3.9	3.6	3.7	0.0	70.6
1981	46.9	2.8	3.0	3.7	0.0	56.4
1982	46.9	1.7	2.7	3.1	0.0	54.4
1983	40.8	0.6	2.4	2.6	0.0	46.4
1984	34.7	0.5	2.3	2.6	0.0	40.1
1985	15.5	0.5	2.3	2.6	0.0	20.9
1986	3.5	0.5	1.9	2.6	0.0	8.4
1987	3.0	0.5	1.9	2.6	0.0	8.0
1988	2.6	0.5	2.0	2.5	0.0	7.6
1989	2.2	0.5	2.0	2.3	0.0	7.2

Source: U.S. Environmental Protection Agency. 1991. National Air Quality and Emissions Trends Report, 1989. EPA-450/4-91-003. Research Triangle Park, NC.

Table 40.--National ambient concentrations of criteria air pollutants, 1975-1988.

Year	Sulfur dioxide (ppm)	Carbon monoxide (ppm)	Ozone (ppm)	Nitrogen dioxide (ppm)	TSP (ug/m3)	L (mg/
1975	0.0154	11.96	0.153	0.029	61.9	1
1976	0.0156	11.32	0.153	0.029	62.8	1
1977	0.0138	10.66	0.155	0.029	62.9	1
1978	0.0126	10.07	0.156	0.029	62.4	1
1979	0.0120	9.07	0.134	0.026	63.1	0
1980	0.0109	8.52	0.136	0.025	64.2	0
1981	0.0104	8.25	0.127	0.025	60.3	0
1982	0.0096	7.86	0.125	0.024	50.1	0
1983	0.0092	7.77	0.137	0.024	49.7	0
1984	0.0094	7.72	0.124	0.024	51.2	0
1985	0.0088	7.03	0.123	0.024	48.8	0
1986	0.0085	7.00	0.118	0.024	48.6	0
1987	0.0083	6.64	0.125	0.024	49.7	0
1988	0.0084	6.56	0.136	0.024	50.5	0

Source: U.S. Environmental Protection Agency, Office of Air Quality Planning and Stan dards. 1990. National Air Quality and Emissions Trends Report, 1988. EPA-450/4-90-0 Research Triangle Park, NC.

Notes: ppm=parts per million. ug/m3=micrograms per cubic meter. mg/m3=milligrams p cubic meter. TSP=total suspended particulates. Sulfur dioxide and nitrogen dioxide re cords are arithmetic means. Carbon monoxide and ozone records are second maximu readings over 8- and 24- hour periods, respectively. TSP records are geometric mean Lead records are maximum quarterly recordings. Data represent composite averages from all sites in the nationwide monitoring network.

Table 41.--Wet deposition of selected pollutants, 1982-1987.

(kilograms per hectare)

Year	Hydrogen ion	Sulfate ion	Nitrate ion	Ammonium ion	Calcium ion
1982	0.41	23.17	13.54	3.03	1.90
1983	0.35	21.63	13.26	3.00	2.04
1984	0.38	22.69	14.63	3.15	2.06
1985	0.37	21.95	14.51	2.92	1.81
1986	0.37	21.26	13.89	2.90	1.60
1987	0.34	19.85	13.62	2.89	1.65

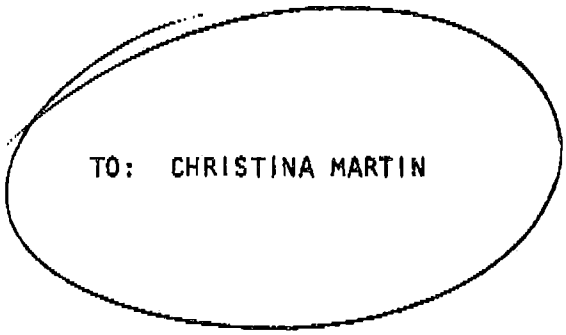
Source: Sisterson, D.L. et al. 1990. Deposition Monitoring: Methods and Results. NAPAP SOS/T State of Science and Technology Report 6. IN: National Acid Deposition Assessment Program, State of Science and Technology, vol. 1, table 6-22, p. 14. Washington, D.C.

Note: Data represent the summary of 1982-1987 trend sites (n=148) annual deposition by year. Means are reported.

DOUG GAMBLE

424 - 36th Place
Manhattan Beach, CA 90266
(213) 546-6409

Sept. 13/91



GRAND CANYON (Tony Snow)

WHEN I FIRST CAME WEST IN MY EARLIER YEARS I TOLD BARBARA I WANTED TO LIVE ON THE EDGE, BUT THIS ISN'T QUITE WHAT I HAD IN MIND.

THE SIZE OF THE SPECTACLE BEHIND ME IS TRULY AWESOME. COMING FROM WASHINGTON, I'M TEMPTED TO SAY [redacted] IT LOOKS LIKE [redacted] SOMETHING THAT STARTED OUT AS A TRENCH AND WENT OVER BUDGET.

AS AIR TRAVELLERS WHOSE FLIGHTS CROSS ARIZONA KNOW, GRAND CANYON IS THE SIGHT THE PILOT ALWAYS POINTS OUT ON ONE SIDE OF THE PLANE -- WHEN YOU'RE SITTING ON THE OTHER SIDE.

WHEN BARBARA WAS HERE IN MAY, IT SNOWED. AT LEAST SHE THOUGHT IT WAS SNOW. WITH THE VISIBILITY THE WAY IT WAS, SHE COULDN'T SEE IT.

WHEN I LEARNED ONE OF THE FIRST RULES OF POLITICS, LITTLE DID I THINK IT WOULD COME IN SO HANDY NOW: "DON'T TAKE ANY BACKWARD STEPS."

NATIONAL SPACE COUNCIL

9-5-91

Tony,

Good to have finally met you ... thanks for the heads up.

Attached is a proposed insert for the environmental speech at the Grand Canyon.

Thanks Mark

Mark J. Albrecht
Executive Secretary

Proposed Insert for POTUS Address on the Environment at Grand Canyon, Arizona, Sept 18, 1991

We need data on critical scientific issues -- global warming, deforestation, and polar icecap melting. Much of this data can only come from space. That's why three fourths of our U.S. Global Change Research Program is devoted to obtaining crucial satellite data. As we had originally planned the program, our first new satellite designed to get this data was not to be launched until the end of the decade. That's not good enough.

I asked Vice President Dan Quayle, Chairman of my National Space Council, to see if we couldn't get the vital data faster. He constituted a panel of our nation's outstanding scientists and engineers. They've been able to not only move the schedule up -- we will begin to get data on the critical global warming questions in the mid-1990s -- but they've also been able to suggest ways to lower the cost by 30%.

By using new technology and expertise developed within the Departments of Defense and Energy we can begin getting critical global warming data by the middle of this decade. NASA has restructured their own environmental monitoring programs to provide comprehensive global change data sooner and for less cost -- making use of new space launch capabilities developed by the Air Force. The key to these successes has been to make use of our full national space program applied to critical environmental problems. A job well done Mr. Quayle!

6061
824-4461

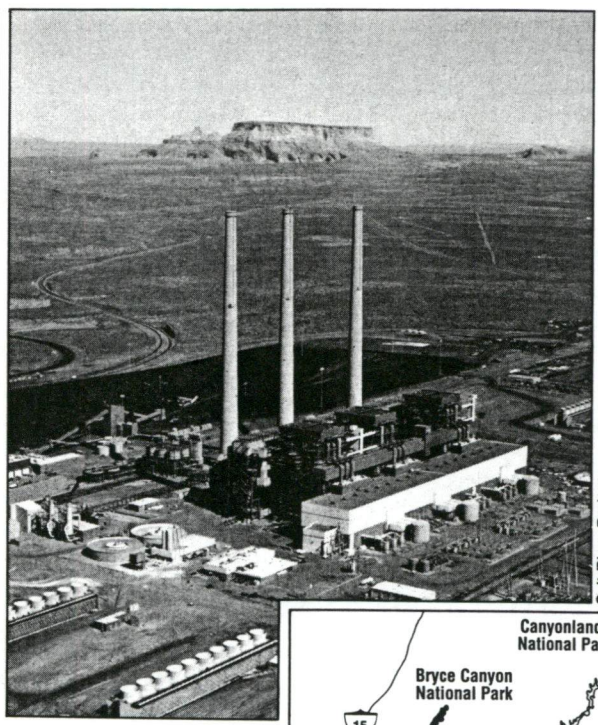
Scientists Battle Over Grand Canyon Pollution

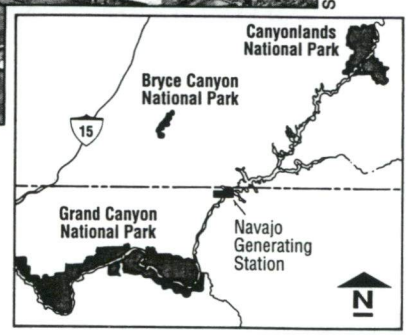
Test results implicating a power plant as the prime cause of wintertime haze have sparked a dispute over the data

BY NOW, millions of Americans are familiar with news reports of how spectacular Grand Canyon vistas are frequently obscured by a fine haze in wintertime. The appearance of air pollution over one of the world's few remaining pristine natural wonders first began to get public attention almost two decades ago. And for nearly that long, environmentalists have suspected that a major contributor to the recurring winter smog was a massive coal-fired power plant that sits on the Arizona-Utah border about 50 miles north of the Grand Canyon. But pinning a pollution charge on the plant has not been easy, and the federal government's efforts to do so have sparked a bitter scientific battle that is little known to the American public.

Two years ago, researchers in both the Environmental Protection Agency (EPA) and the National Park Service believed they finally had a smoking gun. Trace elements detected at a monitoring station in the Grand Canyon pointed to sulfur dioxide emissions from the 2250-megawatt plant, known as the Navajo Generating Station. The evidence, they contended, might be enough to require installation of pollution control devices on the facility's smokestacks—equipment that could cost as much as $500 million.

But the plant's owners*, which include the Interior Department and private and public utility companies, have fired back. Their scientists and engineers are contesting the claim that results from a single monitoring station provide definitive evidence of their complicity in a national disgrace, and they have raised troubling questions about the thoroughness of research underlying looming regulatory actions, the adequacy of the peer review to which the study results were subjected, and the possible effect of court-imposed deadlines on the research process.





Prime suspect. *A test to determine sources of pollutants in the Canyonlands National Park fingered the Navajo plant as a contributor to haze in the Grand Canyon.*

Indeed, the utility won a small legal victory last month in the U.S. District Court for Southern California. The court lifted a legal deadline that mandated a decision by February 1990 on whether emissions from the Navajo plant are sufficiently large to require the installation of pollution equipment. Instead, EPA and the park service now have up to 1 year to consider additional comments on the research findings. One important new input might be the views of a committee of the National Academy of Sciences, which has recently been asked by the Department of Interior to look at the data.

This hotly contested evidence comes from the Winter Haze Intensive Tracer Experiment (WHITEX), a $2-million test project sponsored by a consortium† of government agencies and utility organizations, including EPA, the park service, and, ironically as it turned out, one of the plant's owners, the Salt River Project (SRP). Conducted in the winter of 1987, the original purpose of the experiment was to evaluate proposed techniques for determining the sources of haze-causing pollutants not in Grand Canyon National Park, but in the Canyonlands National Park, a preserve that lies northeast of the Navajo plant—in the opposite direction from the Grand Canyon (see map).

Indeed, one of the quandaries that has puzzled some residents of the region about the Grand Canyon haze is that winter winds seem to blow generally in a northeasterly direction—from the Navajo plant toward Canyonlands and not the Grand Canyon. That was a key reason why the experimenters had erected a battery of monitoring stations in and around the Canyonlands—and why there was only one sampling station upwind of the plant at Hopi Point in the Grand Canyon National Park.

But then came the shocker. Deuterated methane, a rarely used sulfur tracer that is supposed to mimic the dispersion behavior of sulfur dioxide, was released from one of the Navajo plant's tall stacks over a 6-week period in 1987. Just as predicted, the chemical was detected in the Canyonlands monitoring stations, but it was also picked up by the sampling station in the Grand Canyon National Park.

Suddenly, although the WHITEX experiment was not initially intended to be a basis for regulation—and was not even focused on Grand Canyon pollutants—the park service and EPA came to believe it provided compelling evidence for taking action against the Navajo plant. The amount of deuterated methane picked up by the Grand Canyon's Hopi Point station and the chemical characterization of air particles there indicated that the Navajo plant is the chief contributor of sulfates in the park, concluded a park service team headed by physicist William Malm. Previously, wintertime haze had been attributed to widespread regional pollution, much like that which occurs in the summer when sulfates from as far away as the Los Angeles Basin degrade visibility in the Grand Canyon.

David Stonefield, an environmental engi-

*The Navajo Generating Station is owned by the Salt River Project (21.7%), the Los Angeles Department of Water and Power (21.2%), the U.S. Department of Interior's Bureau of Reclamation (24.3%), Arizona Public Service (14%), Nevada Power Co. (11.3%), and Tucson Electric Power Co. (7.5%).

†The WHITEX study was conducted under the sponsorship of SCENES, a group formed in 1984 to study visibility impairment issues. Its members include: Southern California Edison Company, the Environmental Protection Agency, Department of Defense, Electric Power Research Institute, and the Salt River Project.

neer with EPA's Office of Air Quality Planning and Standards, says WHITEX "is one of the best databases for the attribution of visibility impairment to a source that we have anywhere in the country." But that assertion is challenged by Jerry Shapiro, a physicist and consultant for SRP, who charges that "the experiment was poorly designed for the Grand Canyon." He says that in focusing only on a single source, the test says nothing about relative contributions of sulfur emissions from utility plants in Utah and other industrial sources.

Shep Burton of Systems Applications, Inc., who is a consultant to one of the plant's owners, SRP, and a member of EPA's Clean Air Scientific Advisory Committee, argues that the statistical correlations between the amounts of tracer detected at Hopi Point and sulfur emissions from the Navajo plant are weak. Furthermore, he says the models linking regional humidity to sulfate production assume "some very high conversion rates" that inflate the plant's contributions of sulfates to the Grand Canyon.

"Those guys [at EPA and Interior] are going to come unglued by the statisticians," predicts Burton. In particular, he faults the park service's study for lack of data on issues such as the contribution of other pollution sources, the complex terrain and wind patterns of the Grand Canyon, and the age, course, and distribution of the Navajo plant's emission plume during the time that the experiment was conducted. These issues, Burton says, are critical in determining the degree to which the generating station is a major contributor to episodes of severe wintertime haze, or whether a mix of regional sources plays a dominant role. Should the latter be the case, EPA could not require the installation of stack scrubbers to reduce sulfur emissions at the Navajo plant.

Despite the criticisms leveled at them, Malm and EPA officials are standing by their findings. "The [tracer] correlation is weak all by itself," admits Malm, "but when you factor in relative humidity and arsenic [to account for emissions from smelters], the evidence is quite strong."

The plant's owners and their consultants are not limiting their criticisms to the report's conclusions, however. They are also attacking EPA's review procedures for such research, contending that EPA's regulatory action is premature because the park service study had not been peer-reviewed.

But Stonefield and Malm say the report underwent considerable review by the agency staff and independent consultants. Moreover, they note that the utility, its consultants, outside scientists, and other interested parties have had ample opportunity to comment on the draft report in meetings with agency scientists and government consultants. The draft report, however, was not subjected to the kind of peer review that might be accorded a journal article, Stonefield concedes, explaining that that kind of review "is too narrow a process to be used in a regulatory sense."

Indeed, neither the Department of the Interior nor EPA have standing scientific advisory committees geared to assemble independent scientific panels to evaluate controversial agency research results. This lack of formal review procedures concerns some officials in EPA's Office of Research. Said one program leader who asked not to be identified, "The problem is that the regulatory offices are very ambitious, and they do not have staffs with strong scientific backgrounds. Consequently, they sometimes go forward with things that are not based on very good science."

SRP, in fact, is so convinced that EPA's actions are based on bad science that it is conducting its own $10-million study of the Navajo plant's effect on wintertime visibility in the canyon. This experiment will draw on data from multiple monitoring stations in and around the Grand Canyon and the results may be available next fall. Malm says this experiment is exciting, but he doubts that its results will differ greatly from the park service's conclusions.

Just how strong a case the park service and EPA have actually built will become more evident in early April when the National Academy of Sciences' Committee on Haze in National Parks and Wilderness Areas: Source Apportionment and Control Options issues a letter report critiquing the WHITEX study. The 13-member panel will issue a more detailed report on methods for attributing emissions to specific polluters in the spring of 1991.

■ MARK CRAWFORD

MIT Picks Biologist as President

The Massachusetts Institute of Technology is about to abandon a long-standing tradition of selecting a president with a background in physical sciences, engineering, or business management. Phillip A. Sharp, 46, a biologist and director of MIT's Center for Cancer Research, was named last week as the unanimous choice of the faculty and MIT Corporation search committees to succeed president Paul Gray, who is stepping down in June. Sharp's nomination now goes to MIT's Governing Board, where it is expected to encounter no opposition.

Though Sharp is highly regarded in his field—he won the 1988 Lasker Award for his work in gene encoding—his selection is regarded as something of a surprise, for he has not been a prominent player in campus politics. Indeed, he emerged as a candidate in a roundabout way. When the search for Gray's successor formally began in September, Sharp was named vice chairman of the faculty search committee and became the acting chairman during the first several weeks of the process when economist Robert Solow was away.

MIT Photo by Donna Coveney

And then there was one. *Nominee Phillip Sharp.*

Sharp's performance impressed faculty members and MIT's trustees, says committee member Eugene Skolnikoff, a professor in the political science department. "Members of the committee soon came to the conclusion that he ought to be a candidate," says Skolnikoff. "At first he resisted, but then he agreed to be considered and resigned from the committee."

Sharp was not an early front-runner, according to members of the selection committee. Both the faculty committee and MIT trustees expressed a preference for candidates from outside the institute. One leading insider was provost John Deutch. But Deutch was perceived by some faculty members as having an abrasive management style and was blamed for closing the Applied Biology Department without consulting the faculty at large. Deutch withdrew from the running last month, and as the list of an estimated 200 candidates was finally narrowed down to three, Sharp's name was still there.

What tipped the scale in his favor? According to one member of the faculty committee, it was not just his excellent research record: "He is enthusiastic, very strongly involved in undergraduate education, and he has a management style that works well in this kind of environment."

■ MARK CRAWFORD

The Washington Times APR 17 1991

WARREN BROOKES

Coolheadedness on warming G1

The National Academy of Science has apparently learned something from its feverish (and ultimately *wrong*) warnings about acid rain and asbestos a decade ago, and have decided to be more coolheaded about global warming.

Contrary to network reports, the bottom lines of the NAS report were threefold: First, there is no evidence the warming we have seen is anything but natural variability of temperature cycles. The panel essentially agreed with Professor Richard Lindzen of the Massachusetts Institute of Technology that "the evidence is just not there."

In fact, the NASA satellite measuring system shows *no* trend at all in the 1980s. As NASA's Roy Spencer said recently, "People believe the [land] thermometer data to buttress their theories about the greenhouse effect." His partner at Alabama University, John Christy, said, "Before we make decisions about our emissions, we better know what's happening with our climate."

Second, none of the climate "models" used to predict the greenhouse warming scenarios provides a "reliable forecast." For example, they have no hard data on either cloud cover or ocean currents, two of the most powerful forces in temperature cycles.

Third, however, "despite the great uncertainties, greenhouse warming is a potential threat sufficient to justify action now." But as if to hedge its bets, the NAS panel recommended actions it said would not cost much to the national economy, to which Mr. Lindzen replies: "If that's so, we should do them. But why pin them on global warming?"

In short, the NAS panel essentially ratified the much-criticized Bush administration position that much more science needs to be done before we can make hard policy that might actually cost us large sums of economic capital.

There is good reason for this caution. In the first place, U.S. fossil fuel consumption, targeted by environmentalists as the chief culprit in warming, still accounts for less than 5 percent of net additions to greenhouse gases. Even a major reduction in their use would be easily overwhelmed by even modest increases in China and Russia and the Third World.

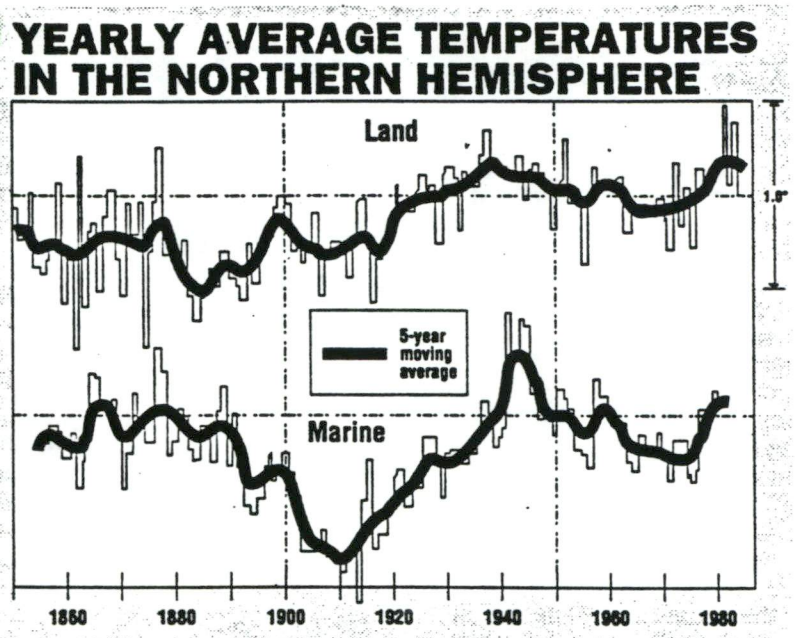


Chart by Henry Christopher / The Washington Times

In the second place, one of the largest contributions to greenhouse gases comes from rising food production and thus population itself. Who wants to propose slashing food production as a method of cutting back on world population? Any takers?

More and more, global warming looks like nothing more than a premise for posturing by politicians, and fund-raising by environmental groups. Sen. Albert Gore, Tennessee Democrat, a thinly veiled candidate for the presidency in 1992, has made global climate change a centerpiece of his political agenda. He has also said his original mentor on this issue was one-time Harvard Professor Roger Revelle, a current member of the NAS and winner in 1990 of its National Medal of Science.

But Mr. Revelle has become much more coolheaded about warming than his protege Mr. Gore. This month, the Washington Cosmos Club launched its impressive new scholarly journal Cosmos, with, among others, an article by Mr. Revelle in conjunction with University of Virginia Professor S. Fred Singer and Chauncey Starr, another NAS member and gold medal winner and former University of California Los Angeles dean of engineering.

We commend the title of this article to Mr. Gore's attention: "What To Do About Greenhouse Warming: Look Before You Leap." Its conclusions represent a complete endorsement of the Bush position and a total rejection of Mr. Gore's activist posture: "We can sum up our conclusions in a simple message: *The scientific base for a greenhouse warming is too uncertain to justify drastic action at this time.*" (Emphasis theirs.)

The authors take readers through a carefully reasoned review of the issue, pointing out first the undeniable fact that most of the warming

CONTINUED 12

The Washington Times APR 17 1991

"trend" we have seen in the last century "occurred *before* the major rise in greenhouse gas concentration." Even so, the total rise was far below what the models "predict." (See graph.)

While they admit the climate models are badly flawed, they agree with NAS panel member Stephen Schneider, who says "models are better than handwaving," but they ask "how much better?"

Most of all they ask, even if the world experiences a 1 degree to 2 degree warming from greenhouse gases, "is this necessarily bad?" They remind us that when the planet was plunging through the "Little Ice Age" in the early 19th century, actual climate cooling "caused large agricultural losses and even famines," and they suggest "if cooling is bad, then warming should be good," providing it's "slow enough that adjustment is relatively cost-free."

The authors cite studies on the positive effects of CO2 enrichment to crops, longer growing seasons, greater precipitation that "should increase by 10-15 percent, and polar temperatures should warm the most, thus reducing the driving force for severe winter-weather events."

As for the question of rising sea levels due to declining ice caps, they cite the contrary evidence from NASA's Jay Swally in Science Magazine that "Greenland ice sheets are gaining in thickness."

The Cosmos article winds up: "Summarizing the available evidence, we conclude that even if significant warming were to occur in the next century, the net impact to the entire planet may well be beneficial — with some regions enjoying improved climate, some encountering worse."

While they endorse cost-free measures, including a shift to nuclear power, they warn that, "Drastic, precipitous — and especially unilateral — steps to delay the putative greenhouse impacts can cost jobs and prosperity and increase the human costs of global poverty, without being effective."

Mr. Gore, call your professor, and cool down.

Correction: Last week, this column said polystyrene was being reviewed and classified by the EPA. It should have said it was "styrene," the monomer that is reacted to create the polymer, polystyrene.

Warren T. Brookes is a nationally syndicated economics columnist.

Wash. Post 8-14-91

Philippine Volcano Dust Temporarily Cools Earth

By William Booth
Washington Post Staff Writer

The explosion of Mount Pinatubo in the Philippines last June, now believed to be the largest volcanic eruption of the century, filled the skies with enough dust to cool the Earth far more than any effects of global warming might warm it—at least for a few years—according to new findings released yesterday.

Images from satellites show the Earth girdled by a cloud of light-reflecting volcanic ash and gas, which is whirling around the equator on a current of air about 15 miles above the Earth's surface. The particles reflect incoming sunlight back into space and keep it from striking and heating the Earth.

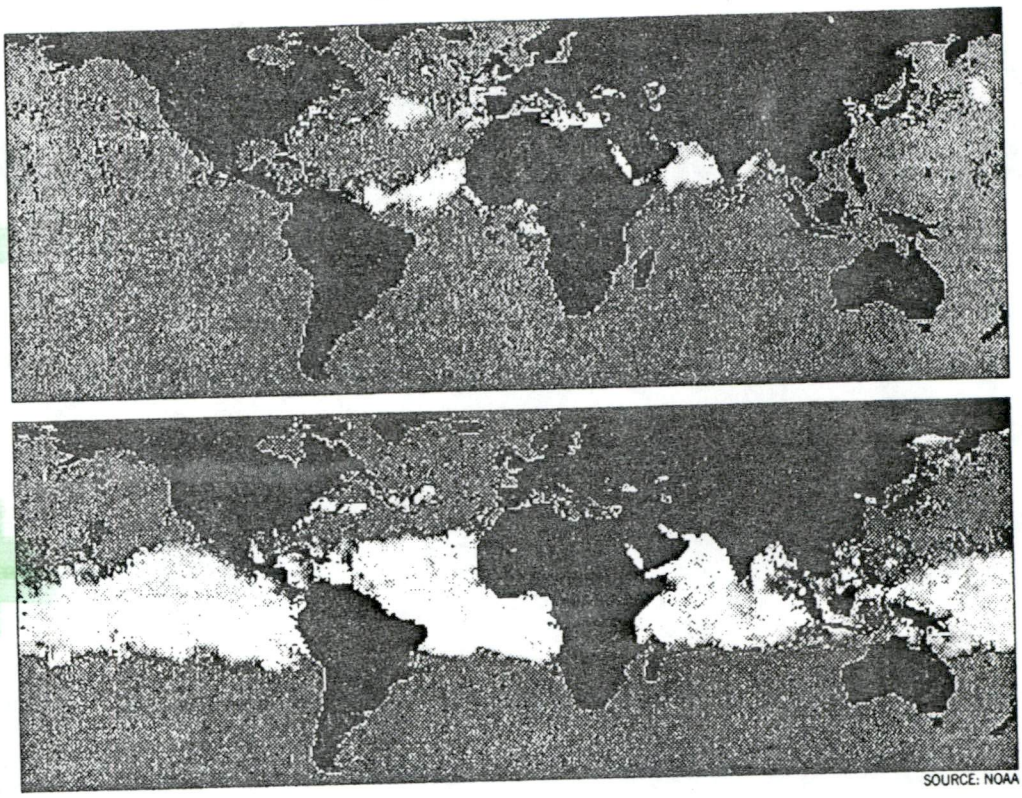
Scientists at the National Oceanic and Atmospheric Administration (NOAA), who used polar-orbiting weather satellites to look down on the volcanic cloud, say the dust is thick enough to lower average temperatures in the tropics by about 4 degrees Fahrenheit.

Veteran astronauts on the last shuttle flight reported that they had never seen the Earth look so hazy, and they speculated that the volcano was to blame.

As the cloud disperses in the fall and spreads its load of sulfuric acid droplets evenly over all latitudes of the globe, NOAA scientist Larry Stowe has predicted, worldwide average temperatures could fall by about 1 degree Fahrenheit.

The temperature change is so subtle it will

See COOLING, A30, Col. 1



SOURCE: NOAA

Dust clouds thrown high into the stratosphere by the eruption of Mount Pinatubo in the Philippines girdle the tropics in the lower image, taken by a weather satellite five weeks after the eruption and enhanced by a National Oceanic and Atmospheric Administration computer. The upper image, taken before the eruption, shows some dust from the Sahara and from the Arabian peninsula. Because the satellite cannot distinguish dust over land, reflections appear only over water.

BA President Disputes Quayle on Litigation Proposals

David S. Broder

to the microphone and told him the administration was unfairly blaming

Quayle, who had stood stony-faced at Curtin's side while the

ica if we sit down and work together."

The 500 members of the ABA's

Volcano Dust Temporarily Cools Earth

COOLING, From A1

probably not be noticed by most people. For example, in Washington, records show the average daily temperature drops by about 1 degree Fahrenheit, from 78.9 degrees in July to 77.6 in August, but few people discern the slight relief.

However, for climate specialists, a 1-degree drop would be more than enough to temporarily offset any effects attributed to global warming.

"Pinatubo is plenty big enough to swamp any signal you'd see from global warming," said Vernon Kousky of the Climate Analysis Center in Camp Springs, Md. "It'll mask the signal for at least several years."

Many scientists believe that the gradual buildup of "greenhouse gases" from power plants and automobile tailpipes will increase global temperatures by a few tenths of a degree each decade, eventually raising average temperatures by 4 or 5 degrees by the middle of the 21st century. The Pinatubo eruption could lower temperature by a full degree in one year.

Environmentalists say they fear that the temporary cooling will bolster the Bush administration's go-slow approach to global warming. The administration has said it is too early to know if warming will occur, and what its effects will be.

"It would be most foolish to use this hiatus in the warming trend as an excuse for inaction," said Michael Oppenheimer, a senior scientist at the Environmental Defense Fund, an advocacy group that is pushing for curbs on greenhouse gases. "The cooling is only temporary."

How long the cooling lasts, and how low the mercury drops, depend on the size of Pinatubo's blast, which researchers are still busy calculating. Indeed, United Airlines pilots reported two more large eruptions in the last two days, according to NOAA scienists.

Patrick McCormick of the National Aeronautics and Space Administration estimates the big blast that Pinatubo experienced on June 15 and 16 is probably twice, and perhaps three times, as large as the 1982 eruption of El Chichon in Mexico.

Researchers believe that El Chichon depressed global temperatures by a few tenths of a degree for two or three years. Pinatubo's effect could last five or 10 years, said McCormick of NASA's Langley Research Center in Hampton, Va.

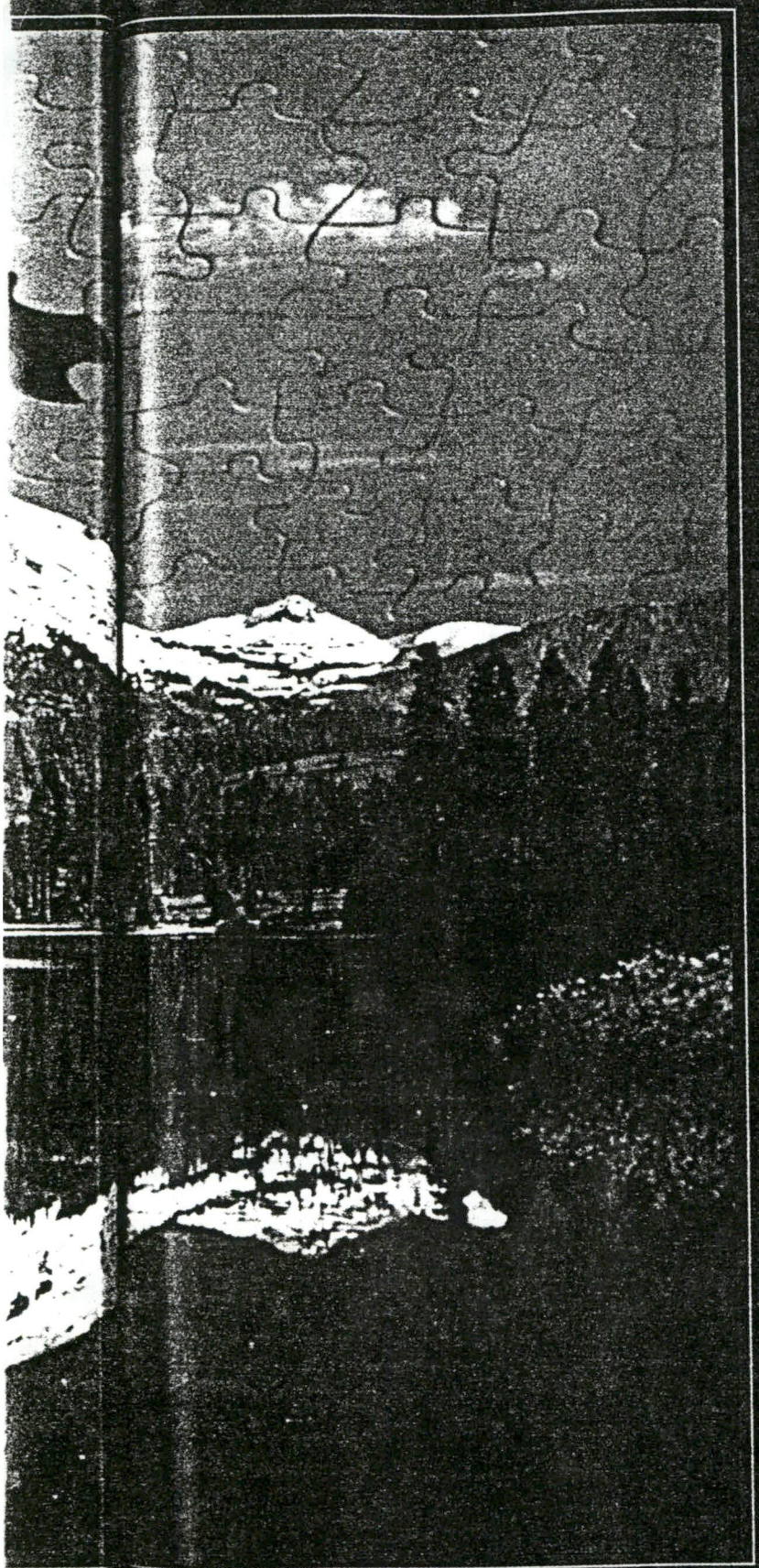
"Long after the eruption," McCormick said, "the system is still reeling."

The size of the volcanic cooling also depends on other factors. Many researchers suspect that the Earth is entering another El Niño period, when surface waters in the Pacific Ocean warm up. An El Niño event produces a variety of changes in the world's weather, including knocking the jet stream off course and generally raising global temperatures.

If a strong El Niño warming appears this autumn, the cooling effects of Pinatubo would be reduced. The two phenomena may not cancel each other out completely, however. If Pinatubo is as big as researchers think, its effect would probably still be apparent, even in the normal up and down of global temperatures.

In addition to cooling off the Earth, scientists believe Pinatubo may play a more insidious role. In the wake of the El Chichon plume, researchers detected a pronounced decrease in the Earth's protective ozone layer as it came into contact with the ash and gas. Some experts estimate that as much as 10 percent of the ozone was destroyed, though ozone does replace itself over time.

Researchers still aren't sure how the volcanic cloud destroys ozone. The tiny droplets of sulfuric acid in the volcanic cloud appear to increase the amount of chlorine in the atmosphere, which breaks the ozone molecules apart.



THE OMNI OVERVIEW

Is Earth's complex climate machine on the blink—or is it just having a bad century?

THE GREENHOUSE EFFECT: APOCALYPSE NOW OR CHICKEN LITTLE?

BY ROBERT SILVERBERG

The world's temperature has been rising lately, just as apocalypse-minded "greenhouse effect" scientists have predicted. And there's no doubt that the levels of carbon dioxide, methane, and other heat-retaining "greenhouse gases" in our atmosphere are also climbing. We seem to be well along our way toward the torrid, sultry, terrifying future that the climatologists say is coming—a world of melting polar ice caps, drowned coastal cities, and vast migrations as new patterns of drought and heat make great sections of the globe uninhabitable.

Or are we? Some scientists are not so sure that the recent doomsday scenarios ought to be taken so readily at face value. They call for cautious examination of the whole greenhouse concept before we plunge into any sort of crash program for purifying our atmosphere—a program that the congressional Office of Technology Assessment estimates could cost as much as $150 billion a year over the next 25 years, simply to reduce carbon dioxide emissions to about 65 percent of today's levels.

While the scientists bicker,

PAINTINGS BY DOUG WEBB

what's the public to make of the baffling mass of seemingly conflicting data on global warming? History provides few clues; our climate records have proved an imperfect tool for prediction at best. It's enough to tempt even the most scientifically savvy among us to dismiss the issue altogether.

But that's just what we cannot afford to do. Crisis or not, it's time for a rational approach to unveiling the mysteries of the global climate machine. Whether the greenhouse effect foreshadows a cataclysmic event or a mere blip on the climatic time line, the current debate deserves close attention.

The greenhouse-effect theory of climate is nothing new. The concept dates back to 1822, when the French mathematician Jean Fourier likened the earth's atmosphere to the glass walls of a plant conservatory. A greenhouse's walls allow solar energy to enter, then trap its component of heat by blocking the outward radiation of infrared waves. Later in the nineteenth century scientists discovered that the heat-trapping component of our atmosphere is carbon dioxide (CO_2); and in 1897 the Swedish chemist S. A. Arrhenius, studying the relationship between global temperatures and the quantity of CO_2 in the atmosphere, calculated that a doubling of the present amount of atmospheric CO_2 would produce a mean global warming of 4° to 6°C or 7° to 11°F—with accompanying catastrophic environmental changes.

WHAT ARE WE TO MAKE OF THE MASS OF CONFLICTING DATA? THE CURRENT DEBATE WARRANTS OUR ATTENTION AND STUDY.

The amount of CO_2 in the atmosphere is minute: a little more than 300 parts per million, or one thirtieth of one percent. But that percentage has been growing rapidly in the century since Arrhenius. Vast quantities of CO_2 were locked up long ago in the "fossil fuels"—coal, oil, natural gas—that were created by the decay of organic matter at a time when the earth's climate was much warmer than it is today. We are now busily unlocking that treasure house of energy and our rate of consumption is rising from year to year, with the liberation of CO_2 rising in proportion as well.

Between 1860 and 1959 the combustion of coal and other fossil fuels released an amount of CO_2 equal to 14 percent of the total already in the atmosphere. Some of this was absorbed by the oceans; the rest remained in the air. By 1960 the quantity of atmospheric CO_2 was about 7 percent greater than it had been in the middle of the nineteenth century.

But that was only the beginning. Between 1958 and 1962 alone, the CO_2 content of the atmosphere grew by 1.15 percent. In those five years, the burning of fossil fuels released 53 billion tons of CO_2, and 26 billion tons of that accumulated in the atmosphere. And the CO_2 level has risen in each year since: In the past 30 years it has gone from 315 parts per million to 355, an increase of more than 20 percent in the past century and more than 10 percent in a single generation.

Nor is CO_2 the only gas that produces the greenhouse effect. Methane (CH_4), which is released by decaying matter in marshes and tundra, the actions of termites, and cattle breaking wind, has some 20 times the heat-trapping quality of CO_2. Methane is increasing in our atmosphere at a rate of about 1 percent a year. So, too, are the various nitrogen oxides thrown off by factory smokestacks, automobile exhausts, and the breakdown of agricultural fertilizers. Then there are the sinister chlorofluorocarbons (CFCs) emitted by refrigerators, air conditioners, aerosol devices, and other products of twentieth-century ingenuity. Neither methane nor nitrogen oxide nor CFCs played any part in Arrhenius's original greenhouse-effect calculations.

With all four kinds of greenhouse gases piling up in the atmosphere at a rate unprecedented in the planet's history, then we must be right on course for the catastrophic warming that the Arrhenius data indicate. A rise of 7° to 11°F in the mean global temperature may not sound like very much. But in fact just such a drop, some 25,000 years ago, sent glaciers down across Europe and North America and plunged the world into an ice age lasting thousands of years. An increase of little more than that magnitude 200 million years ago created the muggy, swampy, tropical world in which the dinosaurs flourished.

If a temperature increase of the Arrhenius magnitude were to happen now, floods caused by the melting of the polar ice caps would submerge thousands of miles of low-lying coastline within a matter of 40 or 50 years. The rising oceans would cover all of Florida south of Lake Okeechobee, and Washington, DC, would be covered almost to the White House and the Capitol steps. Low-lying islands throughout the

world would disappear. Rainfall patterns would shift, turning the grain-belt districts in the interiors of our continents into dust bowls and bringing devastating torrential deluges elsewhere. Some rivers would become virtually dry; others would rise to the point of becoming unnavigable. Millions would starve. The climate crisis would disrupt the living habits of entire nations. No wonder that Roger Revelle and Hans Suess of the Scripps Institution of Oceanogra-

• Warmer global temperatures don't necessarily spell doom, especially if upward changes turn out to be less severe than some climatologists predicted.

Scientists, moreover, need to place the unquestionable statistics on global warming in the Eighties in a larger historical context. The world indeed saw a general pattern of warming temperatures around 1890, just as the modern era of industrial expansion was hitting its first great peak and greenhouse gas emissions began to climb. A steady pattern of rising temperatures was recorded over the succeeding decades.

But the rate of temperature increase between 1920 and 1940 exceeded the level that could be accounted for by greenhouse-effect calculations alone. And then in 1940 global temperatures began to turn *cooler* again—precisely at the time when World War II was spurring another tremendous expansion in industrial activity. For the next thirty years, *as atmospheric pollution increased year by year,* mean world temperatures dropped steadily. The winter of 1962–63, for instance, brought England its coldest winter since 1740, averaging 32°F for three consecutive months. Not until 1970 did temperatures start climbing again, a rise that so far has gone on unchecked.

Climatological history reveals all manner of sharp temperature fluctuations during eras utterly unaffected by human environmental meddling. The ice ages that periodically afflict this planet are the most spectacular examples. The temperature increase during the era of the dinosaurs constitutes another. Prehistoric shifts in rainfall distribution stimulated the development of extraordinary human cultures in prehistoric Egypt and Mesopotamia and wiped out one in the Sahara. More recently, a period of climate cooling lasting from the fifteenth to the eighteenth century brought a "little ice age" to preindustrial Europe that killed the rich vineyards of England and destroyed the colonies that the Norsemen had planted in Greenland. In Queen Elizabeth's time, people skated on the frozen Thames in winter. By 1800 the climate was turning warmer again; the Thames has not frozen over since 1814. And so it has gone, up and down, through all the billions of years of our planet's existence.

Many forces affect Earth's climate, not all of which we understand. The chief climatic factor is the energy we receive from the sun. But the amount of solar radiation we get is not necessarily consistent throughout time. The sun has undergone many changes in size and radiative power in the last few billion years. Its output seems to vary, furthermore, in relation to the 11-year sunspot cycle—the low-temperature points of the "little ice age" period in medieval and Renaissance Europe coincided with prolonged periods of low sunspot activity recorded in 1280–1350, 1450–1550, and 1645–1715. Larger changes in solar activity, the result of forces we don't really comprehend (and certainly could never hope to control), may correlate with the severe glacial periods in the remote past and with periods of above-average warmth during the icy interludes.

Volcanic activity, moreover, can produce cooling phases. The giant eruption of Krakatoa, near Java, in 1883, spewed 13 cubic miles of debris into the air and reduced the sunlight falling on distant European observatories from 10 to 20 percent for the following three years. Other great eruptions in 1902 (in the West Indies) and 1912 (in Alaska) had the same effect. An almost total absence of major volcanic blasts between 1920 and 1940 may have been responsible for the period of unusually rapid warming that was recorded then, rather than the increase in atmospheric greenhouse-gas levels that was going on at the same time. We just don't know.

Changes in the earth's position relative to the sun, movements of the earth along its own axis, and the migration of the continents over long periods of time, must all be considered possible causes of the great temperature shifts that are evident in the geological and fossil records. Against such immense geophysical upheavals, a rise in the level of greenhouse gases may turn out to be a very small factor indeed.

Then, too, we have no assurance that the undeniable increase in atmospheric CO_2 and the other greenhouse gases will have the predicted severe consequences. Large-scale feedback processes may protect us against the folly of our own pollutions.

Atmospheric CO_2, for example, stimulates plant growth. Plants absorb CO_2 in the course of the process of photosynthesis. The more plants there are, the more CO_2 they will take in, thereby helping to reduce the atmospheric oversupply. This is *negative feedback*—a self-correcting mechanism in which a problem generates its own solution.

Another kind of negative feedback that may ease our greenhouse problem: Clouds reflect sunlight back to space, thus cooling the climate. Increased ocean evaporation caused by rising temperatures may enhance cloud cover,

CONTINUED ON PAGE 86

"There you have it, gentlemen—the fine line between genuine religious conviction and trendy moral posturing."

GREENHOUSE

CONTINUED FROM PAGE 54

helping to bring temperatures back down. (On the other hand, clouds can also serve as traps for infrared radiation; thus an increase in cloud cover could strengthen the warming trend. This would be an example of *positive* feedback, which amplifies a situation rather than correcting it.)

What's more, warmer temperatures hasten the breakdown of methane into the less damaging CO_2, a beneficial process. But a rise in ocean temperature might foster the release of oceanic methane into the atmosphere, further heating it—another positive-feedback event. The warming of the seas would also reduce their capacity to absorb CO_2, making more trouble for us, since the ocean swallows up much of the CO_2 we put into the atmosphere now. This is balanced, however, by the likelihood that the oceans—which are vast thermal sinks that keep planetary temperatures stable—would absorb much of the increase in heat produced by greenhouse effects, thereby minimizing or even canceling out any global warming that might occur. Similarly, the emergence of immense forests in areas now too cold for vegetation—particularly the Arctic and subarctic tundra—might lead to a net planetary gain in the amount of CO_2 absorbed during photosynthesis. Or the warming of the frigid tundra could release the CO_2 and methane now stored in its soil in the form of peat, making matters worse.

Adding to the general perplexity is the argument raised by University of East Anglia climatologist T. M. Wigley in the British scientific journal *Nature* last winter. Wigley points out that the burning of fossil fuels releases not only the dreaded greenhouse gases, but also sulfur dioxide particles, or "aerosols," which serve to reflect sunlight and moderate the temperature of the planet. A sudden and radical reduction in fossil fuel consumption, Wigley maintains, would diminish the cooling effect of the aerosols that the fossil fuels produce. And so a cutback in the use of greenhouse-effect fuels might actually *increase* the global warming trend.

The consequent rise in temperature could more than compensate for any cooling that a reduction in greenhouse gases would create, leaving us in even bigger trouble than we might be heading for otherwise. Robert Charlson, an atmospheric chemist at the University of Washington, calls this problem "a sleeping giant of a sort" and "something that has been missed, and the consequences are not trivial. It is going to complicate matters in setting policy."

These feedback forces illustrate just how tricky the whole problem is, and just how uncertain our climatologists really are about what is likely to happen. Even after two centuries of serious study, we have only an approximate understanding of the forces that drive our climate. In many cases, we are not sure which is the cause and which the effect. During a 10,000-year warm spell in the last ice age, for instance, atmospheric CO_2 and methane levels were far higher than they were in the surrounding colder periods. But did that increase in greenhouse gases create the warm spell, or was it the other way around? No one can say. And a study of the Alaskan permafrost conducted by the U.S. Geological Survey shows a thawing of several degrees in the past 100 years but a drop in temperature of more than a degree for the period 1984–87 alone. One suggested explanation is that the shrinkage of the Arctic snow cover during the warming period of the Eighties has reduced the amount of insulation that the snow provides, allowing greater radiation of heat from the permafrost. So a warming produces a cooling: negative feedback at work again.

Whether all these intricate processes will cancel each other out, leaving our climate more or less unscathed, is something that only time is going to tell. We are indeed conducting a geophysical experiment with the planet as our laboratory, and the outcome is far from certain, despite the confidence that various theorists express. At the moment there are no facts, only speculations, when we talk about global warming. We have had no experience with greenhouse effects from which we can predict what's ahead.

Computer simulations alone won't give us the answers, nor are our meteorological records accurate enough over a long period of time to provide us with a clear view of what has actually been going on. Scientists can measure CO_2 concentrations in ancient times by looking at ice cores brought up from polar depths, but the weather bureau records of 1850 and 1900 and even 1950 are statistically unreliable because the samplings tended to be too small, and the methods of measurement often had built-in inaccuracies that make comparisons with today's weather misleading. If we aren't sure where we have been, how can we be certain about where we are going?

The middle-of-the-road scientific position, though, seems to be that *some* climatic warming will happen during the

first half of the twenty-first century as a result of the changes in the atmosphere that we have already brought about—though it may be a mean increase of only a degree or so, rather than the 5° to 10° that the most extreme environmentalists are predicting.

A minor warming of that sort would require some local readjustments. Low-lying coastal settlements in marginal areas where flooding has traditionally been a problem might have to be abandoned. Rainfall patterns would probably change to some extent, and some of today's productive agricultural regions may experience water shortages. Middle-latitude zones might become too warm for efficient farming.

But these negatives would be balanced by corresponding positive changes elsewhere. Vast areas in Canada, the Soviet Union, and the northern United States, their development now hampered by cold weather much of the year, would experience a beneficial access of warmth. What farmers in Arkansas might lose, those in Saskatchewan would gain.

The same with rainfall patterns: Regions now blighted by chronic drought would become fertile. All over the planet, the increase in CO_2 levels would make plant growth more vigorous. Seas now blocked by ice much of the year would be open to navigation. And so forth: not catastrophe but change. And we are an adaptable species.

Part of the problem of knowing whether global warming will be good or bad is our geophysical ignorance. "We don't even know within a factor of ten how much total biomass there is on Earth," said NASA scientist Gerald Soffen at a greenhouse effect discussion at the 1991 meeting of the American Association for the Advancement of Science. "Is life expanding or not? We can't say." Another AAAS panelist, botanist Lynn Margulis of the University of Massachusetts, added, "We have millions of species, each processing carbon differently, and we don't understand any of them perfectly. If we try to guess how life will respond [to global warming] we'd really be fools rushing in."

We should not, of course, rule out the possibility that we are indeed heading for catastrophic climatic events. But the conservative climatologists, who deny that these events will be apocalyptic, hold that it's unwise to launch crash programs of industrial cutback that might well have economic consequences for many countries far more serious than any climatic change that's in the cards. We need to wait for further evidence that a severe global warming is actually coming.

Meanwhile, as we await that further evidence, what can we do to ward off the worst-case scenarios? One smart move would be to try—within the limits of economic realities—to reduce industrial emissions and the use of fossil fuels in general. Not in any panicky way, with visions of the oceans covering our coasts and our forests turning into tropical jungles, but with a calm, clear-eyed resolve, based on the understanding that it's a dumb idea for any creature to foul its own nest. The junk we've been putting into the atmosphere can't possibly do us any good, and there's a reasonable chance that it can do us great harm. Therefore we should clean up our act, not by closing down the factories and switching overnight from cars to bicycles, but by zeroing in on the chief causes of pollution and finding rational ways of eliminating them, and by putting programs of energy conservation into use.

A halt in the indiscriminate destruction of forests in Third World countries would help, too. Those trees—the lungs of the planet—are one of the most powerful climatic moderators we have, and once they're gone, implacable deserts will replace them; tropical soils are surprisingly infertile and undergo dismaying changes once their forest cover is stripped away.

Another wise move would be systematic reforestation of areas already denuded. It isn't just that trees are pretty. They soak up CO_2—a forest the size of Alaska would take in a billion tons of it a year—and give off oxygen. Having them around is a fundamentally good idea.

These conservation measures, none of them so stringent that they will unsettle any nation's economy, may of themselves succeed in stabilizing our atmosphere. The worst-case greenhouse world isn't necessarily on the way. Prudent planetary housekeeping is in order right now. Hysteria isn't.

Because even now many of the processes that rule our climate are mysteries to us, many scientists are uncomfortable with the recent outcries for radical environmental reform. "Whenever you try to do this quickly, you run up against our ignorance and the quality of the data," says Michael Schlesinger, a climatologist at the University of Illinois, and his caution is echoed in many other quarters. We have greatly changed the face of our planet; but whether those changes have set a devastating climatic change in motion is something we simply don't know. For once, more studies really *are* needed. What we have to do now is to watch and wait. ∞

4-15-91

FACT SHEET

The recent National Academy of Sciences (NAS) report on climate change is not inconsistent with the Administration's approach to this important issue and is a contribution to our growing understanding of global climate change. The study, "Policy Implications of Greenhouse Warming," summarizes the science and the limitations of our knowledge and recommends a number of actions that could be taken to meet the challenge of climate change. It highlights the uncertainties in modeling and the current inconsistencies between trends in temperature and accumulation of greenhouse gases. In setting a least cost hierarchy, it rejects options requiring great expense.

- Bush Administration policies, including measures enacted in the Clean Air Act and proposed in the National Energy Strategy, are projected to maintain U.S. greenhouse gas emissions through the year 2030 at current levels, even accounting for growth in economic activity. The NAS study calls for a 10 to 40 percent reduction in greenhouse gas emissions at a constant 1990 activity level. Using the NAS static assumptions ("no-growth") approach, which does not factor economic growth into the greenhouse emissions calculation, Administration policies will yield greenhouse emissions reductions comfortably within the range advocated by the NAS study.

- Targets and timetables for the future reduction or limitation of greenhouse gases as an aggregate, or of carbon dioxide alone, are not advocated by the NAS study.

- Elements of the comprehensive approach, endorsed by the Administration, are highlighted. The study considers climate change in terms of all greenhouse gases (using CO_2 equivalent), not CO_2 alone, and the contribution of CFCs, which are important greenhouse gases.

- The Administration's policies address all greenhouse gases. Precursors of ozone and nitrogen oxides are controlled in the Clean Air Act. Methane will be reduced by proposed rules on landfill emissions. CO_2 will be reduced by various energy efficiency measures and by the powerful incentives from the Clean Air Act's caps on utility emissions plus the flexibility allowed in achieving those caps. CO_2 will also be reduced by tree planting. CFCs will be phased out by the Clean Air Act's provisions. A tax on production during the phase-out will accelerate these reductions.

- Efforts to limit deforestation, and modest domestic and international reforestation efforts, are recommended in the NAS report. The Administration has proposed a multi-year reforestation proposal to plant one billion trees per year on 1.5 million acres, and to improve forest management practices. The United States also supports debt-for-nature swaps, and is active in pushing for a global forestry agreement.

- A strong research program is endorsed by the NAS panel as an important element of our response to the possibility of greenhouse warming. The U.S. is currently investing almost $1.2 billion in our global climate change research program, which includes studies of the scientific, social and economic questions surrounding climate change and possible policy responses.

- Research and development priorities cited by the NAS study in areas such as solar energy and other alternative energy sources, and energy efficiency are receiving additional resources in the President's FY 1992 budget. The budget includes strong efforts in biomass resources, and expansion of solar and other alternative energy research efforts through cost-shared collaborative ventures.

- The study recommends R&D into the possibilities for adaptation and the need to study geoengineering options. Because natural sources account for 96 percent of the annual CO_2 flux, it makes sense to investigate these options -- although it would be premature to pursue them at this time.

- Continued development of nuclear power is strongly advocated by the NAS study. The President's National Energy Strategy supports the development of a new generation of safe nuclear reactors.

President Bush has established a comprehensive strategy for action on climate change which is outlined in the brochure America's Climate Change Strategy, and will be implemented through the National Energy Strategy (NES), the Clean Air Act, and various other means. The strategy is part of the Administration's commitment to responsible stewardship of our planet, which includes the promotion of economic growth and sound environmental policies.

BusinessWeek JUN 17 1991

THE HOT AIR INFLATING THE GREENHOUSE EFFECT

P. 16

BY GARY S. BECKER

The expansion of the world's economy is a potentially serious threat to the environment, but some advocacy groups and scientists have tried to frighten people into action with grossly exaggerated claims about the seriousness of certain risks.

A prime example is the pile of books and articles published during the past decade envisioning the most dreadful consequences from global warming caused by the greenhouse effect. That refers to an increase in the atmospheric concentrations of carbon dioxide (CO_2), chlorofluorocarbons (CFCs), and other heat-trapping gases. The buildup of these gases during the past 150 years is claimed to be responsible for most of the 0.3C to 0.6C rise in surface temperature during this century.

These studies of the greenhouse effect expect temperatures to rise a lot more—their estimates range from 2C to 5C—by the time atmospheric concentrations of greenhouse gases reach double their 1860 levels, sometime during the first half of the next century. Worried by such predictions, the 1988 Toronto Conference on the Changing Atmosphere, attended by 48 countries, recommended cutting CO_2 emissions by 2005 to 80% of their 1988 level—requiring a major reduction in world economic output. Senator Timothy E. Wirth (D-Colo.) has proposed a tax on the carbon emitted from fuels that would rise to $100 a ton by 2000—raising the cost of a ton of coal or oil by several hundred percent.

MINOR EFFECTS. Such extreme proposals to cut back carbon emissions are responses to forecasts of global warming that are highly questionable. One difficulty with the greenhouse explanation is that when the rapid buildup of these gases began 50 years ago, most of the temperature rise had already occurred. And a recent survey of the evidence issued by the National Academy of Sciences (NAS), *Policy Implications of Greenhouse Warming*, concludes that the increased concentration of greenhouse gases since the end of the 19th century need not necessarily have been the primary cause of the rise in global temperature in those years.

As to the future, even if the continuing growth of CO_2 and other gases in the atmosphere raises global temperatures, it's anyone's guess how that would affect the world's economy and ordinary living. Any likely amount of warming will probably have minor effects on manufacturing, mining, transportation, finance, and most other services. However, some crops would suffer from too much heat and dryness, countries with warm climates would get less comfortable, and in extreme cases, some coastal regions would be flooded by melting glaciers. On the other hand, warming would presumably benefit cold climates such as Canada's and encourage farming in high-latitude regions.

Thus, it appears that the consequences of such warming may be serious but probably would not be so bad. How should public policy respond to a possible, but far from certain, greenhouse warming? A recent study by William Nordhaus of Yale University and the NAS report support the Montreal Protocol that calls for the phasing out of chlorofluorocarbons, which are used in refrigeration and to clean electronic components, by 2000. CFCs are not a major source of global warming, but they damage the earth's protective ozone layer and can be phased out at what appears to be a modest cost.

EDUCATED GUESSES. However, Nordhaus' study and the NAS report are skeptical about the advisability of drastic action to reduce CO_2 emissions. Nordhaus cautions that estimates of damages are no better than educated guesses, and he suggests only modest taxes on coal and other fuels, for he concludes that even large increases in CO_2 emissions during the next 50 years are unlikely to have a major adverse impact. The NAS report proposes a few general policies to improve energy use, further research on the likelihood and effects of warming, and preparation to take more drastic steps should they become necessary.

A study at the University of Chicago conducted by Ian Parry is examining the consequences of the enormous uncertainty about the magnitude of and damages from any greenhouse effect. His work supports the conclusion of Nordhaus and the NAS: Only extreme and unlikely circumstances justify high fuel taxes to cut down drastically the CO_2 emitted into the atmosphere.

The greenhouse effect is just one important illustration of the misleading claims about many environmental risks. Population growth, a perennial source of environmental fears, is another. To take one familiar example, Paul R. Ehrlich warned in his popular 1968 book *The Population Bomb* that hundreds of millions would starve to death in the 1970s and 1980s because the world's population was growing so rapidly. Although this widely reported forecast proved to be ludicrously wide of the mark, Ehrlich and other published doomsdayers continue to be taken seriously.

So little is known about global warming and other potential environmental risks that it is hard to generate effective policies even when the evidence is presented accurately. It becomes almost impossible when advocates bombard the public with worst-case scenarios. ■

Global Warming: A New Warning

A report on the greenhouse effect could prod the White House clique that wants to go slow on protecting the environment

By RICHARD LACAYO

It may not be easy to determine if the greenhouse effect is causing a worldwide rise in global temperatures, but the heated atmosphere around the White House has been unmistakable whenever that topic—or any other environmental question—was raised. From the earliest days of the Bush Administration, there has been heavy friction between William Reilly, director of the Environmental Protection Agency, and a White House faction led by White House chief of staff John Sununu and Budget Director Richard Darman, who are apt to see red when they hear the word green. For them, policies designed to protect the environment look like brakes on economic growth and therefore should be implemented cautiously, if they are put into effect at all.

Last week a panel of the National Academy of Sciences issued a long-awaited report on global warming—the theory that a buildup of carbon dioxide and other so-called greenhouse gases in the atmosphere is causing temperatures to climb, threatening crops and coastal areas that could be drowned under rising oceans if the polar ice caps melt. Though both sides could find some support for their positions in the study, its findings and recommendations could prod the go-slow faction in the White House.

While acknowledging that predictions of global warming are highly uncertain, the panel insists that should not be used as an excuse for delaying action to lessen its possible effects. The panel concluded there is a "reasonable chance" that by the middle of the next century global temperatures will rise anywhere from 2° F to 9° F. That threat, the panel declared, is "sufficient to justify action now."

Then the panel laid out the action it wants, the first time a scientific body has issued recommendations on the subject. Basically, they add up to taking out what the panel called "insurance" against the worst-case scenario of global warming. Among other things, the commission urged the White House to toughen the inadequate energy plan that it unveiled in February. To achieve a 30% increase in automobile fuel efficiency, the panel called for "tax incentives" or regulation, the latter a notion that makes the President flinch. The report also suggested raising overall automobile mileage standards from the current level of 27.5 to 32.5 m.p.g. The President has so far resisted that move, though members of the panel met with him privately at the White House last week to urge the idea.

JUDI BOTTON

EPA chief William Reilly aboard oil platform in the Gulf of Mexico

A scientific panel insists that uncertainty about climbing temperatures should not be an excuse for delaying action to lessen its possible effects

The report brushed aside claims, many emanating from the White House, that reducing greenhouse emissions would be wildly expensive and a blow to economic growth. In February the Administration trotted out estimates that energy-tax increases of as much as $250 for each ton of removed gases would be needed to curb emissions significantly. To the contrary, the panel estimated that reduction of between 10% and 40% in greenhouse emissions could be achieved by doing such comparatively simple things as making buildings and power plants more energy efficient at little or no cost to the economy.

The faction led by Darman and Sununu, however, could point with ... to some parts of the study. Fo... the commission declined to r... explicit target dates or percentag... the reduction of CO_2 emissio... steps, which have been taken by m... ropean nations, are firmly opposed ... Administration. Moreover, the U.S. h... ready adopted some of the other meas... that the report urges, including investin... global climate research (to the tune of $... billion) and planting millions of trees that ... can become storehouses for CO_2. Though Bush undertook those actions for other reasons, they double as defenses against global warming. The panel also used a cost-benefit analysis that takes into account the price of implementing its recommendations, an approach that Darman and Sununu favor.

The report's main benefit could be to reinforce a new spirit of cooperation between the sniping Administration factions. Last year Reilly won a major victory when Congress passed the Clean Air Act over Darman's objections. But Darman and Sununu had seemed to have the upper hand, and the President's ear, on global warming. Bush campaigned on the promise to curb the increase of greenhouse gases, which are produced chiefly by the burning of coal and oil. But the emissions are the exhaust of an industrial economy that Bush is loath to regulate. His instinct was strengthened by the fact that computer models predicting the impact of global warming are imprecise, leaving scientists unsure just how bad the problem is likely to get. Sununu seized upon those uncertainties, insisting it would be foolish to take costly preventive measures against a calamity that might never happen.

But during the past year, Administration infighting on the greenhouse effect seems to have subsided. "Everyone is getting along swimmingly," insists a Sununu aide. While that may be an overstatement, it appears that global warming will no longer be a cause for conflict in the President's immediate circle—at least for now. Pollsters tell the White House that the issue is not high on the public's list of environmental concerns, ranking below more immediate problems like waste disposal, pollution and the disappearance of natural areas. With no pressure from below and little inclination to move at the top, the Administration is likely to keep the warming issue on a low boil. Will that be enough to stave off a change in the weather? Keep an eye on the thermometer. —*Reported by Michael Duffy/Washington*

Volcanoes Can Muddle the Greenhouse

Cleaning up climate records reveals that the largest volcanic eruptions cool the climate for a few years, complicating identification of the greenhouse warming; climate disasters loom too

AS SCIENTISTS AND POLITICIANS anxiously eye signs of global greenhouse warming, climatologists are finding the best evidence yet that a massive volcanic eruption can temporarily bring the mercury down a notch or two. Such a cooling could be enough to set the current global warming back more than a decade, confusing any efforts to link it to the greenhouse effect.

By effectively eliminating some nonvolcanic climate changes from the messy record of the past 100 years, researchers have detected drops in global temperature of several tenths of a degree within 1 to 2 years of volcanic eruptions. Apparently, the debris spewed into the stratosphere blocked sunlight and caused the temperature drops. Climatologist James Angell, who a few years ago could find little evidence that volcanic eruptions caused global cooling, is impressed by the new work: "a pretty good assessment" is how he describes it.

For all their potential social significance, the climatic effects of volcanoes have been hard to detect. The problem has been identifying a volcanic cooling among the nearly continuous warmings and coolings of a similar size that fill the climate record.

The solution seems to be in cleaning up the climate record by removing the temperature variations caused by any known, nonvolcanic causes. Meteorologists Clifford Mass of the University of Washington and David Portman of Atmospheric and Environmental Research, Inc., in Cambridge, who was a student of Mass's, recently took that approach by correcting for the effect of the El Niño cycle. El Niño's abnormally warm waters in the equatorial Pacific tend to warm the atmosphere, just as the abnormally cold waters of the other half of the cycle, called La Niña, cool the atmosphere.

When Mass and Portman adjusted the temperature record for the effect of the El Niño cycle, they found that the five larger eruptions of the nine they studied cooled the hemisphere by 0.1° to 0.5°C, while the four smaller events produced little or no temperature signal. (For comparison, the sizzling 1980s are some 0.34°C warmer than earlier decades.) The largest climate effect followed the massive eruption of Krakatau in 1883, with a temperature drop of 0.5°C. On average, the five largest eruptions dipped the hemispheric temperature about 0.3°C for 2 to 3 years, in line with theoretical predictions.

"I think it's obvious that what's been screwing us up has been El Niño," comments Angell, who tracks climate trends for the National Oceanic and Atmospheric Administration in Silver Spring, Maryland. He had done his own El Niño cycle correction while Mass and Portman were working on theirs and found similar volcanic effects. For example, the 1982 eruption of El Chichón in Mexico was widely expected to affect climate (*Science*, 10 September 1982, p. 1023), but no cooling appeared because it coincided with an El Niño. Take the effect of the El Niño out, however, as Mass and Portman and Angell did independently, and you see a global cooling of several tenths of a degree.

An understanding of this swamping of El Chichón's climate effect by El Niño can help in the search for the greenhouse warming.

U.S. Geological Survey

One that failed. *Mount St. Helens had the explosive power to loft ash into the stratosphere, but it lacked the sulfur to form a lasting, climate-altering aerosol.*

A Krakatau sunset. *Artist William Ascroft sketched this pastel on the bank of the Thames 3 months after the 1883 eruption of Krakatau in Indonesia. The eruption debris produced extraordinarily long and beautiful sunsets worldwide.* [*From plate 11 in* Krakatau, 1883—The Volcanic Eruption and its Effects, *T. Simkin and R. S. Fiske (Smithsonian Institution Press, Washington, DC, 1983). Originally from chromolithographs forming the frontispiece of the Royal Society of London's 1888 report on the eruption.*]

For example, the year 1983 was warmer than normal, but with the El Niño of the century under way and a greenhouse warming presumably accelerating, an all-time record would have seemed more likely. Those opposing the conclusion that the greenhouse is here now could cite the failure to set a record as further support for a wait-and-see approach. But knowing now that the volcanic veil from El Chichón tended to rein in any warming, scientists and policymakers might still argue for actions to control greenhouse gas emissions.

Climatologists seem to have demonstrated that eruptions will cool global temperatures, but they are still debating about how quickly this effect kicks in. "Several papers have suggested an immediate hemispheric cooling 1 to 3 months after an eruption," says Mass, "but I hope that we debunked that idea."

If the volcanic effect were as rapid as claimed by some, it would imply that the climate system is far more sensitive than computer models of climate suggest. One of Mass and Portman's arguments against such sensitivity is that in some suggestive cases the immediate cooling is merely a continuation of a pre-eruption cooling and is therefore unrelated to the eruption event. In other cases, it is an artifact of the data preparation, they say.

Try as Mass and Portman might, such physical and methodological reservations do not seem to have debunked immediate volcanic coolings just yet. "It's murky for the reasons Mass and Portman cite," says Raymond Bradley of the University of Massachusetts, who recently published his own study, "but, from my analysis, I'm pretty convinced there's an immediate effect." Only more large eruptions are likely to resolve this question.

Another remaining uncertainty is whether volcano-induced coolings have ever snowballed into prolonged episodes of cold. Some researchers have suggested, for instance, that concerted volcanic eruptions have cooled climate over decades, centuries, and even millions of years. The temperature records and the eruption records are best for the decade-by-decade changes of the past 100 years, but even then the records are not good enough to resolve the matter. Opinions still vary widely.

"Clearly, you can explain only a small amount of the variability during the past century with volcanoes," says Mass. "If the change is more than a few tenths of a degree or longer than 2 to 3 years, individual eruptions can't explain it." Mass contends that because only the few large eruptions have a demonstrable climatic effect, there simply have not been enough significant eruptions to explain, say, the global 0.2°C cooling between 1940 and 1960. Angell agrees. "It doesn't seem the big eruptions have had enough effect," he says.

On the other hand, "in the past 100 years," says climate modeler Alan Robock of the University of Maryland, "I think volcanoes were quite important. The '20s and '30s were a time of no large eruptions. The atmosphere was very clear, and it was warming." Robock, unlike Mass, sees a chance for closely spaced, moderate-size eruptions to have a significant cumulative effect on the atmoshpere.

Resolving the question of decadal volcanic effects will require a distinct improvement in the record of eruptions and their effect on the atmosphere. Geologists might have some idea of the size of many, though not all, eruptions, but an eruption's power over climate depends as much on its chemical composition as its size. Only tiny sulfuric acid droplets, derived from a volcano's gaseous sulfur, have lasting effects on the stratosphere such as cooling the lower atmosphere and creating gaudy sunsets. Ash falls out too quickly. There are good records for only the past few decades of the ash and acid that drift about in the stratosphere. Earlier than that, researchers are looking to such places as glaciers and polar ice sheets, where the stratosphere's acid fallout is preserved.

Sorting out matters of tenths of a degree may have academic as well as political implications, but the real drama in the volcano-climate arena is the potential for global disaster. The eruptions of the past century studied by Mass and Portman are geological midgets compared to earlier cataclysms. For instance, the large 1883 eruption of Krakatau produced only one-tenth of the ash of another Indonesian volcano, Tambora, which spewed 100 billion cubic meters 70 years earlier. This event was followed by "the year without a summer" in 1816 in New England and northern Europe, if not around the world. Snow and frosts in June and July brought hardship to both regions. Debate continues over whether even an eruption of that size could divert the jet stream and drop temperatures 5°C, as happened then.

But the geologic record gets more disastrous. As recently as 75,000 years ago, Toba in Indonesia spewed an estimated 1 trillion cubic meters of magma along with its accompanying gases. And even normally quiet, Hawaiian-style eruptions can rage into cataclysms. Fifteen million years ago the Columbia flood basalts surged over Oregon and Washington, some flows gushing 700 billion cubic meters of fluid lava in only a few days. Geologists stand in awe of these eruptions. Climatologists can only hope that they do not have a firsthand opportunity to record the atmosphere's reaction to such a megaeruption. ■ RICHARD A. KERR

ADDITIONAL READING

J. K. Angell, "Impact of El Niño on the delineation of tropospheric cooling due to volcanic eruptions," *J. Geophys. Res.* 93, 3697 (1988).

R. S. Bradley, "The explosive volcanic eruption signal in Northern Hemisphere continental temperature records," *Clim. Change* 12, 221 (1988).

C. F. Mass and D. A. Portman, "Major volcanic eruptions and climate: A critical evaluation," *J. Clim.* 2, 566 (1989).

SCIENTIFIC AMERICAN July 1990 Volume 263 Number 1

The Great Climate Debate

Greenhouse effect and the prospect of global warming is the subject of scientific and political controversy. Should we take steps now to avoid consequences we cannot foresee?

by Robert M. White

In the waning years of the 10th century, millions braced themselves for the apocalypse, believing that the approaching year 1000 was the very millennium—the end of the heavens and the earth prophesied in the Bible's Book of Revelation. Not surprisingly, the prospect of the impending Day of Wrath terrified normally sane people into rash and (in retrospect) foolish actions. Some gave away all of their possessions; others hastened to do harsh penance for their deeds.

In this final decade of the 20th century, a different kind of apocalypse causes widespread concern. This time the hand of God has been replaced by more visible agents: belching smokestacks, gasoline-powered automobiles, power-generating stations and the voracious destruction of forests, all of which may be turning up the heat on an overburdened environment. Global climate warming, some claim, threatens the very habitability of the planet. Others hold that the predictions of environmental collapse are not well founded and are goading us into hasty political action. Is our planet the "Endangered Earth," as *Time* magazine would have it in its 1988 year-end cover story? Or is it as *Forbes* magazine put it, "The Global Warming Panic: A Classic Case of Overreaction"?

Debate in the media reflects uncertainty among climatologists and geophysicists. Some of the world's eminent authorities on the atmosphere recently hurled verbal brickbats at one another in the pages of the prestigious journal *Science*. Their charges of "junk science" and "science by consensus" reflect the acrimonious nature of the debate within the scientific community. Some members of the National Academy of Sciences, including one of its former presidents, charge that policymakers are being induced to take unwise actions on the basis of uncertain scientific evidence. Set against this view is the recent statement of the Union of Concerned Scientists urging action by the government. It was signed by 52 Nobel laureates and more than 700 members of the NAS.

In spite of the scientific uncertainty, government and nongovernment groups are rushing to outdo one another in urging drastic action now to "stabilize" the global climate. From Washington to Toronto and The Hague, from Cairo to Moscow, international conferences of experts and political leaders have called for action. Soviet President Mikhail S. Gorbachev, President George Bush, British Prime Minister Margaret Thatcher and French President François Mitterand share similar views on the climate-warming issue.

Back home, debate within the Bush administration on how the U.S. government should act is intense. Caught between the urgings for action from the Environmental Protection Agency and Congress and cautions from his science adviser and chief of staff, President Bush called two major conferences to address the issue of climate warming. The first, held in April, brought together the heads of scientific, economic and environmental agencies of many governments. The second will be an initial meeting of governments, scheduled for early 1991, to begin negotiation of an international convention to stabilize global climate.

While there are still doubts in the White House, Congress has been environmentally hyperactive. Many pieces of legislation have been introduced to address the predicted climate warming. Leading the bipartisan effort have been Senator Timothy E. Wirth of Colorado, Senator Al Gore of Tennessee and Congresswoman Claudine Schneider of Rhode Island. Some of this legislation is comprehensive and far-reaching. It offers suggestions for action on the energy, agriculture and transportation fronts as well as for intensified research.

The actions proposed would radically change the most vital functions of human economies. They could include such diverse actions as using energy more efficiently, shifting the fossil-fuel mix from oil and coal to natural gas, relying more heavily on renewable energy sources and using more nuclear and solar energy. Measures could also include implementing reforestation, phasing out use of chlorofluorocarbons (CFC's) and changing agricultural practices.

Policy initiatives of this kind would

ROBERT M. WHITE is president of the National Academy of Engineering. He was formerly chief of the U.S. Weather Bureau and administrator of the National Oceanic and Atmospheric Administration. He has also served as president of both the University Corporation for Atmospheric Research and the American Meteorological Society. In 1979 he was chairman of the first World Climate Conference of the World Meteorological Organization.

alter the technology and economics of energy. Our use of land and water would also need to change. Economic growth in nations dependent on fossil fuels might be slowed. And the problems of arresting the growth of global population would become even more pressing. How can national and international policy formulation be moving so rapidly to address the specter of climate warming when agreement about the science is lacking and the economic and social costs of action have hardly been tallied? At the root of this thinking is a confluence of diverse scientific, economic and environmental forces.

The idea that the actions of humanity might change the composition of the atmosphere and hence the world's climate has deep historical roots. As early as the 1860's, it was suggested that slight changes in atmospheric composition might bring about major variations in climate. Increases in carbon dioxide (CO_2) and other atmospheric trace gases can contribute to what has been called greenhouse warming because these compounds allow the sun's energy to reach the surface of the earth, thereby warming it, while preventing much of that energy from being reradiated to outer space.

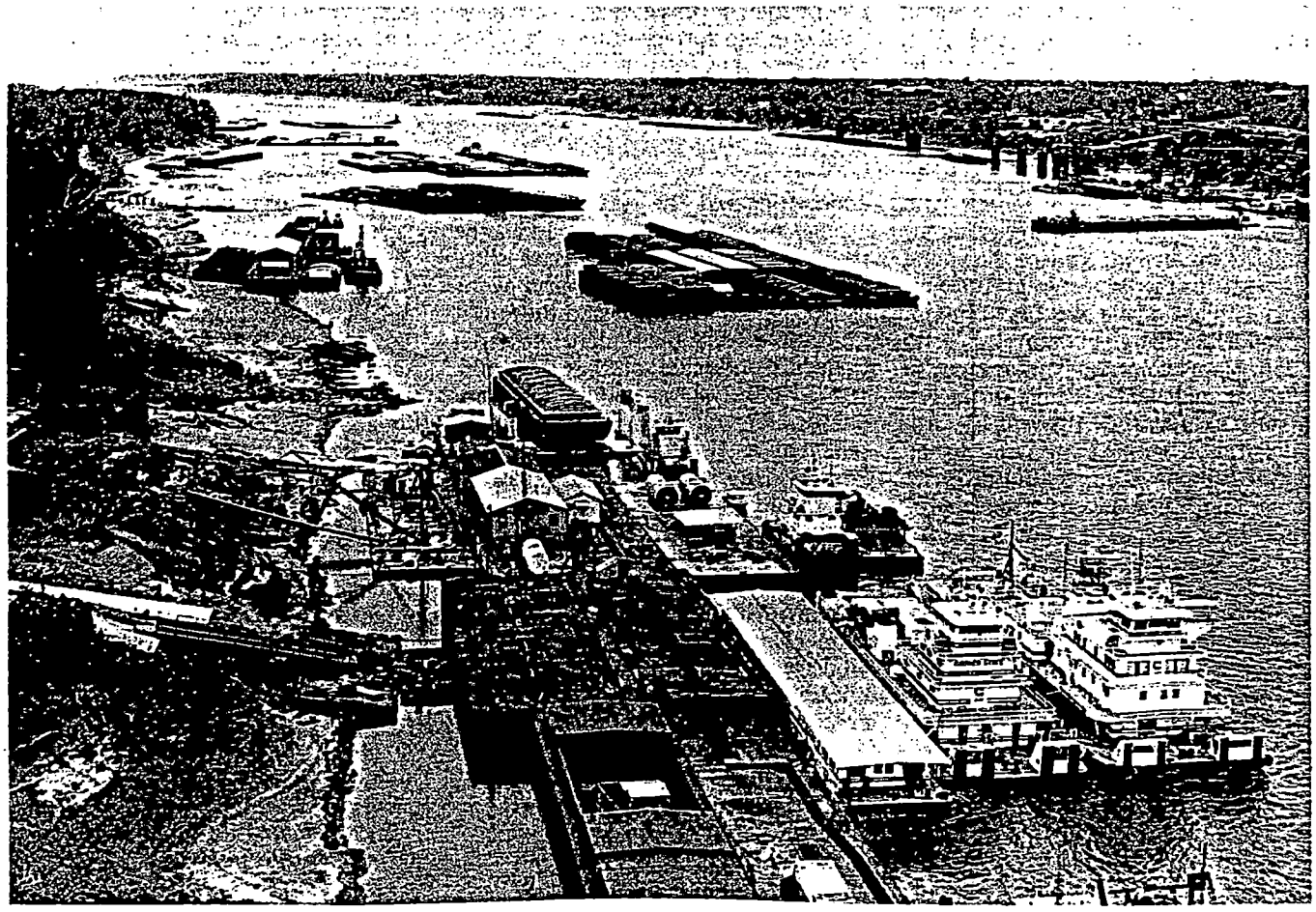
At the end of the 19th century the Swedish scientist Svante A. Arrhenius calculated how changes in carbon dioxide content would affect the temperature at the earth's surface. He estimated that a doubling of carbon dioxide would produce a global warming of about seven to 11 degrees Fahrenheit (four to six degrees Celsius), not too far off modern calculations. Yet it was only with the inception of the International Geophysical Year, a worldwide experiment in 1957 to monitor the global environment, that scientific data validating the increase of carbon dioxide in the atmosphere became available.

Roger Revelle, then director of the Scripps Institution of Oceanography, his colleague Hans E. Suess and C. David Keeling, his student, undertook such measurements. Revelle had long contended that humans were carrying out an unintended geophysical experiment on the atmosphere by burning fossil fuels. Determined to monitor the carbon dioxide content of the atmosphere, he persuaded Keeling to develop the instrumentation.

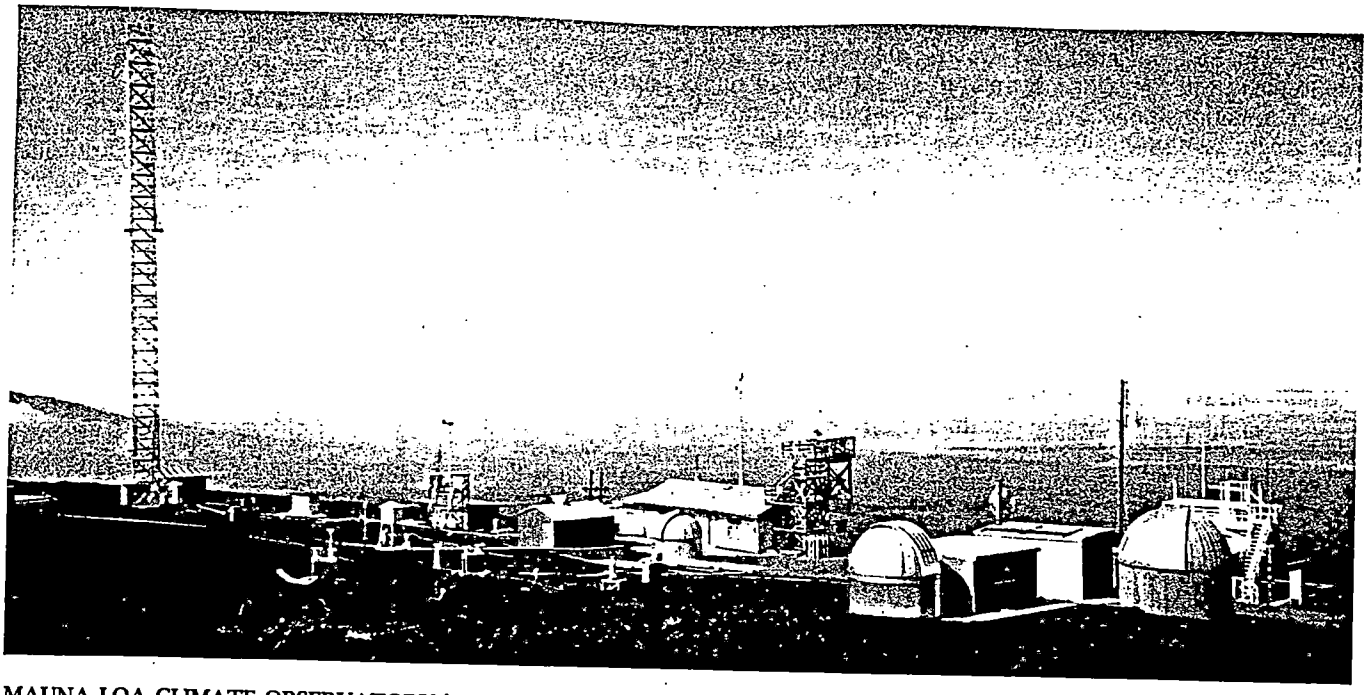
The measuring devices were placed in the Mauna Loa climate observatory in Hawaii at an altitude of about 11,000 feet. Beginning in 1957, the data they collected revealed a systematic increase in atmospheric carbon dioxide. Keeling's observations were verified at the South Pole and at other locations around the world. To date, the change from 290 parts per million in 1880 to 352 parts per million in 1989 represents more than a 20 percent increase over the course of the past century.

Just before the International Geophysical Year began, on the other side of the continent from Scripps, another development key to unraveling the climatic consequences of increasing carbon dioxide emissions was taking place. Under the leadership of the world-famous mathematician John von Neumann at the Institute for Advanced Study in Princeton, N.J., the first attempts were made to represent the atmosphere mathematically on digital computers.

Von Neumann's team of brilliant young scientists was headed by Jule G. Charney. Later known as the father of



BARGES STRANDED by all-time low water levels on the Mississippi River were one effect of the record-breaking drought of 1988. That long, hot summer thrust the greenhouse effect into the public eye and set off the present policy debate.



MAUNA LOA CLIMATE OBSERVATORY in Hawaii is located at about 11,000 feet. Data collected here, beginning in 1957 and continuing through the present, were the first to document a steady increase in atmospheric carbon dioxide levels.

numerical weather prediction and arguably the most important American figure in the transformation of weather prediction from art to science, Charney demonstrated the feasibility of using computers to perform the task. Von Neumann and Charney calculated the first 24-hour weather forecast in 1950 on a primitive digital computer, the ENIAC, maintained by the U.S. Army Signal Corps in New Jersey.

Looking beyond these efforts, von Neumann called climate forecasting the "infinite prediction." One of the young scientists in the Princeton group, Norman Phillips, made the first attempt at modeling the global atmosphere in 1956. It was coincidence that later, in 1963, an unusual laboratory of the National Oceanic and Atmospheric Administration (NOAA) was established on the campus of Princeton University under the leadership of Joseph Smagorinsky, a strong-willed and hard-driving young scientist who had been one of von Neumann's group. The laboratory was totally devoted to the mathematical modeling of the atmosphere using the largest and fastest digital computers available.

Called the Geophysical Fluid Dynamics Laboratory, the center harbored researchers from many nations interested in this new approach to the study of the atmosphere. Among them was a young Japanese scientist, Syukuro Manabe. Modest and retiring but completely dedicated to the work, he developed the first climate model in collaboration with his colleague Richard T. Wetherald in the 1960's. In 1975 they calculated that a doubling of the carbon dioxide content of the atmosphere would produce a global climate warming of about five degrees F (three degrees C), averaged over the surface of the earth. This calculation has been verified in many different laboratories and has not changed substantially.

Keeling's observations, together with the calculation of Manabe and Wetherald, triggered the wave of climate-change research that has marked the past two decades. Studies have since been undertaken in many parts of the world, including Europe and the Soviet Union. In the U.S. the National Research Council conducted studies in 1966, 1977, 1979, 1983 and 1987. These inquiries were chaired by such leading scientists as Gordon J. F. MacDonald, Revelle, Thomas F. Malone, Charney, William A. Nierenberg and economist William D. Nordhaus.

Yet because there were no immediate consequences for human health and no evident manifestation of climate change, the work was slow to arouse political concern. The most politically influential study was the one prepared in 1979 at the request of Frank Press, now president of the NAS, who was then White House science adviser to President Jimmy Carter. It was also in 1979 that the World Meteorological Organization in Geneva, recognizing the potential global significance of the issue, convened the first World Climate Conference.

Gradually, scientific awareness that humanity might actually be causing a planetary disruption began to register in the political world. Although there was much debate over the validity of projections from computer models, the observations of greenhouse-gas increases, however, were precise, well measured and verified in many parts of the world. These were corroborated by additional data that documented increases in other greenhouse gases such as methane, or natural gas, and CFC's.

Meanwhile mathematical-modeling groups in this country had been established not only by the NOAA but also by the National Aeronautics and Space Administration, the Department of Energy and the National Science Foundation. The leaders of these laboratories became the "gurus" of climate warming. Incisive and original in their work, Stephen H. Schneider of the NSF's National Center for Atmospheric Research in Boulder, Colo., and James E. Hansen, the leader of NASA's Goddard Institute for Space Studies, were soon to become frequent witnesses at innumerable congressional committee hearings on the subject.

Although the mathematical models of all the groups yielded similar results, the details of the geographic distribution of climate changes differed from one model to the other. All projected that an increase in carbon dioxide would bring about a gradual warming, but the timing of this warming would depend on the rate of global energy use. They all agreed that

if reasonable assumptions were made about future global energy consumption, it would be around the middle of the next century that the carbon dioxide content of the atmosphere might double.

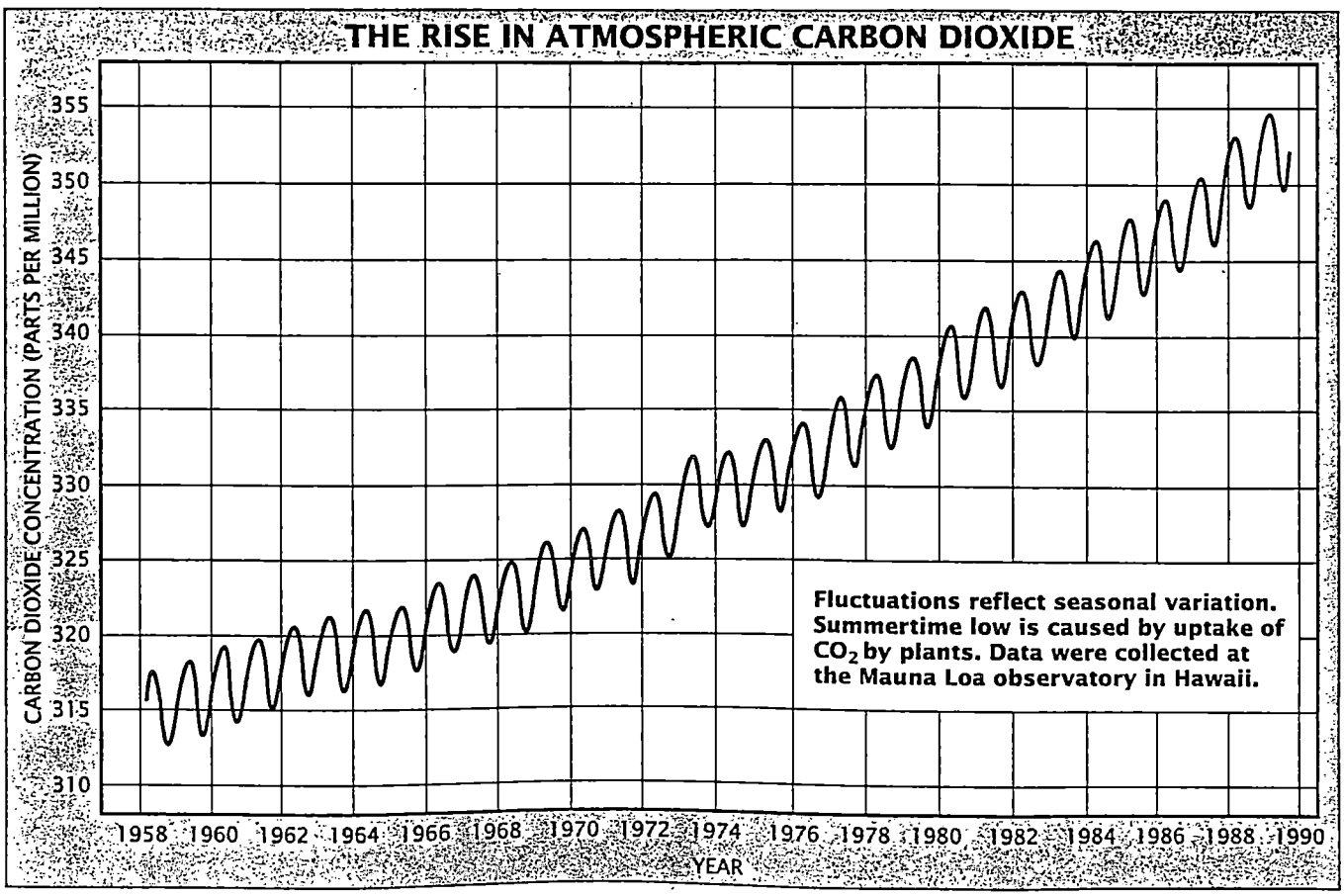
Just how much this doubling of carbon dioxide would increase temperatures, however, varied greatly from model to model. Some predicted as little as a two-degree F (one-degree C) increase, whereas others predicted increases of as much as nine degrees F (five degrees C). The differences in predictions became central elements in the debate about whether the models were sufficiently reliable to warrant policy actions. Further, it made a great difference whether the actual increase was at one or the other end of this range. At the low end, the normal resilience of society would probably be sufficient to accommodate the changed climate. Changes at the high end portended severe disruptions.

These projected temperature changes may appear innocuous because variations of this magnitude are experienced in the normal course of daily and seasonal weather. Their full implications can be appreciated by noting that it took only a two-degree F average decrease in temperatures in Europe to cause the run of several frigid centuries (from the 1400's to the 1800's) known as the Little Ice Age. Nine degrees F is believed to be the difference in temperature that separates the end of the last great ice age 12,000 years ago from the present. Further, the projections indicate that the Northern Hemisphere would experience in just a half century an unprecedented temperature change, 10 to 50 times faster than the change since the last ice age.

Those who are not familiar with mathematical models or the way computers are used to make these projections can be forgiven for being confused—or even annoyed—by the great disparities in the results. Among investigators it is understood that mathematical models are only approximations that attempt to simulate the processes that govern atmospheric behavior. The atmosphere is so complex that it is impossible to represent it in very great detail in these mathematical models. It is possible to represent only certain features and to make assumptions about how the oceans and the atmosphere interact, how the rate at which the oceans take up carbon dioxide varies and how clouds affect the exchange of energy between the earth and the atmosphere. Even the largest computers cannot represent the atmosphere, oceans and land surface in fine detail. Indeed, scientists approximate the conditions in the atmosphere by thinking of it as a set of observations spaced about 500 kilometers apart.

The political calls for action are being played out against the backdrop of that uncertainty. On one side, the view is that if there is a chance that model predictions could be correct, the consequences could be so dire that immediate action to arrest climate change would be imperative. The alternative view, equally cogent, is that commitment to action with vast economic and social consequences is unwarranted in light of both the scientific uncertainty and the absence of knowledge of the economic costs. John H. Sununu, White House chief of staff, in remarks he made at the annual meeting of the National Academy of Engineering in the fall of 1989 gave voice to this position:

> *Although I agree that* [global warming] *is a critical issue, the fact is that the models with which analysis is being done and with which policy is being moved, as good as they may be, still are based on element sizes measured in hundreds of kilometers in length and width, and tens of kilometers in thickness. I suspect that no one who has ever been involved in engineering simulation would feel comfortable making major*



decisions in which the elements were orders of magnitude greater than the details on which they were looking for information. And yet the fact is that we are moving toward binding international policy based on conclusions being drawn by policymakers who have no sense at all of the difference between the levels of confidence they should have and levels of confidence they want to have. A system is not valid just because it gives you the answers you want. And yet so much policy is being made in reaction to that principle.

The solution to the dilemma should be simple: Since the carbon dioxide content of the atmosphere has increased by more than 20 percent over the past century, we ought to be able to detect the climate warming in the global temperature record during the same period. Researchers have sought to do this, but it is a much more difficult task than it first appears. The problem is that climate is always in a state of natural fluctuation. Separating out the changes that are caused by increasing carbon dioxide from the natural changes is tricky scientific business. Moreover, the climatic temperature record is based on scattered and irregular observations not taken specifically for the purposes of determining climatic conditions.

Even so, careful analysis of these temperature records by scientists in the U.S. and in the U.K. sought to detect whether a climate warming has occurred and whether such warming is consistent with the prediction of the models. The prevailing view is that the climatic record over the past century for the entire globe reveals a net increase in temperature ranging from .5 to 1.0 degree F (from .3 to .8 degree C). But set against this conclusion is the disturbing result that similar increases in temperature cannot be detected over the past century in the U.S., where observations are numerous and accurate.

Even if the temperature rise is real, a puzzle remains that workers have been unable to unravel: Is the rise in global temperatures a natural fluctuation or a result of the increase in greenhouse gases? All that can be said is that the observed increase is consistent with the lower end of the temperature increases predicted by the computer models. Consequently, the temperature records, as well as the predictions of mathematical models, provide substance both to those who believe the evidence warrants action now and to those who believe the evidence is still too weak.

The rush to policy action was, I believe, catalyzed by the disastrous drought of the summer of 1988. During this drought, one of the worst on record, the water in the Mississippi River fell so low that navigation was impossible over long stretches, urban water supplies were threatened and crops throughout the grain belt were devastated. Both officials and the public wondered whether this was the greenhouse effect manifest. Indeed, records show that in the U.S. five of the years of the 1980's were among the hottest on record, and the average temperature for the decade as a whole was the warmest since instrumental records have been kept.

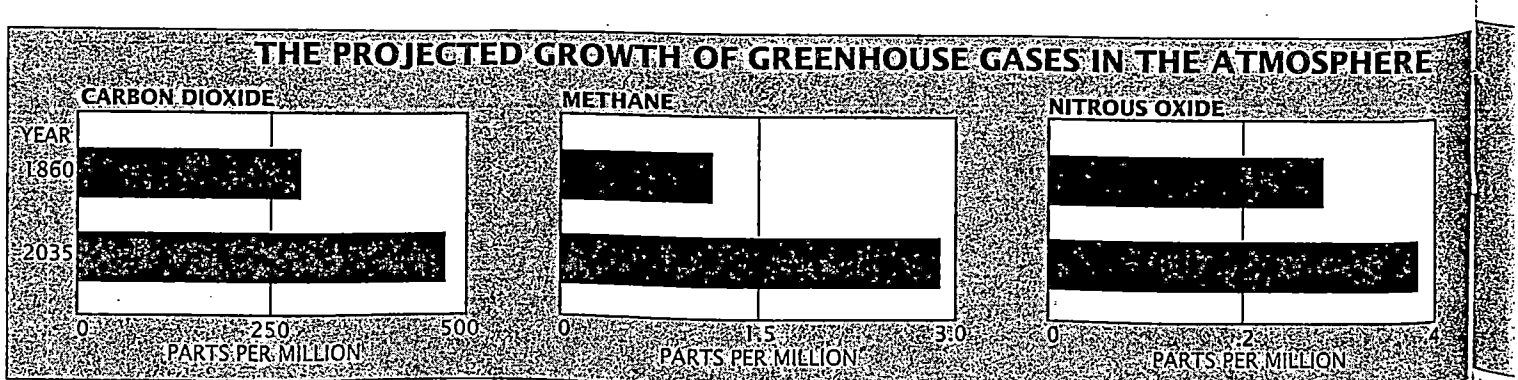
Prompted by heat and drought, congressional hearings addressed the question of whether the greenhouse effect had arrived. These hearings were unremarkable except for a statement by Hansen. When he stated that he was 99 percent certain that the greenhouse warming had begun, as evidenced by the sequence of warm years in the 1980's, the public took notice. His opinion prompted members of Congress to consider whether the prudent course was to move rapidly to legislation aimed at protecting the habitability of the planet from catastrophic consequences.

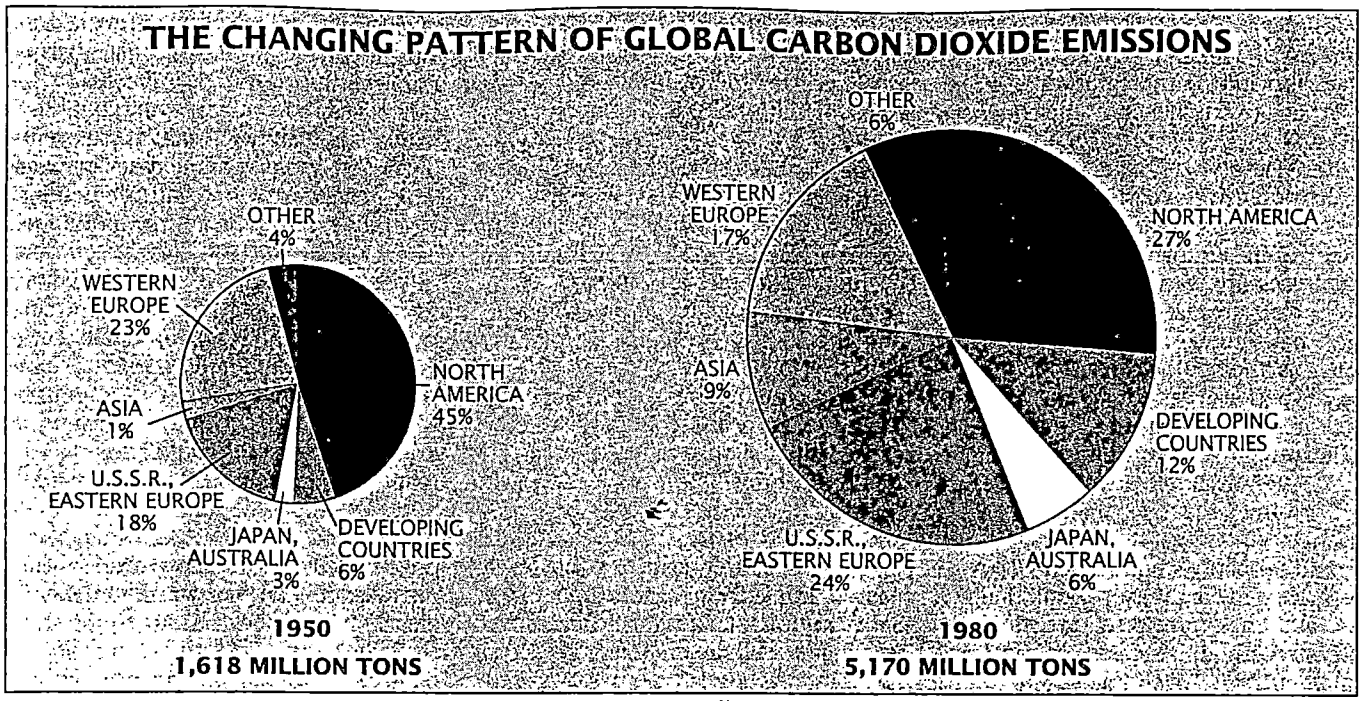
Hearings followed hearings. Both the atmospheric researchers and the more general environmental community began to choose sides on whether immediate policy action was justified. The reaction from environmentalists was quick and vociferous. Several environmental and scientific groups began to advocate international agreements restricting the emissions of greenhouse gases.

At this point, some influential atmospheric researchers, who believed that policy actions were beginning to outrun the scientific evidence, weighed in with their views. Richard S. Lindzen of the Massachusetts Institute of Technology and Jerome Namias of Scripps, the nation's most distinguished long-range weather-forecasting expert, wrote a letter to President Bush urging that no action be taken. Three other members of the NAS, including its former president Frederick Seitz, joined in a report, published under the auspices of the Marshall Institute, calling into question the scientific basis for policy actions. They recommended a major research program in mathematical modeling. They pointed out that there might be alternative explanations for the climate warming that had taken place. Thus, the great climate debate had been joined.

Meteorologists did not look with favor on the prospect of yet another public debate involving their field: they had been proved wrong many times before. As long ago as 1924, Sir Gilbert Walker, then head of the British government's Indian weather service, discerned unusually close connections between rainfall, temperature and pressures in the Pacific Ocean and the Indian subcontinent. Claims were made that the problem of forecasting the Indian monsoon was solved. Were it true, it would have been a great boon to Indian agriculture. But it was soon recognized that the correlations had little predictive power.

Later, in the 1940's and 1950's, widespread claims were made, based on the work of the late Irving Langmuir, Nobel laureate from the General Electric Company, and Vincent J. Schaefer of the State University of New York at Albany, that seeding clouds with dry ice or crystals of silver iodide could bring about an increase in rainfall. Several decades of research into the possi-





bilities of increasing rainfall, changing the intensity of hurricanes and modifying hailstorms by cloud-seeding techniques proved abortive.

Then, in the early 1980's, it was postulated that dust thrown into the atmosphere by a nuclear exchange between the Soviet Union and the U.S. would result in a "nuclear winter." This idea was deflated by Schneider and his colleague Stanley L. Thompson, who showed with the same models used in the prediction of climate that the "initial nuclear winter hypothesis can now be relegated to a vanishingly low level of probability."

Given this "cry wolf" history, it is not surprising that many meteorologists harbor deep reservations about taking costly actions on the basis of the predictions of a climate warming. But the push for policy has other constituents. Climate warming also unites those who are concerned about biodiversity and species extinction, economic development, human population growth, urban air pollution, acid precipitation and ozone depletion.

Political leaders stimulated by public concerns about environmental deterioration see these issues as important platforms and as springboards to public office. Those interested in increasing the competitiveness of American industry see greater energy efficiency as an important step toward that goal. It also serves the interest of those concerned about U.S. dependence on foreign energy sources. The issue of nuclear power is also underscored. Because fossil fuels are the main source of atmospheric carbon dioxide, strategies for stabilizing climate must envision non-fossil-fuel sources. Here at last is justification that proponents of nuclear power can forcefully advance to support expansion of nuclear power facilities throughout the world.

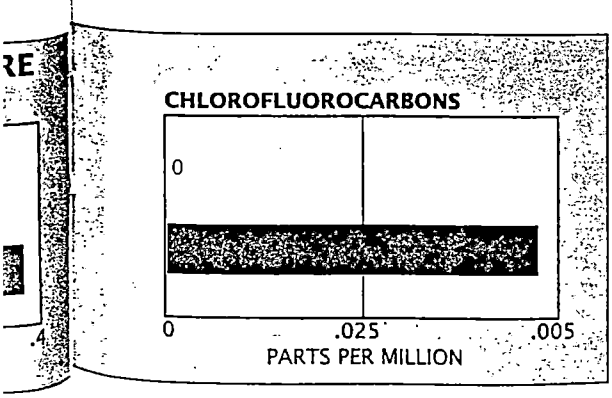
The issue of global climate warming also offers an opportunity for advancing the "new economic order" long advocated by Third World nations. International action will require technological and economic assistance to such nations if they are to participate in a global effort to reduce atmospheric pollution or arrest deforestation. In fact, the world faces the prospect that the greatest increases in emissions of carbon dioxide will occur in developing countries as their need for economic growth is followed by increased demand for energy.

In like manner, those interested in arresting population growth, especially in the Third World, point out that the climate-warming problem is probably not solvable as long as the number of human beings continues to rise. After all, it is people who consume natural resources and energy and who farm the land. Without population control, prospects for stabilizing the climate and arresting the deterioration of the habitability of the planet are abysmal.

Are the consequences of climate warming to be feared? People experience extremes of temperature in the natural course of events. The fact is that we do not know enough to predict the severity of the consequences. Because the warming would not be uniform over the surface of the earth, it would probably produce both winners and losers among regions and nations. Some parts of the earth would become warmer, some wetter and some drier. It is not possible on the basis of the evidence at hand to predict who would benefit and who would lose in such a global redistribution of so-called climatic resources.

Some aspects of global climate warming would be greatly beneficial in the view of agricultural researchers. Increased carbon dioxide will foster more active photosynthesis and enhance crop growth, to say nothing about the lowered plant requirements for water in a CO_2-enhanced atmosphere. In the words of Jerry D. Mahlman, director of the Geophysical Fluid Dynamics Laboratory, "The things we can say with confidence, the policymakers are not interested in. And the things [they] are interested in, we don't know with confidence."

Models do, however, agree that the polar regions of the world would undergo greater increases in temperature than would the tropics. Some of the projections of temperature increases in polar areas are startling in their magnitude, predicting as much as 18 degrees



F (10 degrees C) on the average in the Northern Hemisphere and only slight increases in tropical regions.

What are the general consequences of such a change in the temperature difference between equatorial and polar regions? We experience similar differences every year as the seasons change. In summer when arctic temperatures are warm, we do not suffer the great storms of winter; precipitation belts move farther north. Areas such as the southwestern part of the U.S. experience very dry conditions.

If arctic regions were to undergo significantly greater warming than equatorial regions and if precipitation belts were to move farther north, countries in the north temperate and polar zones would probably stand to benefit greatly. Their growing season would lengthen, and their precipitation would increase. With suitable soils, agriculture might thrive. These are speculations, however.

Such speculations are formulated in "scenarios" asking the question, What if? Unfortunately, an infinite number of such "what if" questions may be asked. What if the flow of rivers in the American Southwest, already fully utilized, were to be reduced by 20 percent? What if temperatures were to increase in the corn belt and precipitation were to move farther north? What, then, would be the consequences in the U.S. for agriculture, for resource availability, for energy generation, for national parks and conservation of nature?

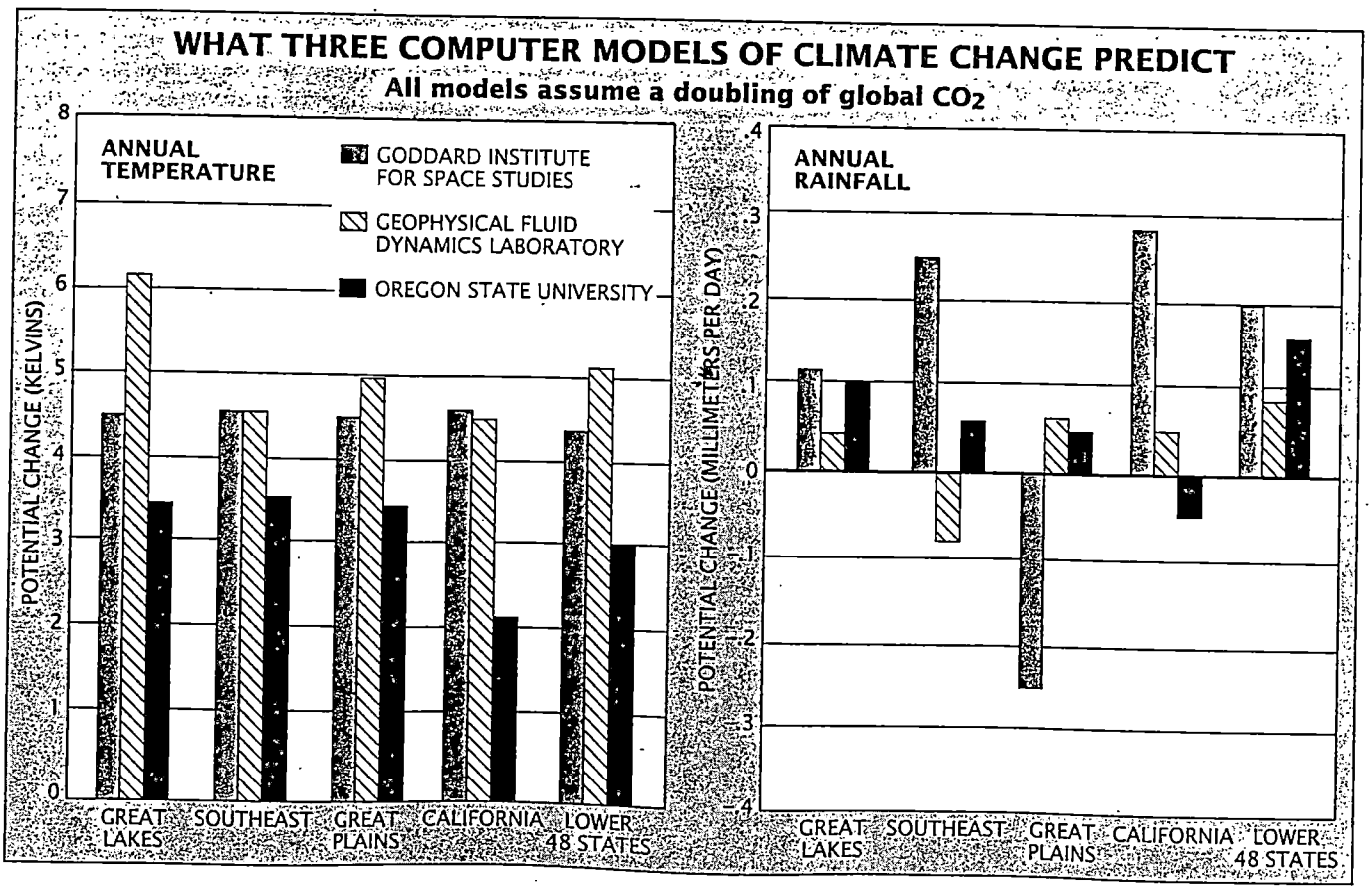
The consequences of changed climates can be seen in historical records going back thousands of years, and we have seen them in recent climatic events. We know, for example, that the Danes were able to settle Greenland and the Vikings to sail the North Atlantic to North America during a period of warm climate around the year 1000. Then a significant change in climate caused the collapse of the Danish settlements, prevented further exploration of the North American continent and ushered in the Little Ice Age. In just the past few years we have witnessed the effects of drought in the Sahel region of Africa and northeast Brazil, as well as in parts of North America.

Such scenarios can suggest apocalyptic possibilities. A recent film in the *Infinite Voyage* television series showed the U.S. Capitol under water as the result of one possible climate-warming scenario. Some foresee vast migrations of people as areas of the world become uninhabitable. Others see threats to national sovereignty and national security. President Gorbachev has stated that ecological security, not military security, will be the principal concern of all nations in the next century as environmental conditions cause disruptions worldwide.

But scenarios should be qualified with the caveat that although the events portrayed might in some cases be plausible, they are not real predictions. What, then, is a wise course in the face of great uncertainty? Clearly, it would be one that recognized uncertainty but would not permit that uncertainty to forestall action. Steps for which other economic and environmental reasons make sense would be taken first, whether or not a climate warming is taking place [see "The Changing Climate," by Stephen H. Schneider; SCIENTIFIC AMERICAN, September, 1989].

Then, as scientific knowledge reduced uncertainties, more costly measures could be taken if warranted, hence closely tying policy actions to the state of knowledge. Scientists and others have called this a "no regrets" policy. In gambling it would be known as "spreading your bets."

A recent report of the Council of Economic Advisers lends weight to this approach. It states that the cost of controlling carbon dioxide emissions and of taking other actions to address climate change would run into hundreds of billions of dollars. Because such reallocations of resources raise the specter of grave economic consequences, we need to be reasonably sure such ac-



tions are worth the cost. Any rational no-regrets policy would foster as one of its prime objectives adequate investment by governments in global monitoring and mathematical modeling to reduce the scientific uncertainties.

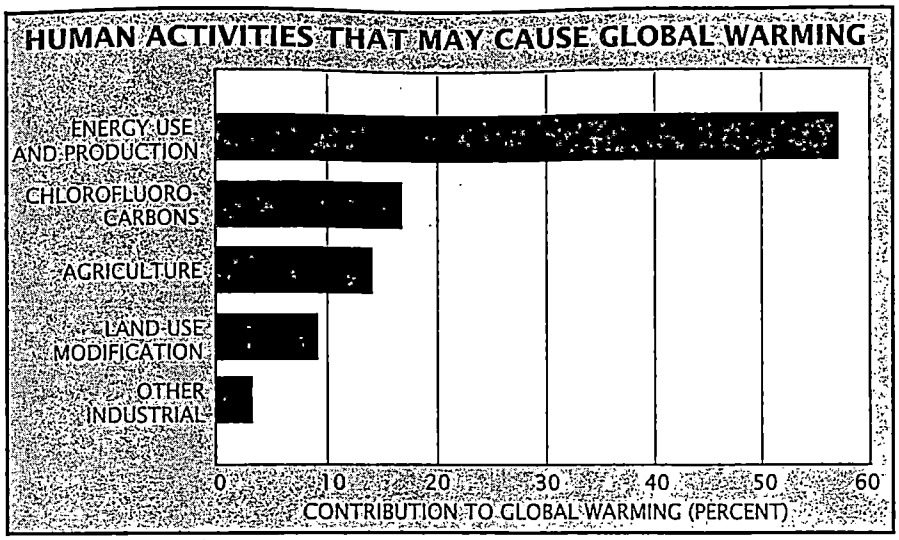
Where might we start? Energy conservation and efficiency along with the phaseout of CFC production would be the first priority for national and international action. Achieving greater energy efficiency justifies itself handily in economic terms. Increased energy efficiency would also ameliorate urban air pollution and acid precipitation. Shifts in the fossil-fuel mix from coal and oil to natural gas could significantly reduce carbon dioxide emissions per thermal unit. Technology is also available for more efficient power generation and for increased gasoline mileage.

Wisdom would also dictate major investments in nonfossil-energy sources. The circumstances favor significant new investments in passively safe, publicly acceptable nuclear power. Further development of forms of solar energy—photovoltaics or biomass, for example—makes good sense. Reforestation and forest preservation constitute a benign policy that yields many ecological and climatic benefits. Research aimed at producing stress- and disease-resistant crops would also be wise.

The public, however, must not be misled. These no-regrets initial policy steps will not solve the climate-warming problem. Their effectiveness will only modestly retard climate warming, and the future may require more drastic actions. No matter what policy actions we take, fully arresting the climate warming just does not seem to be in the cards.

The difficulties of reaching an international agreement on procedures for mitigating climate warming will be difficult and lengthy. The negotiations for the Law of the Sea Treaty provide a good lesson. They consumed 15 years and produced a treaty that the U.S. has yet to sign because of demands by developing nations for significant technology transfer and economic assistance. These issues will be even more complicated and more pervasive in any "Law of the Atmosphere Treaty."

It is likely that humanity will have to adapt to some climate changes. Modes of adaptation by society have not been well studied. Individuals, corporations and communities can adapt to climatic vicissitudes in myriad ways. Farmers can change crops, water use can be regulated and management practices can be altered.



Other modes of adaptation would be needed if climate changes were severe. Sea-level rise, which is one of the predicted concomitants of a climate warming, might inundate low-lying coastal areas and cause salt water to intrude into freshwater bodies. Were this to occur, society would have to decide whether to invest in protective structures along coasts or adapt by changing land-use patterns. The North Sea dikes in the Netherlands are an outstanding example of adaptation to relative rise in sea level.

Some adaptations would take considerable time to implement. If the price of energy were to escalate, energy-efficient habitations would be necessary. Present cities with their great suburban sprawl are not energy efficient, and so we might return to more compact cities. If we chose to maintain agriculture in dry areas, society would need to decide whether to invest in the necessary irrigation systems. In fact, the economic growth of the entire western part of the U.S. has been based on major investments in water storage and transport for irrigation and industrial use.

Fortunately, time may for once be on our side. Governments generally act only when threats become real. They act in the face of military threats or when areas are endangered and destroyed by natural disasters. If the climate changes, the expectation is that it will do so gradually. We should be able to see the initial evidence of coastal inundation in an increasing frequency of high tides and in the undercutting of seacoasts. Climate warming itself should be evident in a rising frequency of heat waves or in other weather anomalies. The effects of a global climate warming are likely to take 30 to 50 years to become serious, and that is a long enough span in which actions to adapt to these changes should be possible.

What of the debate in the atmospheric, environmental and political communities? Our global environment is under attack on many fronts. Climate warming is but one, perhaps the most complex, of these issues. If the changes occurring in our atmosphere are likely to cause consequences, we must understand the problems and promote sensible policies to remedy them. What would be unwise is to lapse into apocalyptic thinking or ostrichlike denial. We like to believe ourselves far more sophisticated, more enlightened, than preceding generations. Until we can calmly and objectively approach our environmental challenges without promoting public hysteria and exciting shortsighted, self-interested reaction, we cannot claim that we are.

FURTHER READING

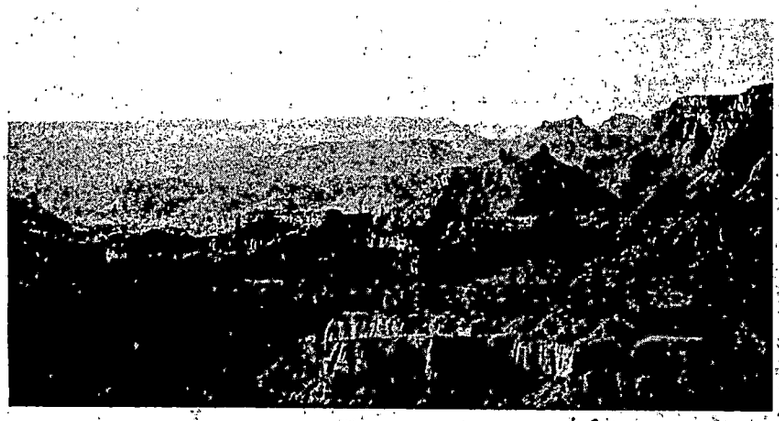
THERMAL EQUILIBRIUM OF THE ATMOSPHERE WITH A GIVEN DISTRIBUTION OF RELATIVE HUMIDITY. Syukuro Manabe and Richard T. Wetherald in *Journal of Atmospheric Science*, Vol. 24, pages 241-259; May, 1967.

CHANGING CLIMATE: REPORT OF THE CARBON DIOXIDE ASSESSMENT COMMITTEE. National Research Council, Carbon Dioxide Assessment Committee. National Academy Press, 1983.

THE GREENHOUSE EFFECT, CLIMATIC CHANGE, AND ECOSYSTEMS. Edited by Bert Bolin and Bo R. Doos. John Wiley & Sons, Inc., 1986.

GLOBAL TRENDS OF MEASURED SURFACE AIR TEMPERATURE. James Hansen and Sergej Lebedeff in *Journal of Geophysical Research*, Vol. 92, D11, pages 13345-13372; November 20, 1987.

THE GREENHOUSE EFFECT: SCIENCE AND POLICY. Stephen H. Schneider in *Science*, Vol. 243, No. 4892, pages 771-781; February 10, 1989.



On a clear day at the Grand Canyon it is possible to see 200 miles or more.

Under certain conditions a combination of manmade pollutants and natural sources reduces the range of visibility to less than 80 miles.

CLEARING THE AIR

BY POLLY HAYS

For decades, visitors from all over the world have come to northern Arizona to *see* the Grand Canyon. Today there is evidence that we are seeing less of it than we used to, and about half of the reduction in visibility at the Grand Canyon may be due to human sources.

A growing body of scientific data collected over the past twelve years has enabled National Park Service (NPS) researchers to characterize the air quality at the Grand Canyon, to identify the causes of air pollution and poor visibility, and to begin to pinpoint sources of these pollutants. For example, recent research shows that the Navajo Generating Station, a coal-fired power plant located about 100 miles northeast of Grand Canyon Village near Page, Arizona, may contribute significantly to reduced wintertime visibility at the Grand Canyon.

In 1916, when the NPS was established by Congress, the new agency was directed to "conserve the scenery and the natural objects . . . and to provide for the enjoyment of the same in such manner. . . as to leave them unimpaired for future generations."

Preserving air quality was implied in this statement, but specific laws to protect air resources, especially visibility, came in 1977 when Congress amended the Clean Air Act with provisions to "remedy any existing and prevent any future manmade visibility impairment" in "Class I" areas. The Grand Canyon was designated a Class I area at this time, along with 47 other units of the national park system.

Charged with the responsibility for protecting air quality in these areas, the National Park Service began an extensive program of research and monitoring in order to fulfill this obligation.

Through an ongoing program coordinated by the NPS Air Quality Division in Denver and Fort Collins, Colorado, park personnel have collected data in the field using equipment as simple as 35mm cameras, and as sophisticated as computers. Combined with knowledge of weather and wind patterns, this information has enabled the National Park Service to determine the causes and sources of poor visibility in many park service areas. Visibility is reduced by natural sources such as water droplets, forest fires, and windblown dust, but research suggests that the single most important contributor to poor visibility nationwide is fine sulfate particles. These are primarily the result of sulfur oxide emissions from power plants and other industrial sources.

At the Grand Canyon, analysis shows that about half of the visibility reduction is due to sulfate particles. During the summer months, this pollution comes from distant sources. Coal, copper smelters, and other industries in southern California, southern Arizona, New Mexico, and Mexico are suspected as the cause.

However, prevailing weather patterns indicate that winter haze might be primarily due to local sources. Because the Grand Canyon is hundreds of miles from a major urban area, and there is little industry in the region, the Navajo Generating Station was suspected as a source because it has no sulfur dioxide (SO_2) emission control equipment. This plant is now estimated to be the single largest SO_2 emission source in the west.

To test this assumption the NPS, in cooperation with the Environmental Protection Agency (EPA) and the electric utility industry, conducted the Winter Haze Intensive Tracer Experiment (WHITEX) for six weeks during the winter of 1987.

This was a regionwide field study to see if winter haze at Grand Canyon National Park and other parks of the Colorado Plateau region could be attributed to the Navajo Generating Station. In addition to a stepped-up program of visibility and particulate monitoring, a chemical tracer was injected into the stacks of the NGS during the WHITEX study. This tracer served as a fingerprint to track emissions from the powerplant as they spread over the region.

Analysis of the WHITEX data involved several steps. First, the data were evaluated to determine the kinds of gases and particles present in the air. Analysis showed that fine particles were responsible for most of the visibility reduction, and that the largest share of these fine particles was sulfates.

On the days with the worst visibility, sulfates were responsible for 73% of the visibility reduction from manmade sources. This information comes from monitoring stations located on the rim of the canyon. Photographs show that on some occasions the visible haze is primarily below the rim, and that the problem may be even greater than these numbers indicate.

Next, the Navajo Generating Station's contribution to poor visibility was calculated. Tracer data for days with the worst visibility were analyzed using two different techniques. Similar results from both analyses show that on these days the Navajo Generating Station's average contribution to observed visibility reduction was 40-50%, and on two of the three worst visibility days it was 60-75%.

Third, prevailing weather conditions during the WHITEX study were examined. The days with the worst visibility were found to be linked to specific weather conditions. A build-up of air pollution from local sources resulted when there was a regional high pressure system and an inversion. Historical weather data show that between November and March these weather conditions occur about 30% of the time in this area.

Based on the analysis of the WHITEX data, the NPS feels that it is reasonable to conclude that between November and March, manmade pollution causes a noticeable visibility problem at the Grand Canyon under certain weather conditions that are present up to 30% of the time.

Under these winter conditions, the Navajo Generating Station is the single largest contributor to poor visibility at the Grand Canyon, causing 40-50% of the problem on the average, and up to 70% of the problem on the worst days.

In February 1989, the NPS presented these conclusions to the Environmental Protection Agency. Under the visibility provisions of the Clean Air Act, "if a major stationary source began operating after August 7, 1962, and emits any air pollutant which may reasonably be anticipated to cause or contribute to any visibility impairment in a Class I area, then that source shall be required to install and operate 'best available retrofit technology' (BART) to eliminate or reduce such impairment."

On September 5, 1989, the EPA used the findings of the WHITEX study to support a proposed ruling which finds that the Navajo Generating Station is "a major contributor to the winter pollution haze" at Grand Canyon. By Summer 1990, the EPA will propose a second ruling which will outline the amount of pollution control equipment to be required at the plant. Both of these rulings are subject to a 60-day public comment period. Comments may be addressed to: Environmental Protection Agency, 401 M Street SW, Washington, D.C. 20460.

Many diverse groups, including environmental organizations and the joint owners of the Navajo Generating Station (the Salt River Project, U.S. Bureau of Reclamation, Arizona Public Service Company, Los Angeles Department of Water and Power, Nevada Power, and Tucson Gas and Electric) have an interest in this issue, and not all of them are in agreement with the EPA ruling. Some have called for additional studies, and others wonder who will pay for the proposed pollution control systems. Although these pollution controls are anticipated to cost up to several billion, the increase to an individual consumer's monthly electric bill would be little more than the price of a candy bar.

As policy options are discussed, the National Park Service remains firm in its commitment to protection of park resources. The NPS now realizes that efforts to preserve Class I air quality at Grand Canyon must of necessity require that changes be made outside the park's boundary. If these efforts successfully reach out and control the sources of pollution, the quality of the air will be improved not just at the Grand Canyon, but nationwide.

The Guide is published by Grand Canyon Natural History Association to provide information about Grand Canyon National Park.

Evelyn Bettencourt, Guide Editor
McQuiston & Daughter, Inc., Designers

The Guide is printed on recycled paper.