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2001

ACID RAIN: THE STATE OF THE SCIENCE AND RESEARCH NEEDS FOR THE FUTURE

HEARING

BEFORE THE

COMMITTEE ON SCIENCE
HOUSE OF REPRESENTATIVES

ONE HUNDRED SEVENTH CONGRESS

FIRST SESSION

MAY 3, 2001

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ACID RAIN: THE STATE OF THE SCIENCE AND RESEARCH NEEDS FOR THE FUTURE

THURSDAY, MAY 3, 2001

House of Representatives,
Committee on Science,
Washington, DC.

The Full Committee met, pursuant to call, at 3:30 p.m., in Room 2318 of the Rayburn House Office Building, Hon. Sherwood L. Boehlert (chairman of the committee) presiding.

Committee on Science

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U.S. House of Representatives

Washington, DC 20515

Hearing on

Acid Rain: The State of the Science and Research Needs for the Future

Thursday, May 3, 2001
3:00 PM–5:00 PM
National Conference Sponsored by the Center for Environmental Information
Holiday Inn Capitol, 550 C St. SW, Washington, DC

Witness List

Dr. Charles T. Driscoll

University Professor of Environmental

Systems Engineering,

Syracuse University, NY

Dr. Jill S. Baron

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Research Ecologist,

Colorado State University

Dr. Ellis Cowling

University Distinguished Professor At-Large,

North Carolina State University

Dr. Gerald J. Keeler

Associate Professor of Civil and

Environmental Engineering,

University of Michigan

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HEARING CHARTER

FIELD HEARING

Acid Rain: The State of the Sciences and

Research Needs for the Future

Thursday, May 3, 2001

3:00–5:00 p.m.

Columbia Ballroom, Holiday Inn Capitol

550 C Street, SW, Washington, DC

On Thursday, May 3, at 3:00 p.m. the Science Committee will conduct a field hearing at a national conference on acid rain sponsored by the Center for Environmental Information. The conference will be attended by over 200 scientists from around the country and will be held at the Holiday Inn Capitol in downtown Washington, DC (550 C Street, SW).

The Hearing will examine the latest scientific findings regarding acid rain's impact on sensitive ecosystems and those ecosystem's ability to recover. The Committee also intends to explore the continuing threat posed by acid rain and associated air pollution and the adequacy of our nation's air pollution monitoring systems for continued tracking of ecosystem health.

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Witnesses are still being finalized but will likely include the following:

Dr. Charles Driscoll, Syracuse University, NY, will discuss the latest science on air pollution that causes acid rain, ozone and particulates. One of the leading experts on acid rain, Driscoll recently co-authored a comprehensive study concluding that even full implementation of the acid rain provision in the 1990 Clean Air Act Amendments would not be sufficient to allow the recovery of sensitive ecosystems.

Ellis Cowling, North Carolina State University, NC, will discuss the impacts of air pollution on forests, fish, and surface and ground water quality in the Southeast and the importance of monitoring networks. Cowling is a forest pathologist who became a world leader in atmosphere-biosphere research.

Jill Baron, Colorado State University, CO, will discuss the impacts of nitrogen deposition in the Colorado Front Range. Baron will testify how growing nitrogen additions to the environment are altering the forest ecosystem in the Rocky Mountains.

Jerry Keeler, University of Michigan, MI, will discuss the our evolving understanding of the sources of mercury pollution, mercury's fate in the environment, and future research and monitoring needs.

BACKGROUND

The Sources and Effects of Acid Rain:

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Sulfur dioxide (SO) and nitrogen oxides (NO**X**) are emitted into the atmosphere primarily from the

burning of fossil fuels in electric utilities, industrial boilers and motor vehicles. These emissions can be carried by prevailing winds many miles from their source through the atmosphere where they react with oxygen, sunlight, and other compounds in the air to form acid rain.

Our understanding of the impact of acid rain has evolved over the last several decades as scientists have studied the sources and fate of pollution in the environment. Scientists now know, for example, that in the Adirondack Mountains of New York State, probably one of the most acid-sensitive ecosystems in the United States, over 30 percent of the lakes are so acidic at times that they kill young fish that swim in their waters, while an additional 10 percent are "chronically" acidic, unable to support any fish life at any point during the year. More than half of large canopy red spruce trees in New York and Vermont have died since the 1960s, a fact that scientists only recently can attribute to acid rain. And in Pennsylvania, acid rain is now understood to be the cause of the deaths of an extensive number of sugar maple trees.

Outside the Northeast, scientists have found adverse impacts of acid rain in the Great Smoky Mountains in Tennessee and North Carolina and in the Allegheny Mountains of West Virginia, where the spring snowmelt can overwhelm young native brook trout with acid, reducing the diversity of fish species and stressing the ecosystem.

While scientists earlier believed that controlling SO emissions would allow ecosystems to recover, they now understand better the detrimental effects of NO**X**. In addition to its role in acid rain, nitrate deposition that results from NO**X** emissions also has a fertilizing effect, upsetting the nutrient balance in such estuaries as the Chesapeake Bay and Tampa Bay and contributing to eutrophication and algal blooms.

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In the last few years, scientists understanding of mercury pollution has improved rapidly. Like SO and NO**X** mercury is also a product of coal combustion, and has been shown to become more biologically available in acidic bodies of water. A potent neurotoxin, mercury is the basis for most fish consumption advisories, which have been issued for thousands of water bodies nationwide, including almost all areas of the Great Lakes and their connecting waters. Women of childbearing age are the most likely to be at risk from mercury exposure. Scientists still have much to learn about mercury, however, including which chemical forms of mercury comes from which sources, what happens to mercury in the atmosphere and in the environment, etc.

Efforts to Address Acid Rain:

In 1990, Congress amended Title IV of the Clean Air Act to address the problem of acid rain by requiring cuts in the amounts of sulfur dioxide (SO) and nitrogen oxides (NO**X**) electric utilities and industrial boilers are allowed to release into the air.

The acid rain title of the 1990 Amendments called for placing a cap on utility SO emissions to achieve a total reduction of 10 million tons below 1980 levels by 2010. The legislation established an innovative trading program to allow each SO emitter, such as electric utilities and large industrial boilers, to emit up to the amount covered by the "allowances" it holds. A facility that emits less than its allowance may sell its surplus and keep the profit, while one that emits more must go to the market and buy enough additional

allowances to cover its emissions or pay a penalty. Although this kind of market approach to regulation was highly controversial when first proposed, its success in reducing SO emissions cheaper and faster has made it a model of successful market-based regulation.

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The legislation also called for a reduction of NO**X** emissions from both utilities and mobile sources of 2 million tons below 1980 levels. While that goal has been met, the legislation did not set a cap on NO**X** emissions. And, even though additional regulations controlling NO**X** emissions have been issued under other titles of the Clean Air Act, NO**X** emissions are expected to rise slightly in the future.

Despite reductions in SO emissions, some sensitive ecosystems continue to decline or are improving more slowly than expected. A recent review of acid rain science in the scientific journal *BioScience* concluded that even "full implementation" of the acid rain provisions of the 1990 Act would not be sufficient to allow for the recovery of sensitive ecosystems. Some in Congress have responded by introducing legislation calling for steeper cuts in emissions of acid rain forming pollutants.

Clean Air Research:

Title IX of the Clean Air Act Amendments of 1990 called for research and monitoring under the National Acid Precipitation Assessment Program (NAPAP). Congress required NAPAP to issue periodic reports on the status of emissions, deposition, ecosystem recovery, and the costs and benefits of emissions control programs. The latest report is attached to this charter.

Air pollution monitoring plays an important role in assessing the effectiveness of efforts to control air pollution. Because of the short term variability of weather patterns, long term monitoring networks are critical for assessing the impact of reductions in pollution emissions.

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The two primary air pollution monitoring networks are the National Atmospheric Deposition Program (NADP) and the Clean Air Status and Trends Network (CASTNet). The NADP, a partnership between universities, industry, and federal and state agencies, analyzes the chemistry of wet deposition, such as rain and snow, at nearly 200 monitoring sites in predominantly rural locations across the country.

A new sub-network of the NADP is the Mercury Deposition Network, which measures mercury levels at 40 sites in 16 states and two Canadian provinces.

The CASTNet provides atmospheric data on the dry deposition portion of total acid deposition, ground-level ozone and other forms of atmospheric pollution. It consists of 79 monitoring stations located primarily in the east and operated by EPA and the National Park Service. The CASTNet also measures the chemical constituents of PM2.5, which are regulated under the most recent National Ambient Air Quality Standards (NAAQS).

Acid Rain: The State of the Science and Research Needs for the Future

Chairman **BOEHLERT.** The hearing will come to order. It's a pleasure to welcome you here this afternoon. We had hoped to have this hearing at the Holiday Inn, the site of your conference, but the lords of the back room of the House advise us that there may be a series of procedural votes this afternoon, and rather than be over there at the Holiday Inn, although worthy of the deed, and then have to interrupt every eighteen minutes and come over here and vote, we thought we'd bring you over here. So, I thank you for your cooperation.

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[The prepared statement of Sherwood Boehlert follows:]

PREPARED STATEMENT OF CHAIRMAN SHERWOOD BOEHLERT

It's a pleasure to be here this afternoon at this important conference. We're holding this hearing because we want to be sure that Congress takes note of the important research findings that have been aired over the past two days. We will take pains to ensure that the information in today's hearing record is widely circulated and known.

That will be an especially pleasurable task for me because acid rain is one of the first issues I focused on when I first came to Congress back in 1983. To many back then, acid rain was just a theory—and not a very credible one at that. But up in the Adirondacks, in the northern part of my District and beyond, the evidence was accumulating that acid rain was all too real. The dead lakes and thinning trees told an alarming story that many people were not interested in hearing.

Back then, I used to frequently quote from a speech by Tom Kean, who was at that time the governor of New Jersey. Kean said that if all we did was study acid rain, "we'd end up with the best documented environmental disaster in history." It was a good line, and it sounds even more prescient now because of the way things have turned out.

First, we heeded the warning, we overcame the naysayers, and we did indeed take action. We passed the Title IV of the Clean Air Act Amendments of 1990, and we launched the war on acid rain, and I'm quite proud of my role in helping to draft that legislation. And, even more encouragingly, as the latest research shows, that legislation has made a real—if insufficient—difference.

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Second, the continuing research has, as we had expected, demonstrated that the problems caused by acid rain are truly severe, varied and widespread. We can now document the impacts of acid rain on lakes, aquatic species, trees and soil in ways that we could only guess at in the early '80s.

So what we've ended up with is genuine action, real improvement, and growing documentation that we need to do still more. And I'm trying to get the Congress to do more as an author of both H.R. 25, the Acid Rain Control Act, and H.R. 1256, the Clean Smokestacks Act. Those bills would require significant

additional cuts in sulfur dioxide, nitrogen oxides and new cuts in mercury.

But to make the case for those additional cuts we need to rely on the best, most recent, credible science. And that's why today's hearing is so important.

We'll hear this afternoon from the top scientists in the country studying acid deposition and related problems to get a clearer sense of what steps we need to take. And—and this is especially important from a Science Committee perspective—we'll hear what kind of research and what kind of monitoring networks the federal government needs to support to ensure that we continue to get the science we need to avert disaster.

The response to acid rain has thus far been a story of the system succeeding—a story of Congress acting on the basis of the best research, even in the face of uncertainty, and then trying to update policy on the basis of continuing research. That's a pattern we need to perpetuate. We need to keep funding the research and heeding its results. Today's hearing should further those goals.

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We're holding this hearing because we want to be sure that Congress takes note of the important research findings that have been aired over the past 2 days. We will take pains to assure that the information in today's hearing record is widely circulated and known. That will be an especially pleasurable task for me, because acid rain is one of the first issues I focused on when I came to Congress back in 1983.

To many, back then, acid rain was just a theory, and not a very credible one at that. But up in the Adirondacks, the northern part of my district and beyond, the evidence was accumulating that acid rain was all too real. The dead lakes and thinning trees told an alarming story that many people were not interested in hearing.

Back then I used to frequently quote from a speech by Tom Kean, who at that time was Governor of New Jersey. In response to those who called for continuous delay and more study, Kean said that if all we do is continue to study the problem, we will end up with the best documented environmental disaster in history. It was a convincing line, and it sounds even more prescient now because of the way things have turned out. First, we heeded the warning. We overcame the naysayers and we did indeed take action. We passed the Title IV of the Clean Air Acts of 1990, and we launched the war on acid rain. And I'm quite proud of the role I was privileged to play in helping draft that legislation. And even more encouragingly, as the latest research shows, that legislation has made a real, if insufficient, difference.

Second, the continuing research has, as we had expected, demonstrated that the problems caused by acid rain are truly severe, varied, and widespread. We can now document the impact of acid rain on lakes and aquatic systems, trees, and soil in ways that we could only guess about in the early '80's.

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So what we have ended up with is genuine action, real improvement, and growing documentation that we still need to do more. I am trying to get the Congress to do more as an author, co-author, of H.R. 25, The

Acid Rain Control Act, and H.R. 1256, the Clean Smokestacks Act. These Bills would require significant additional cuts in sulfur dioxide, nitrogen oxides, and new cuts in mercury. But to make a case for those additional cuts, we need to rely on the best, most recent, credible science, and that's why today's hearing is so important.

We will hear, this afternoon, from the top scientists in the country, studying acid deposition and related problems, to get a clear sense of what steps we need to take. And this is especially important from a Science Committee perspective. We will hear what kind of research and what kind of monitoring networks the Federal Government needs to support to assure that we continue to get the science we need to avert disaster.

Response to acid rain has thus far been a story of the system succeeding, a story of Congress acting on the basis of the best research, even in the face of uncertainty and at times, I might add, adversity; and then trying to update policy on the basis of continuing research. That's a pattern we need to perpetuate. We need to keep funding the research, and heeding it's results. Today's hearing should further those goals.

And I am privileged to ask for unanimous consent that our colleagues, not members of this Committee, Mr. McHugh and Mr. Sweeney be permitted to participate in today's hearing, submit any statements they care to for the record, and participate in the questioning of the witnesses.

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I ask for that privilege because Mr. McHugh represents the heart of the Adirondack Mountains, and has long been a champion of working to combat the problem of acid deposition. And Mr. Sweeney, a more recent addition to the Congress, is a valued partner in this fight.

So it's a pleasure, Mr. McHugh to have you with us, and without objection, so ordered.

The Chairman now is privileged to recognize a distinguished gentleman from Colorado, Mr. Udall.

STATEMENT OF HON. MARK UDALL, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF COLORADO

Mr. **UDALL.** Thank you Mr. Chairman, and I welcome my colleague, Mr. McHugh, as well, and it is terrific to have him here today, participating in this important hearing.

Mr. Chairman, I'd like to make a brief statement, and I am eager to move on to hear what the panelists have to say.

Many people think the acid rain problem was solved back in the 1990's with the passage of the 1990 Clean Air Act Amendments, and I would also recognize my colleague, the Chairman, who played an important role in those amendments and their passage, and was present in the oval office, as I understand it, when they were signed into law.

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Though significant progress has been made in reducing sulfur admissions to pre-1973 levels, nitrogen oxide and ammonia emissions remain high. In my home state, Colorado, atmospheric hydrogen deposition has increased in the past 10 years, and is harming Colorado's pristine wilderness areas.

Nitrogen deposition is doubly problematic, because it also causes eutrophication, a condition that results in noxious algae blooms in high lakes, which we have many in Colorado.

While the total amount of acid deposition in Colorado is far less than that in the East, Western soils are much more vulnerable to the problem. In the West, changes in soil nitrogen levels have been observed to alter the species composition and functioning of entire alpine forest and grassland communities.

Recent work by Dr. Baron who is here on the panel today, a researcher at the USGS in the Natural Resource Ecology Lab at Colorado State University, has clearly demonstrated that even small increases in atmospheric nitrogen deposition in Colorado's front range produces measurable changes in natural undisturbed ecosystems.

In Colorado the main sources of acid-causing emissions are cars, and factories, and agricultural activity, especially feed-lots and fertilizer use.

Steps must be taken now to ensure that pristine eco-types in Colorado and elsewhere are preserved for future generations. And our Chairman, Mr. Boehlert made the case eloquently earlier for action, not study.

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So, I'm glad to be here to listen on this important topic, and thank you again, Mr. Chairman, for the time.

[The prepared statement of the Honorable Mark Udall follows:]

PREPARED STATEMENT OF THE HONORABLE MARK UDALL

Thank you, Mr. Chairman, for putting together this important hearing and for giving me the opportunity to introduce fellow Coloradan DR. JILL BARON, a research ecologist with the biological research division of the U.S. Geological Survey. Dr. Baron is also a Senior Research Ecologist at the Natural Resources Ecology Laboratory at Colorado State University, where she earned her Ph.D. in 1991.

Dr. Baron is principal investigator of along-term ecological research and monitoring program that works toward understanding Rocky Mountain biogeochemical cycles, and the influences of land use, climate change, and atmospheric deposition on ecosystem processes. Her recent interests lie in applying knowledge of biogeochemistry and long-term processes toward ecosystem management of mountain environments, freshwater ecosystems, and human-dominated basins such as the South Platte River of Colorado.

Prior to earning her Ph.D., Dr. Baron was a research biologist and later a research ecologist for the National Park Service. She earned her M.S. in Land Resources at the University of Wisconsin in Madison, and her B.S. in botany and geology from Cornell University.

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Welcome, Dr. Baron.

I'd like to make a brief opening statement, if I may, Mr. Chairman.

Many people think the acid rain problem was solved back in the 1990s with the passage of the 1990 Clean Air Act Amendments. Though significant progress has been made in reducing sulfur emissions to pre-1973 levels, nitrogen oxide and ammonia emissions remain high.

In my home state of Colorado, atmospheric nitrogen deposition has increased in the past 10 years and is harming Colorado's pristine wilderness.

Nitrogen deposition is doubly problematic because it also causes eutrophication, a condition that results in noxious algae blooms, in high lakes.

While the total amount of acid deposition in Colorado is far less than that in the East, western soils are much more vulnerable to the problem.

In the West, changes in soil nitrogen levels have been observed to alter the species composition and functioning of entire alpine, forest, and grassland communities.

Recent work by Dr. Baron (a researcher at the USGS and the Natural Resource Ecology Laboratory at Colorado State University) has clearly demonstrated that even small increases in atmospheric nitrogen deposition in the Colorado Front Range produce measurable changes in natural, undisturbed ecosystems.

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In Colorado, the main sources of acid-causing emissions are cars and factories and agricultural activity, especially feedlots and fertilizer use.

Steps must be taken now to ensure that pristine ecotypes in Colorado and elsewhere are preserved for future generations.

I am glad to be here to listen to testimony on this important topic.

Chairman **BOEHLERT.** Thank you. The Chair is privileged to recognize Mr. McHugh.

STATEMENT OF HON. JOHN MC HUGH, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF NEW YORK

Mr. **MCHUGH.** Thank you, Mr. Chairman, and let me begin by expressing my appreciation to you, to Mr. Udall, and to the Committee for your gracious hospitality in letting me participate and sit in on this very, very important hearing. And an added word of appreciation to you for your leadership, not just in helping to convene this valuable session, but for so much work over so many years, and what many are coming to perhaps belatedly, but nevertheless very importantly, come to recognize what you have known for

so long, as to what an enormous problem this is and continues to be.

I have had a real opportunity, and one of honor, to work with you, and as you noted, more recently with Mr. Sweeney on this initiative, and of course my initial concern is for the Adirondacks, and I know you share that sentiment, Mr. Chairman.

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It is a beautiful place, a place of really unparalleled beauty and wonder. It's bigger than the Grand Canyon Glacier, Yellowstone, and Yosemite National Parks combined, and it is a treasure that has been entrusted to us. And as this hearing, I trust, will underscore very vividly, it is a treasure that is under attack. Simply put, the Adirondacks are being ravaged by this killer called acid rain. More than 20% of the lakes there are already dead. 55% are highly acidic, and in fact this is a scourge that is growing across this nation. Beyond its impact of course on the natural environment, the kinds of degradation that acid rain effects can be witnessed, and our national monuments can be witnessed on the facAE9ade of the state capital in Albany. And its impact grows.

It's like the canaries of old that the miners used to carry into the bowels of the earth to warn them of noxious gases and impure air. The Adirondacks today are really a harbinger for the rest of the nation. We've seen the effects of this phenomenon on places like the Appalachian trout streams, and throughout Virginia, wild brook populations being devastated, and on, and on, and on. The time back has long since passed.

We, of course, are focused on H.R. 25 and hope that today's hearing will help add impetus to what we recognize as already a very necessary step to take.

And with that, Mr. Chairman, I would ask for unanimous consent to submit a more complete statement for the record, and yield back to you again with my thanks and my compliments for your leadership.

[The prepared statement of Representative John M. McHugh follows:]

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PREPARED STATEMENT OF REPRESENTATIVE JOHN M. MCHUGH

EPA says H.R. 25 provides more than $60 billion in human health and other benefits

I am honored to join my Northern New York colleague, Science Committee Chairman Sherwood Boehlert at his hearing. Acid rain is truly hitting us back home where we live, in one of the world's natural treasures, the Adirondack Park and its High Peaks region. Bigger than the Grand Canyon, Glacier, Yellowstone, and Yosemite National Parks combined, the Adirondack Park contains a stunning array of mountains, wild lands, forests, rivers and lakes, waterfalls, and deep gorges. I am humbled by the fact that an enormous portion of the Adirondacks is in my Congressional District.

Yet the Adirondack Mountains are being ravaged by the silent killer of acid rain: more than 20 percent of

the lakes there are already dead and 55 percent are highly acidic. Acid rain is literally eating away at our cultural heritage as our historic buildings and monuments are threatened. Each year, health problems such as chronic bronchitis and asthma are effected by the acidic deposition. The severe damage to the citizens and our economy is clear.

And recent studies have shown that the Adirondacks is a harbinger of what other areas will face, as forests and lakes in sensitive areas throughout the country are threatened by acid rain. In Virginia, thousands of miles of Appalachian trout streams are at risk of becoming chronically acidic, unable to support wild brook trout populations. And in the southern Appalachians, acid rain is altering soil chemistry and leaching valuable nutrients from the soil.

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That's why we're here today: To underscore the urgent need to pass H.R. 25, the Acid Rain Control Act. This bill would cut the allowable emissions of sulfur in half and cut nitrogen emissions 70 percent by 2007. And it does this by establishing for nitrogen oxides the same market-based trading program that has been so successful at curbing sulfur dioxide emissions.

According to the U.S. Environmental Protection Agency (EPA), in a report finalized last year, H.R. 25 and its previous Senate companion bill (S.172) would result in more than $60 billion in annual benefits to improvements to human health, visibility, aquatic and forest ecosystems, and buildings and cultural structures. At the same time, the EPA estimates costs of H.R. 25 to be about $5 billion. I think it is safe to say that this is the kind of cost-effective legislation we strive to achieve, with 12 times the benefits for the costs involved.

I look forward to working with my good friends Chairman Boehlert and the bill's sponsor, Representative John Sweeney, to pass H.R. 25 this year. The bill provides an efficient way to clean our air, protect public health and safety, and conserve the environment by reducing hazardous air pollutants. The Adirondacks deserve no less.

A copy of the EPA's report may be obtained on the Internet at:
http://www.epa.gov/airmarkets/articles/s172report.pdf

Chairman **BOEHLERT.** Thank you very much. Without objection, so ordered.

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And I ask unanimous consent that all members have five legislative days to submit opening statements for the record.

[The prepared statement of the Honorable Constance Morella follows:]

PREPARED STATEMENT OF THE HONORABLE CONSTANCE MORELLA

Mr. Chairman, thank you for holding this hearing on an important topic that has wide-ranging impact. I want to applaud your efforts on reducing the negative effects of acid rain and appreciate your leadership on this issue. We have achieved tremendous success in the reduction of sulfur dioxides as a result of the 1990 amendments to the Clean Air Act, but we still have much work to do.

New research has surfaced indicating that the problem is more extensive than once believed. We have only recently learned about the lingering effects of sulfur deposited in soils and surface waters, delaying and in some cases stopping the recovery of certain ecosystems. We have discovered nitrogen compounds have a greater contribution than was previously believed and require a more concerted effort in their monitoring and reduction. And finally, we have found a new threat in the atmospheric deposition of mercury.

These threats are not limited to the pine and maple forests of the industrial Northeast where the problems were first identified. Increased cattle ranching and vehicle use has caused a rise in acid-producing NO**X** in the western states. In the southeast, thicker soils have delayed the effects, but recently acid levels in waterways are rising at an alarming rate. In my home state of Maryland, there is increased concern over the Chesapeake Watershed and what effect the rising acidity may have.

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Such problems should be of great concern to all of us and I look forward to the testimony of the esteemed panel. I would hope they would use their time to address the impact of these new discoveries, what we have learned, what we still don't know, and what steps we need to take to fill the gaps in our understanding of these pollutants and their effect on our environment.

[The prepared statement of Congressman John E. Sweeney follows:]

PREPARED STATEMENT OF CONGRESSMAN JOHN E. SWEENEY

Thank you, Chairman Boehlert, for the invitation to participate in this field hearing focusing on one of the most urgent environmental problems facing the State of New York and the nation—the issue of acid rain.

I had the pleasure of speaking with many of participants in this Center for Environmental Information conference earlier today, and I am pleased to see the combination of the experiences and expertise of so many people addressing the acid rain problem facing our nation.

Acid rain is truly a national problem, and the participation of these concerned citizens hailing from dozens of states not only proves this point, but will help make the case throughout our country. Thank you all for your contributions.

I have seen firsthand the devastation that has slowly and steadily eroded the ecological health of the region.

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Since coming to Congress, I have been working to stop acid rain damage to the Adirondacks on two fronts: emissions legislation and funding for acid rain research.

With my colleagues Mr. Boehlert and Mr. McHugh on H.R. 25, the Acid Rain Control Act, I am working hard to advocate for further emissions reductions using the framework of the current acid rain program.

The bill would provide cuts to sulfur dioxide and nitrogen oxides to stop the damage of acid rain to our precious Adirondack Park. The bill would also require that the EPA keep its commitment to regulate mercury from power plants in a timely manner.

Introduced the first day of the new Congressional Session, H.R. 25—so designated as a sign of its importance—currently has 26 cosponsors. We now have the opportunity to reach out to more members from many more states and seek their support for this legislation—and I ask for your help in doing just that.

We also have a unique opportunity to work with President Bush and EPA Administrator Whitman. Both have made strong public commitments to further reductions in Sulfur, Nitrogen and Mercury, and I am working hard to transform those commitments into legislative action.

Five years ago, H.R. 25 was a radical concept. I am confident that we have a real opportunity to make our vision a reality.

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I am also pleased, as a member of Appropriations Committee, to be working on an equally important front —to ensure adequate funding for acid rain monitoring and other basic research.

Information derived from acid rain research lays the groundwork for the evaluation of our current programs and for the advancement of acid rain policy initiatives. *I am a firm believer in the idea that sound science drives good policy.*

Although I won't go into too much detail, it is imperative that we continue the highly successful acid rain monitoring programs—such as the Adirondack Lake Survey Corporation, which does water quality sampling of 52 lakes in the Adirondack Park, and the cloud water monitoring program at Whiteface Mountain. I will continue to work to ensure that these programs receive full funding.

Again, these research efforts—which you are highlighting here this week—pay dividends by providing a greater understanding of the impacts of acid rain. Let me give some examples.

Another Adirondack scourge, black flies, is being compounded by acid rain; because black flies thrive in acidic waters the acid rain problem has exacerbated the black fly problem in the Adirondacks.

Loons, which are the symbol of a healthy Adirondack wilderness, are adversely affected by higher levels of mercury, one of the deadliest toxic metals associated with acid rain; Cranberry Lake and Stillwater Reservoir, located in the Adirondack Five Pond Wilderness Area, have substantial mercury contamination.

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Research has shown that our spruce forests are dying because the trees, made weak by acid rain, are threatened by insect infestation and are susceptible to winter injury.

Adirondack lakes, such as Honnendaga Lake, that are dead appear to be clear and beautiful. It is ironic that these lakes, which are so aesthetically pleasing, are devoid of life.

Lakes are an eerie shade of blue because acid rain has killed off plankton and other microscopic life that gives a healthy lake its aquamarine color.

Amid all of this bad news does come a bit of good. Data now shows that while acid deposition continues to do damage as evidenced above, the current acid rain program, based on the 1990 Clean Air Act Amendments, has shown measurable success and is putting us within reach of a recovery.

This data confirms that the current acid rain program can be an effective model for instituting greater emissions controls.

Without good science, we could not make such a determination, nor could we understand the full extent of the acid rain problem.

To that end, I want to thank the witnesses for their participation in this hearing and for their devotion to this issue. Your work and commitment to this issue are crucial to our efforts to form good public policy. I would like to closely identify with your.

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Again, we have a legitimate opportunity for progress in this Congress. This is a fight we can't afford to lose. Thank you, Mr. Chairman.

Our first and only panel consists of four very distinguished witnesses. I want to thank you at the outset for serving as very valued resources for this committee. The names we're all familiar with, those of us who are engaged in this activity, because of your distinguished record, and your service, and your approach to the problem.

First I'm privileged to introduce a neighbor, Dr. Charles Driscoll, University Professor of Environmental Systems Engineering at Syracuse University, in my neck of the woods; Dr. Ellis Cowling, University Distinguished Professor at Large, North Carolina State University; Dr. Jerry Keeler, Associate Professor of Civil and Environmental Engineering, the University of Michigan. Mr. Udall has asked for the privilege of introducing Dr. Baron.

Mr. **UDALL.** Thank you, Mr. Chairman. It is my great privilege to introduce a fellow Coloradian, Dr. Jill Baron who is a Research Ecologist of the Biological Research Division of the U. S. Geological Survey. Dr. Baron is also Senior Research Ecologist at the National Resources Ecology Laboratory at Colorado State University, where she earned her Ph.D. in 1991. Welcome Dr. Baron.

Chairman **BOEHLERT.** Thank you so much, and we would ask each of the witnesses to try to summarize your presentation. We're not arbitrary in sticking to the 5 minute open rule. If it was up to me, we'd let you talk on as long as you need to, to help us, for the record, in our task of convincing others that acid rain is not some vast left wing conspiracy—it's something very real that's doing great damage to our environment.

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Dr. Driscoll, you're up first.

STATEMENT OF CHARLES DRISCOLL, UNIVERSITY PROFESSOR OF ENVIRONMENTAL SYSTEMS ENGINEERING, SYRACUSE UNIVERSITY, NEW YORK

Dr. **DRISCOLL.** Thank you very much Congressman Boehlert, Udall, and McHugh, and members of the staff. I appreciate the opportunity to come here and tell you a little bit about our work on acid rain and mercury in the Northeastern U.S. The focus of my work is primarily in the Adirondacks in New England. We have a number of study sites in the Adirondacks, so I will try to give you some information from that area of the country.

Dr. **DRISCOLL.** I want to talk briefly about three things. First, a little bit of information on acid rain; second, a little bit of information on mercury; and then third, a plea to consider monitoring efforts to assess the effects of current and proposed future legislation on acid rain and mercury.

Okay, next slide please. So, I'm going to show you a few slides, a few maps, and this is a map of just the eastern half of the US, and I'm not trying to slight my colleague from Colorado, but it's clearly, clearly the acid rain problem clearly goes throughout the US, but unfortunately I was forced to shorten things because, to fit everything on one page. But this gives you an idea of inputs of sulfuric acid across the eastern half of the country. The more red the color, the greater the impact. And I have shown levels for the three different times, the early '80's, the early '90's, and then more recently after phase one of the 1990 Clean Air Act Amendments. And you can see a couple of things, the problem has improved, we have seen decreases over time, but areas are still seeing much, very very high levels.

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Next slide. So basically we have been doing work on affects of acid rain, and we made significant advances in recent years. And briefly I want to summarize what we found with respect to effects. First, over the last 10 years we clearly documented affects of acid rain on soil. And this is relatively new information. And those soil affects include accumulation of sulfur and nitrogen and which, in itself is not a problem, but under lower deposition has the potential to bleed out and delay recovery.

You see the stripping, or loss of critical nutrients like calcium and magnesium from soil, which potentially have affects for trees and aquatic life, as well. We also are seeing clear cut affects on trees, red spruce in high elevation areas of the eastern part of the country have been impacted, and we are starting to

see affects on sugar maple.

And then finally surface waters. We do see, as was mentioned, clear affects on surface waters and the biota in those surface waters.

Next slide. This is a bad slide, and I apologize, I didn't realize we were going to have problems with it, but if you could just show the bottom here.

These are, one thing we are trying to do, to see where we have gone, and where we are going with the acid rain problem is use computer models. And we run computer models over many, many years, in this case I have shown values over 150 years, showing the effect of historical deposition, and what we might expect in the future. And what we see from those calculations is we do see significant effects on soil and water, as we would expect from the field observations, and then looking to the future, we see a certain level of recovery, particularly in response to the 1990 Clean Air Act Amendments, and if we make calculations for proposed future legislation, we do see additional improvement. But the rate of recovery is relatively slow, and that is because of the processes that I just talked about, stripping the bases from soil, and the loss of sulfur that has accumulated in the soil.

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Next slide. Quickly moving on to mercury; the next slide. Mercury is a relatively complicated element. I am going to leave most of this to my colleague, Dr. Keeler; but mercury coming in in the atmosphere largely comes in an inorganic form. It is converted by processes within watersheds and lakes to methyl mercury, and methyl mercury is the form of mercury which is most problematic; and then can be converted to elemental mercury, and then released as gaseous emissions. So there is a lot of complicated processes going on with respect to mercury.

Next slide. The interesting thing, and the troublesome thing about mercury is, even though concentrations are very low in water, it has the ability to bioconcentrate. So the concentrations in fish are a million to ten million times greater than they are in water, and that's the primary method of human exposure of mercury.

There is also a link between mercury accumulation in fish and the acid rain problem that's shown here, the lower the pH of lakes, the higher the fish mercury concentration. So consideration of acid rain and mercury simultaneously is really critical.

Next slide. This is a slide which illustrates how mercury deposition has changed over time, and these are from sediment cores in lakes in the Adirondacks, and you can see a five-fold increase in mercury from the mid-1800's, peaking in about 1980, and then a little bit of a decline today. But we see high, high levels of mercury. So this would appear to be, not from a natural source, but from an outside source, from atmospheric input.

And then, the final slide, again, just a plea for monitoring. We need validation of the control measures. We need to, we need ongoing measurements of precipitation, chemistry, wet deposition, dry deposition, surface water, and other, other things such as biological resources. And so, with that I will close.

[The prepared statement of Dr. Charles Driscoll follows:]

PREPARED STATEMENT OF CHARLES T. DRISCOLL

I would like to briefly comment on three issues pertaining to effects of emissions of air pollutants associated with fossil fuel combustion (i.e., sulfur dioxide, nitrogen oxides and mercury) on sensitive watersheds in the northeastern U.S. These comments focus on: 1) effects of acidic deposition on soils, trees and surface waters, 2) effects of atmospheric mercury deposition on watersheds and lakes in remote regions and 3) monitoring programs to evaluate long-term trends of these pollutants.

ACIDIC DEPOSITION

Acid rain, or acidic deposition, originates from emissions of sulfur dioxide and nitrogen oxides, largely derived from fossil fuel combustion and ammonia, largely released from agricultural activities. Effects of acidic deposition include: 1) accumulation of sulfur and nitrogen, depletion of exchangeable nutrient cations and mobilization of aluminum in soil, 2) stress to red spruce and sugar maple leading to death from climatic disturbance or insect defoliation, and 3) acidification of surface waters and decreases in species richness of aquatic biota. Since 1973 emissions of sulfur dioxide have declined about 35% due to controls on electric utilities in response to the 1970 and 1990 Amendments of the Clean Air Act. These reductions have decreased concentrations of sulfate in surface waters across the northeastern U.S., but with limited improvement in the acid-base status of surface waters. The computer model PnET–BGC has been used to project how an acid impacted forest ecosystem might respond to current proposed additional controls on emissions from electric utilities. Model calculations have indicated that additional controls in sulfur dioxide emissions beyond those required in the 1990 Amendments of the Clean Air Act will be necessary to accelerate chemical recovery of soils and surface waters.

MERCURY

Many lakes in remote regions of eastern North America contain fish with elevated concentrations of mercury. This mercury is largely derived from atmospheric deposition and is predominantly in the form of ionic mercury. In wetlands and lakes, ionic mercury is converted to methyl mercury by bacteria. Methyl mercury is a powerful neurotoxin. Although concentrations of methyl mercury are very low in water, processes allow this substance to bioconcentrate through the aquatic food chain. Large older fish and piscivorus fish generally exhibit the highest concentrations of methyl mercury. Concentrations of methyl mercury are concentrated by a factor of a million to ten million from water to fish. Consumption of fish is the primary mechanism of human exposure to methyl mercury. Birds which consume fish as a large portion of their diet are also susceptible to mercury poisoning. Data from lake regions impacted by acidic deposition show that fish mercury concentrations increase with decreases in lake pH. Thus acidic deposition and acidification of surface waters exacerbates the problem of elevated mercury in fish tissue.

Data from sediment cores collected and dated in remote lakes in the Adirondack region of New York show a 3.5 fold increase in mercury deposition since 1850. Deposition of mercury increased markedly in the late 1800s and in most lake watersheds peaked approximately 20 years ago. There have been modest decreases in sediment mercury deposition in Adirondack lakes in recent years. Initially with the onset of increases in mercury deposition most of the mercury entered remote lakes from direct deposition to the lake surface. Mercury deposited on the land surface was largely retained in soil. Over time watershed retention of mercury has decreased. As a result, today much of the mercury entering many lakes is derived from mercury previously deposited on the land surface. It is anticipated that if atmospheric inputs of mercury would decrease associated with emission controls, mercury that was previously deposited on the land would continue to be transported to lakes, thereby delaying recovery.

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MONITORING

Environmental monitoring is critical to national environmental policy. Monitoring of atmospheric deposition and surface water chemistry provides the only quantitative means of assessing the efficacy of state and federal policy. There are several national monitoring networks that provide data to scientists and policymakers and need greater security and support. Five specific networks require increased federal funding to stabilize, expand and/or update the monitoring network.

1. National Atmospheric Deposition Program (NADP)

The NADP program is a successful inter-agency network that monitors wet deposition of sulfate and nitrate associated with fossil fuel emissions. The U.S. Geological Survey (USGS) is the lead federal agency and the Environmental Protection Agency (EPA) plays a strong supporting role. The coverage and baseline funding for this program are adequate to ensure a high-quality network. However, as the oldest network in the U.S., the system needs substantial modernization and a modest number of new sites. The NADP network currently relies on WWII vintage equipment.

Table 1

1B $2,000,000 to USGS; $600,000 to EPA; $600,000 to National Park Service; $400,000 to U.S. Forest Service.

2. Clean Air Status and Trends Network (CASTNet)

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The CASTNet program, administered by the EPA, measures the component of atmospheric deposition that enters the environment in dry forms such as particles and gases. Monitoring dry deposition is critical to determining the total pollution load across the U.S. In some areas, dry deposition contributes as much as

59% of the total sulfur deposition. At present, CASTNet is a sparse network with only 70 sites nation-wide and none in the central U.S.

Table 2

3. Mercury Deposition Network (MDN)

The mercury deposition network is a patchwork of sites, occurring mostly in the Northeast, that is funded through contributions by state agencies. Some of the highest mercury emitting states, such as Ohio, Kentucky and West Virginia, have no deposition monitoring. Given the tremendous public importance of mercury pollution, it is essential that monitoring be established to develop a mercury deposition baseline and to track changes over time.

Table 3

4. Temporally Integrated Monitoring of Ecosystems (TIME) and Long-Term Monitoring

The TIME/LTM program monitors lake and stream chemistry and documents changes in response to changing emissions and acid deposition. This program is administered through the EPA. TIME/LTM is the only national network that directly measures the impact of atmospheric deposition and quantifies the affect of emissions controls. Funding for the TIME/LTM program is both inadequate and unstable. Funding has been cut 50% over the past two years and the program appears to be sited for discontinuation.

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Table 4

5. Atmospheric Integrated Research Monitoring Network (AIRMon)

The AIRMon program provides high resolution precipitation and dry deposition chemistry using daily sampling methods operated by the National Oceanic and Atmospheric Administration (NOAA). Funding for this program has been flat for ten years resulting in the unfortunate closer of 3 AIRMon dry deposition sites (Sequoia. CA; Panola, GA; and Burlington, VT). Without an increase in annual operating funds, more site closures are inevitable. Moreover, AIRMon equipment dates to 1984 and has exceeded its life expectancy.

Table 5

In addition to the resources required to stabilize and improve these networks, there are other monitoring needs to be able to detect the effects of air pollution emission controls. For example programs are needed to assess the recovery of soils, trees and aquatic biota in response to decreases in acidic deposition. There are few sites at which mercury in studied in soil, surface waters and fish. None of these have been established as long term monitoring sites to determine baseline conditions and to monitor ecosystem response to changes in atmospheric mercury deposition following emission controls. Finally there is a need for comprehensive ecosystem study sites, such as the National Science Foundation, Long-Term Ecological Research (LTER)

program. Comprehensive ecosystem study sites should be viewed as a national resource. At these sites, many environmental measurements are made and ecosystem processes are studied in detail. Through research at comprehensive study sites, cause and effect relationships between air pollution and ecosystem health can be determined, and environmental models used to predict ecosystem response to policy and management strategies can be tested.

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Current Air Quality Monitoring Networks and the Pollutants Monitored

The following two tables summarize key aspects of the monitoring networks. These tables as well as other more detailed air monitoring information are available from a 1999 report, "The Role of Monitoring Networks in the Management of the Nation's Air Quality" (http:bqs.usgs.gov/acidrain/).

Table 6

* Total funding approximately $0.6M, nearly all from State and local sources.

Table 7

Prepared by: Hubbard Brook Research Foundation, May 1, 2001, Tel. 603–653–0390, hbrook@hbresearchfoundation.org

Chairman **BOEHLERT.** Thank you very much. Dr. Cowling.

STATEMENT OF DR. ELLIS COWLING, UNIVERSITY DISTINGUISHED PROFESSOR AT LARGE, NORTH CAROLINA STATE UNIVERSITY

Dr. **COWLING.** Thank you. You have a wonderful statement here on your wall, "Where there is no vision, the people will perish." I will show a slide of the state flower of North Carolina, having some difficulty reproducing, so I appreciate that this statement could be perhaps mentioned in the course of the record here.

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Chairman **BOEHLERT.** Doctor, I wish to assure you that all of the members of this Committee have vision.

Dr. **COWLING.** This first slide is an illustration of what the view from Mt. Mitchell is. Mr. Etheridge has been to Mt. Mitchell, I'm sure, and maybe many others in the Committee.

This is a view in the highest location east of the Mississippi, in the whole of the North American

continent. And the chemistry at the top of that layer, as you can see in the brown haze, is about the same as you might find over the city of Philadelphia on a busy day.

The second slide is a view of the appearance of the flora at the summit of Mt. Mitchell, and this was not due alone to acid deposition, it was due to a great many stresses that this forest experiences, a special nematode at high elevations. There is, of course, heavy wind and ice damage. We have a tower set up there that was taken down by ice on one occasion.

There are also ozone exposure that occur 24 hours a day, and not just in the daytime hours. So there are a great many stress factors that are affecting the health of this forest.

And this next slide is a view on the right-hand side of two blossoms of our state flower that were tainted with a bit of simulated acid rain before being inoculated with a fungal, an Anthraxnos fungus; and those on the left were not. And I think that you can see that dogwood blossom is a lot happier when it is not pre-treated with simulated acid deposition.

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But I'd like to concentrate most of my attention, there are continuing air pollution influences in the southern United States, and I received the invitation to appear 9 days after I had left Raleigh, so I am having to do this something on the run.

I have two things to offer, the statement that I submitted for the conference, which you can read. And one of the things that we emphasized there is that air pollution in the South, in contrast to air pollution in other parts of the eastern half of our country, is not getting better.

And, if you look at the last 10 year record, we have had a 13% increase in the 1 hour, in violations of the 1 hour standard, and a 17% increase in the 8 hour standard.

Mostly I would like to echo what Charlie Driscoll has already said, we need in America monitoring programs that are dependable as a source of insight, so that you can have visions that are well-informed, you can make accurate and appropriate decisions.

Now, I gave that choice of, I was one of the persons who started the National Atmospheric Deposition Program, and the first transparency shows the title that I gave, oh my goodness, but I guess—oh, okay.

I was asked to go back to meet with all of my colleagues in NADP on its twentieth anniversary, and this one line represents what I would most like to communicate to this committee: twenty years down, and a century to go. We would like to believe that 30 years from today, or 40 years from today, there could be an accurate record of the quality that has produced by the 200 people that make NADP work.

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And so, I am going to just encourage your awareness of a few of the other things I said on the day, and if

we can turn to the next slide, it illustrates—this is the network where the 227 locations where every Tuesday morning at 9 o'clock we find out what fell in the previous week. That's the best of these expensive monitoring tools that we can have, to understand how humans are changing the chemical climate of the Earth.

And these next two slides, one for 1985, you have seen maps of this sort before, that compare the red zone on this map with the one of the next one. You could not have the quality of understanding of these changes, which were brought about. This is 1999, I misspoke. This is a product of the Act that you helped pass, Mr. Boehlert, when the Title IV was created.

I presume that red light means my time is up. Do you wish for me to continue, or not?

[The prepared statement of Dr. Ellis Cowling follows:]

PREPARED STATEMENT OF ELLIS COWLING

Acid Rain: The State of the Science and Research Needs for the Future

Ellis Cowling, University Distinguished Professor At-Large, North Carolina State University, 1509 Varsity Drive, Raleigh, NC 27606; 919–515–7564—phone; 919–515–1700—fax; *ellis cowling*@ncsu.edu—e-mail

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Question 1: How has acid rain affected forest, rivers, and other ecosystems in the Southeast and have those ecosystems shown signs of recovery since the Clean Air Act Amendments of 1990?

Question 2: How important are monitoring networks for understanding acid rain and related air pollution, and is federal support for monitoring adequate?

REGIONAL IMPACTS OF AIR POLLUTANTS

IN THE SOUTHEASTERN UNITED STATES

Ellis Cowling, College of Natural Resources, North Carolina State University, Raleigh, North Carolina 27695

Acid rain, ground-level ozone, regional haze, particulate matter, eutrophication, and climate change continue to be major matters of public worry and industrial concern in the southeastern United States. Although Los Angeles is famous for its historically high ozone concentrations, the Houston-Galveston area of Texas is now rivaling Los Angeles as the most remarkable place to observe rapid accumulation of ozone in the US today. Although air concentrations of sulfate aerosol are decreasing in most states in the eastern US, this is not true in the southern Appalachians and most notably not true within the Great Smoky Mountains National Park. Although the number of urban areas designated nonattainment for the 1-hour ozone standard has decreased in recent years, the total number of counties included within ozone non-attainment areas of the south will increase markedly as soon as the 8-hour standard for ozone is implemented. Many of these newly designated ozone non-attainment counties will be rural rather than urban

in character. Although total emissions of sulfur oxides have decreased in most states east of the Mississippi River, emissions of nitrogen oxides have remained about the same or even increased. This difference is especially noteworthy in the southeastern states where emissions of ammonia from animal agriculture also have increased substantially in recent years. The visual range over scenic vistas has decreased in most Class I areas in the southern Appalachians. Although a trend of decreasing ozone concentrations has occurred in the US as a whole, during the 10-year period from 1990–1999 ozone concentrations increased in the southeastern states—the 2nd highest daily maximum one-hour average ozone concentration increased by 13 percent and the 4th highest daily maximum 8-hour average increased by 17 percent. Eight of nine US National Parks showing increased ozone concentrations during 1990–1999 were located in southeastern states (AR, FL, KY, NC, SC, TX).

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All these differences and trends provide substantial justification for continuing investments in research and pollution-management activities aimed at discovering and implementing cost-effective means for decreasing these impacts in the southeast.

Ellis Cowling is a forest biologist at North Carolina State University who became a world leader in air pollution research. Beginning in 1975, he led a group of 200 scientists in creating the National Atmospheric Deposition Program (NADP). This network measures the amounts of nutrients and injurious substances transferred in rain and snow from the atmosphere to forest and agricultural land and surface waters at 200 research sites throughout the U.S. In some parts of our country, these substances are having positive effects on the productivity of crops and forests. In other parts, some of these same substances are having negative effects on forests, fish, and surface and ground water quality. Cowling will discuss how scientists and engineers in NADP (and in the Southern Oxidants Study which he now leads) are increasing scientific and public understanding about environmental change and the sustainability of ecosystems. As Chair of the session on Regional Impacts, he will also lead our discussion of how society can adjust the procedures by which air and water quality are maintained. Cowling has two earned pH degrees—one from the University of Wisconsin and the other from the University of Uppsala in Sweden. He has served as major professor for 66 graduate and postdoctoral students at Yale and at NC State Universities. He has been a member of the National Academy of Sciences since 1973.

Themes to be Addressed:

1) *Celebrating the achievements of NADP's First 20 years*

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2) *Ensuring the long-term stability of the NADP network*

3) *The growing importance of nutrient nitrogen in determining the pollution climate of North America*

4) *Prospects for developing area-wide estimates of total (wet plus dry) deposition through collaboration*

with other organizations in North America and Europe

What are the Most Notable Achievements of NADP's first 20 years?

1) Building and maintaining for 20 years, a uniquely successful partnership among many disparate federal, state, industrial, and university research communities

2) Developing a high quality environmental database that is trusted by both scientific and policy leaders throughout North America and around the world

3) Achieving a remarkable degree of personal and professional satisfaction through collaboration and cooperation among atmospheric, agricultural, forest, aquatic, and terrestrial scientists on a continental scale

Celebrating the Achievements of NADP's first 20 years

1) *Using the bottom-up traditions of the Regional Project System of the State Agricultural Experiment Stations as an organizational paradigm*

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2) *Selecting, developing, and maintaining a single Central Analytical Laboratory at the Illinois State Water Survey (ISWS)*

3) *Winning the confidence of federal agencies (USDA, USGS, USFS, EPA, USF&WS, NPS, BLM), electric utilities, and other organizations to assemble the present 200-station NADP/NTN network under NAPAP*

4) *Maintaining cooperation and intercomparisons with the Canadian CANSAP and CAPMoN networks*

5) *Certification of network-wide QA/QC through site visits by EPA and laboratory intercomparisons by the World Meteorological Organization*

6) *Periodic peer reviews of NADP by NAPAP and the Regional Associations of Directors*

7) *Undertaking special studies of atmospheric transport and deposition of pesticides and heavy metals and creation of NADP's Mercury Deposition Network (MDN) and Atmospheric Integrated Research Monitoring, Network AIRMoN*

8) *Publishing isopleth maps showing spatial gradients in deposition of major nutrient cations and anions*

9) *Learning to use the Internet as a means of data dissemination and information transfer to major users of NADP data and information*

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10) *Consolidation of the NADP Coordination Office in Colorado with the Central Analytical Laboratory in*

Illinois

11) *Demonstration that Title IV of the Clean Air Act Amendments of 1990 is working*

12) *Learning to survive periodic budget crises—a continuing challenge of organizational self-education, future planning, and proactive marketing*

Ensuring the long-term stability of the NADP network

The financial stability and longevity of the NADP program depends critically on the *number, geographical distribution, and organizational or political* clout of satisfied "customers" that include:

Many data users who care about the data, use the data often, and willing to speak out publicly about the important values they derive from analysis and interpretation of the data.

Hence the following recommendations to:

NADP Marketing, Executive, and Technical Committees

NADP Coordinator and his colleagues at the ISWS

NADP Administrative Advisors within CSREES

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Regional Associations of Directors within the SAES

Recommendation I

Use the NADP Web Site and other outreach venues (see list below) to build an enduring support base of "satisfied and vocal customers":

"Inside Rain: A Look at the National Atmospheric Deposition Program,"

"NADP/NTN Wet Deposition in the United States 1995,"

"NADP/NTN Wet Deposition in the United States 1996,"

"NADP/NTN Wet Deposition in the United States 1997,"

"Uses of National Atmospheric Deposition Program National Trends Network Data for Science and Education and Environmental Problem-Solving,"

"Trends in Precipitation Chemistry in the United States, 1983–94: An Analysis of the Effects in 1995 of Phase I of the Clean Air Act Amendments of 1990, Title IV."

Recommendation II

Cultivate and educate the NADP Administrative Advisors in CSEERS and the SAES Directors within the four *Regional Associations of Directors*—Northeast, Southern, North Central, and Western.

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This education is essential to maintain the confidence of current leaders within the Regional Research System of the Land Grant Universities, the State Agricultural Experiment Stations (SAES), and the Cooperative State Research, Education, and Extension Service (CSREES).

Recommendation III

Develop and maintain a standing group of current and former NADP leaders who are *prepared on short notice* to *mount an educational campaign for reaffirmation of support* whenever one of the major NADP support organizations is threatening to withdraw or decrease its support.

Current members of the NADP Executive Committee and a carefully selected, well-connected, and articulate spokespersons including:

Current and former Chairmen of NADP—Stan Coloff, Mike Kelley, Steve Lindberg, Bill McFee, Jim Lynch, Ellis Cowling, etc.

Current and former CSREES Administrative Advisors to NADP

Current and former Directors of NAPAP—Mike Uhart, Dereck Winstanley, Patricia Irving, James Mahoney, and Chris Bernabo.

Current and former scientific leaders in NADP and closely related organizations including Jim Galloway, Jim Gibson, Eville Gorham, Dick Simonin, Rick Linthurst, Walter Heck, David Shriner, Jim Lodge, Rona Birnbaum, Gene Likens, Jerry Millilo, Bruce Hicks, Dan Albritton, Christina Bierbaum, Milton Russell, Senator Patrick Moynihan, Congressman David Price, etc.

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Recommendation IV

Identify within every state within NADP, *a member of the NADP Technical Committee who is willing to serve as the NADP Designated State or University Representative for his or her particular state.*

The responsibility of these State or University Representatives should be to actively cultivate, communicate with, and maintain a roster and current mailing list of "NADP customers" (data users) within his or her own particular state.

Recommendation IVa

NADP data users for each state should include leaders and/or outreach persons in the following organizations:

— NADP Site Operators

— Leaders in various university organizations

— State Agricultural Experiment Station

— College of Agriculture

— College of Forest Resources

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— Water Resources Research Institute

— Public Health and Environment

— Soil Science

— Forestry

— Botany

— Zoology

— Crop Science or Agronomy

— Horticultural Science

— Earth and Atmospheric Sciences

— Fisheries and Wildlife Management

— Outdoor Recreation

— Park, Recreation, and Tourism Mgmt.

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— Marine Biology

— Political Science and Public Admin.

— Multidisciplinary Studies

State Divisions of:

— Air Quality

— Water Quality

— Agriculture

— Environmental Conservation

— Public Health

— Fish and Game

— Parks and Recreation

— Environmental Statistics

NADP data users for each state should include leaders and/or outreach persons in the following organizations:

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Environmental officials of major industries and trade associations

— Electric utilities

— Forest products companies

— Pork producers

— Animal waste research groups

— Poultry producers

— Fish producers

— Cattlemen's association

— Municipal waste managers association, etc.

State and/or Regional District Offices

— U.S. Geological Survey

— Forest Service

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— Fish and Wildlife Service

— Soil Conservation Districts

Regional and local chapters of environmental groups

— Nature Conservancy

— Natural Resources Defense Council

— Environmental Defense Fund

— Conservation Foundation

— Ducks Unlimited

— Sierra Club

Regional research groups

— Chesapeake Bay Research Program

— Tampa Bay Research Program

— Albemarle and Pamlico Sounds Res. Prog.

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— Regional Associations of air quality managers such as NESCAUM, MARAMA, SESARM, etc.

County and municipal public health and parks and recreation departments

Members of the National Teachers Association

Recommendation IVb

At least once each year (and occasionally in between), the *NADP Designated State or University Representative should use the mailing list of data users within each state for at least three general purposes:*

1) Call attention to the time, place, and major presentations during at least the public-information portion of the NADP Annual Meeting

2) Ask if there are additional interests that could be satisfied by available NADP data and information

products or through additional studies or products needed within each state

3) Ask these persons to continue to speak out vocally (and in appropriate institutional publications) about the values they derive from use of the NADP data and information

Recommendation IVc

Every five or so years, the *NADP Designated State or University Representative should organize a state-wide meeting* with organizational leaders from the state to:

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1) Communicate NADP appreciation for continuing multi-organizational support and participation in the program

2) Determine if NADP operations are continuing to be adequately representative of current nutrient-, air quality-, water resource-, natural resource-, and fisheries-management and other environmental concerns within the state

3) Identify improvements that may be needed in the location and/or operation of NADP Collection Sites in the state

4) Identify additional uses that might be made of existing NADP data and information products or other data and information needed within the state

5) Discuss contemporary financial and other aspects of the NADP program during past years and the need for continuing use of the data and participation in the program during future years

Recommendation V

The NADP Executive Committee, Regional and CSEERS Administrative Advisors, and all NADP support organizations should *explore the possibility of building a contingency ("rainy day") fund* to provide *temporary support for high quality NADP sites that are in jeopardy of losing their support.*

One means of doing this is to *add a "contingency surcharge of 2–5*% to the analytical service fees of CAL" which would be administered by the NADP Coordinator with the approval of the Executive Committee to provide time-limited (12–24 months) support for sites that lose support by sponsoring organizations.

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Recommendation VI

Resolution of Mutual Commitment {A "Gentleman's Agreement" }

As responsible leaders within various universities, federal and state agencies, and industrial organizations in the United States, we are pleased to pledge our continuing participation and financial support of the National Atmospheric Deposition Program (NADP).

We believe that continuing multi-organizational support of NADP, collectively totaling less than $4.0 million dollars per year, is by far the most cost effective means by which our country can continue to provide high-quality, scientifically-valid information on contemporary changes in the chemical climate of the United States.

If, at some future time, our organization finds it necessary to decrease our support for this valuable program, *we promise to do our best* to provide a minimum of 2-years' advance notice of the necessity to decrease our participation. We make this promise out of respect for other organizations which will have to make up for our decreased participation.

Rationale For a "Resolution of Mutual Commitment"

The *amount* of precipitation (rain, snow) occurring in urban, suburban, rural, and remote regions in the United States is currently measured on a daily basis at about 4,000 locations. The longevity of these valuable records of precipitation amount varies across the United States from about 150 to 250 years (since about 1750 in many parts of the eastern US and since the early 1800s in other parts of the nation). The total cost of these measurements and routine reporting of results is currently more than $25 million dollars per year.

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For only the past 20 years, the *nature and amount of beneficial nutrient substances, toxic substances, acidic and acidifying substances, and growth-altering substances* dissolved or suspended in precipitation has been measured by NADP on a weekly basis at about 200 locations in the United States. The costs of these measurements and their public reporting is currently borne by a voluntary association of nearly 100 organizations affiliated with about 20 state and private universities, 7 federal and 6 state regulatory and natural resource management agencies, and 5 commercial firms which have voluntarily joined together to support NADP for the past 20 years.

Chairman **BOEHLERT.** Well, I can't—I'd love to have you continue. I can't help but note with some degree of irony. Look at Indiana and Ohio, and they fought the most vigorous. Even set up a group called CSCAR, Committee for the Sensible Control of Acid Rain. It sounded very worthy and noble, and it was funded by interests that were trying to do everything they could to undermine that legislation.

Dr. **COWLING.** I hope you remember 20 years down and a century to go. I hope I'm here to remember it.

Chairman **BOEHLERT.** Dr. Baron?

STATEMENT OF DR. JILL BARON, RESEARCH ECOLOGIST, COLORADO STATE UNIVERSITY

Dr. **BARON.** Mr. Chairman, Congressman Udall, and other distinguished members of the Committee. I am truly honored to be invited to speak to you today.

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On behalf of the United States Geological Survey, I'm going to take you on a whirlwind tour of the sources and effects of atmospheric deposition in the western United States.

Now, I'm an Ecologist with the USGS, and have about 20 years of experience looking at ecological impacts in the Colorado Rocky Mountains, and I'll be talking to you about the entire Western United States. What I want to do is run you through quickly the source of atmospheric deposition, where we see evidence that it's having an effect, what those effects actually are, and then our research and monitoring needs.

Now nitrogen is an interesting beast, because even though 80% of the atmosphere all around us is nitrogen, it's mostly inert gas, and it takes combustion for it to turn into the nitrogen oxides that then go up in the atmosphere and rain down on different areas of the country.

Anthropogenic sources of nitrogen combustion come from fossil fuels, they come from the transportation sector, automobiles, trucks, and heavy machinery, such as construction and farm machinery. They come from public utilities, and industrial sources, and increasingly they come from energy development, such as coal-bed methane, and natural gas.

There is another important source of nitrogen; it's agricultural. It comes from both fertilized fields, and volatilized especially from confined animal feedlots, and large manure piles.

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If you look at a map, and you slice up the Western United States, with due respect to my colleague from New York, what I did is I lopped off the eastern half of the National Atmospheric Deposition Program Map.

Chairman **BOEHLERT.** Barry Goldwater tried that once.

Dr. **BARON.** This was in order to get the scales right, because we do have less deposition in the Western United States. What I did is I lopped off the eastern side. What you can see is hot spots of nitrogen deposition. And I need to step back just a second, and say that what I'm talking about in the Western US is not an acid rain problem, per se. Although we do have acid deposition in Rocky Mountain National Park in the summertime, we have been blessed, however, with cleaner sources of energy in the west than you've had in the east. We have low sulfur coal, we have hydro-power, and we have, at least in my home town, wind energy. So that, although sulfur dioxide isn't, there are sulfur dioxide emissions in the west, and they will be sources of visibility problems, and human health hazards, they haven't contributed to the acid rain that has been so damaging to the Eastern United States.

What we have, instead, is this nitrogen deposition problem. And these hot spots are no surprise. These are areas of high population density, and high agricultural activity. But this map is a little bit misleading. Because it's the National Atmospheric Deposition Program Map, it's only wet deposits, what comes in as

rain and snow. And in California that's only 10% of the total nitrogen deposition that actually comes in.

Southern California is getting 35 kilograms of nitrogen per hectare per year. That's among the highest values in North American, and it's right up there with what you see in Northern Europe, as well. It's a shocking amount of nitrogen.

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In Colorado our wet deposition values are closer to what is actually falling, because we don't get as much dry deposition. And these values of 3 to 6 kilograms per hectare per year don't seem very high until you look at the ecosystems that they are falling on.

Next slide. High elevation Rocky Mountain ecosystems are very harsh environments. Any plant that lives there is a hardy plant indeed. And they have very harsh climates, they have short summers, they have very low levels of nutrients coming in. And nitrogen is, indeed, a nutrient, or a fertilizer coming in. So ecosystems like this, when they get additional nutrients, respond in unexpected ways.

Nitrogen can go down a couple of paths as it flows through an ecosystem like I just showed you. Now, because its a nutrient, the first thing it does is, it fertilizes. And we, indeed, have documented increasing rates of nitrogen cycling and better forest growth in our Colorado Front Range forests. But you can have too much of a good thing, particularly in areas that are wilderness areas, or Clean Air Class One areas, or very unique ecosystems where you might be seeing endangered or threatened species that are changed.

And some plants will respond better to nitrogen than others, and that is what leads you to changes in plant communities. In areas, wetlands and meadows throughout the world that have received nitrogen deposition you get dominances of grasses over flowering plants. And that's certainly being seen in the Southern California, Coastal Sage scrub communities, and also in our alpine tundras of Colorado.

Now forests that grow slower are not changing their species composition that we have seen, but even those plants are taking up as much nitrogen as they can, and they still can't take it all up, and the excess is leaching through as nitrogen saturation. As nitrogen leaches through into aquatic systems, lakes and streams, it takes with it soil base, so it depletes soil fertility. It also, eventually will lead to acidification of our lakes and streams. That's the loss of acid neutralizing capacity.

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Nitrogen flowing into lakes and streams also fertilizes them, as Congressman Udall said, and that leads us to a very slight amount of lake eutrophication that we have documented in our high elevation lakes, as well as the beginning of loss of soil base cations.

So if I summarize, backwards. If I summarize our research and monitoring needs, we definitely need better measurements of emissions throughout the West. And I am speaking here of non-utility emissions and agricultural emissions. We don't know what's coming in. We also need better transport models, because our complex terrain makes it difficult for regular models to work. We need very much better dry and wet

deposition monitors.

If you can see those little dots on this map, it shows vast areas of the west that are not being covered, and we don't know in a region that is rapidly changing and developing, what kinds of atmospheric deposition is coming in. And most of all, we need long-term monitoring and research. There is only a handfull of research sites in the western United States where we can detect trends, and where we can start to look at the ecological processes that are complex enough as it is, and they are not only being affected by nitrogen, but the combined effects of nitrogen, ozone, heavy metals, land use change, and climate.

So, Mr. Chairman, thank you very much for my remarks, and I would be happy to answer questions later.

[The prepared statement of Dr. Jill S. Baron follows:]

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PREPARED STATEMENT OF JILL S. BARON

Mr. Chairman and distinguished Members of the Committee, thank you for this opportunity to present, on behalf of the U.S. Geological Survey, this statement regarding sources, transport, and fate of atmospheric deposition in the Western United States.

I am an ecologist with the U.S. Geological Survey (USGS). In 1981, I began research into the susceptibility of Rocky Mountain National Park lakes to acidic atmospheric deposition. 1, and my colleagues, now have over 20 years in understanding alpine and sub-alpine ecological processes and the influence of atmospheric deposition on these natural environments. The USGS has been quite active in studying the ecological and biogeochemical influences of airborne pollutants throughout the United States, and has produced cutting-edge science from our long-term watershed research and monitoring efforts. I am confident of the results I will present to you today regarding atmospheric deposition and ecological effects for the specific areas we have studied. The response to atmospheric nitrogen deposition in Southern California has been pronounced, and it is well documented by scientists working there. In Colorado, we see significant changes from nitrogen deposition that tell us our ecosystems are just beginning to respond, and our results are also well-documented in the scientific literature. However, the West is very large, and our studies and monitoring are limited in geographic scope. There is also a great amount we do not yet know about combined interactions between many environmental stresses and the plants, animals, and microbes that make up our ecosystems.

Definition of the Issue

The history of atmospheric deposition to the Western United States beyond the 100th Meridian (hereafter referred to as West) differs from that in the Eastern half of the country. Because the West has been settled more recently than the East, it has not experienced emissions of sulfur and nitrogen oxides for as long. Although population in the West is increasing rapidly, human density is still far below much of the rest of the country. This has resulted in a lower density of power plants and industrial facilities that have been a large source of air pollutants elsewhere. Compared to the East, the West is fortunate to have energy sources that generally do not emit high amounts of sulfur dioxide, one of the major precursors to acid rain. Low sulfur coal, hydropower, nuclear, and solar and wind energy have helped the West suffer less the effects of

atmospheric deposition to ecosystems and historical structures common to the East. The major sources of sulfur oxide emissions in the Intermountain West were refineries and smelters for metals such as copper, and many of these smelters have closed over the past 20 years. As they have closed, both emissions and atmospheric deposition of sulfur compounds have decreased significantly (Epstein and Oppenheimer 1986). A final important difference between West and East is that the complex topography and localized arid climates of the West combine to create places where most atmospheric deposition occurs as dry particles and aerosols, such as in Southern California and in the deserts of the Southwest.

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Emissions and atmospheric deposition of nitrogen oxides and ammonium, however, are increasing rapidly and significantly in the West, creating their own set of environmental concerns (Lynch et a1., 1995; Campbell, unpub. data). While we consistently find acid rain, especially in the summer, in Rocky Mountain National Park, it has not yet had a measurable effect on lake chemistry in the Park (NADP/NTN, 2000; Baron et al., 2000; Campbell et al., 1995).

The major anthropogenic source of nitrogen oxides is combustion of fuels at high temperatures. Combustion sources include automobiles, trucks, trains, and heavy farm and construction machinery, the utility and industrial sectors, and increasingly, energy development from coal-bed methane, natural gas. Additional nitrogen comes from agricultural emissions, both from fertilized croplands and from large manure piles of confined animal feeding operations. These are regionally important, and in some areas, such as the Colorado Front Range, account for more than 20 percent of the nitrogen emissions (Baron and Mosier, in prep).

Where are the Regions of Elevated Wet Nitrogen Deposition?

The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) provides our best coverage of precipitation chemistry in the United States, and its records began in 1978. As measured at NADP/NTN sites, wet deposition of nitrogen in the West is lower on an annual average than other more industrialized parts of the world, such as Europe and the Northeast United States (NADP/NTN, 2000). Nevertheless, there are hotspots of elevated wet nitrogen deposition in Southern California and along the Colorado Front Range when compared with the rest of the West (Fenn et al., 1998). These are regions of high population and agricultural activity, and sufficient precipitation to receive the deposition in rain and snow. Wet deposition measurements in Southern California reflect only 10 percent of the total atmospheric nitrogen deposition (Bytnerowicz et al., 1998). Because of its Mediterranean climate, most deposition occurs as dry deposits in Southern California, and is not measured by the NADP/NTN network. Wet deposition to the high mountain areas of the Colorado Front Range are perhaps an order of magnitude lower than those from California, but they are high enough to have caused chemical and ecological change, as described below (Baron et al., 2000; Fenn et al., 1998; NADP/NTN, 2000). Other parts of the West, such as near Tucson, Phoenix, and Las Vegas, may also have high nitrogen deposition, but it falls as dry deposition due to the arid climate.

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Chemical and Ecological Responses to Elevated Nitrogen Deposition

Nitrogen is an essential fertilizer, and atmospheric nitrogen deposition is a boon to croplands and commercial forests around the world. In natural forests and parks, however, it can affect both plant communities and aquatic environments. Some species are better able to use nitrogen for enhanced growth, allowing them to out-compete their neighbors. This can lead to changes in plant and animal community structure. In many parts of the world with long histories of nitrogen additions, grasses now dominate meadows and fields that once had much greater species diversity (Vitousek et al., 1998). This is well-documented in England and the Netherlands, in experimental plots in the Great Plains, and increasingly, in native coastal sage scrub vegetation of Southern California (Padgett and Allen, 1999). Experiments have shown that nitrogen additions have the same effect on alpine tundra (Bowman et al., 1993, 1998, 2000), enhancing grass production at the expense of the wildflowers.

Trees grow and respond to nitrogen additions at a slower pace, and there are few forest species that can out-compete those adapted to harsh western environments. At high elevations of the Rocky Mountains all plants live a hard life, and the cold, short growing season, and limited water help to create a situation called nitrogen saturation, with excess nitrogen flushing into streams and lakes. As nitrogen moves through soils, chemicals essential for forest fertility are stripped into the water, enhancing lake and stream acidification (Driscoll et al., 2001).

Before acidification occurs there will be lake fertilization effects. Many high elevation lakes do not get enough nitrogen for algal growth, so additions from atmospheric deposition cause increased productivity and changes in community composition (Morris and Lewis, 1992; Elser et al., 1990). Excess nitrogen deposition influences plant growth and community composition. Leaching of nitrate through watersheds leads to eutrophication of lakes and streams, and ultimately, to acidification.

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In summary, the best evidence for effects of nitrogen deposition occur in Southern California and the Colorado Front Range. In Southern California, ozone damage, eutrophication of streams, and loss of soil fungi essential to endangered species are evident. On the Colorado Front Range, terrestrial plant communities and algal lake communities are altered and increased nitrogen cycling is poised to create acidification similar to that in the East.

Examples of the Effects of Nitrogen Deposition in the West

Southern California:

— Wet plus dry deposition in Southern California is very high, around 35 kilograms per hectare per year (comparable to deposition in northern Europe and the eastern United States, Bytnerowicz et al., 1999). It, combined with high concentrations of ozone in the San Bernardino Mountains, has caused ponderosa pine growth to be severely reduced (Fenn et al., 1998; Grulke et al., 1999; Arbaugh et al., 1999).

— Perennial streams in the San Bernardino Mountains have average concentrations greater than 10

milligrams of nitrate-N per liter. This average concentration is greater than U.S. Environmental Protection Agency drinking water standards (Fenn and Poth, 1999).

— The coastal sage scrub is a unique environment with a great number of native species, many of them sensitive or listed as threatened or endangered. Researchers have found a direct relationship between the increase of nitrogen deposition and the loss of soil microorganisms such as fungi and bacteria. These microorganisms are essential to the sage scrub community, in that they enhance nutrient uptake by plants, and help decompose dead material (Edgerton-Warburton and Allen, 2000). Without them, native species are weaker and open to invasion by non-native grasses. The non-native annual grasses perpetuate themselves by providing the fuel for frequent fires (Callaway and Davis, 1993). Increased fire, perhaps helped along by the nitrogen deposition, poses risk to people and property as well as the native ecosystem.

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Colorado Front Range:

— Alpine tundra with added nitrogen shows a shift in plant community composition that favors grasses over flowering plants (Bowman et al., 2000, 1998, and 1993).

— In the harsh high elevation environments of the Rockies, nitrogen deposition has significantly increased rates of forest and soil nitrogen cycling—the first stage of expected effects on the road toward nitrogen saturation (Baron et al., 2000; Rueth and Baron, accepted).

— Alpine lakes in areas with elevated nitrogen deposition have significantly higher nitrate concentrations than lakes in low deposition areas—another indication of expected effects from excess nitrogen deposition (Baron et al., 2000; Baron, 1992).

— Lake algal communities have changed significantly in the past SO years. These microscopic plants are the base of the lake food chain. Algae in some alpine lakes is more abundant, and now dominated by species representative of pollution. These species have been shown to dominate in lakes all over the world that have been fertilized or otherwise disturbed, and their presence indicates a profound change in their environment. The communities now found in these remote and otherwise undisturbed lakes are different than any other throughout lake history (Baron et al., 2000; Wolfe et al., 2001).

I would like to spend the remainder of my time emphasizing the need to develop better research and monitoring information throughout the West.

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Research and Monitoring Needs

Monitoring:

— There are hundreds of square miles in the West without any wet deposition monitoring, so our knowledge of atmospheric deposition is incomplete. High elevation regions, especially, are under-represented, but this

is where the greatest amount of wet deposition occurs.

— Dry deposition monitoring is even more sparse, but dominates deposition through much of the West.

— Long-term monitoring of chemical and biological trends in watersheds is greatly needed. There are only a handful of long-term study areas in the West, operated by the U.S. Geological Survey, the National Science Foundation Long-Term Ecological Research program, USDA Forest Service, and some universities. In a region undergoing rapid change in population and energy development, we are very poorly set up to detect the consequences. Managers of public lands depend greatly on objective scientific reports of the condition of their resources. Long-term monitoring is highly effective at detecting trends, and when coupled with research, give early indications of the causes of change.

Research:

— Our confidence in atmospheric transport models is poor in the West, where the complex topography makes modeling extremely difficult. More effort in this area would yield great benefits in understanding source-receptor relationships.

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— The mechanisms of dry deposition are still not well-understood; more research into transport and deposition mechanisms is needed.

— Our understanding of the complex ecological interactions that occur with nitrogen deposition is incomplete. Communities that evolved with low nitrogen availability are changing in novel ways that we do not understand. More research is needed to tell us about possible effects on disturbance regimes such as fire, changes in nutrient cycling and leaching, increased opportunities for invasions and insect outbreaks, and how much nitrogen causes acidification in Western watersheds. Better understanding of ecosystem functions will help managers of public lands, and regulatory agencies make decisions on critical thresholds of ecological change.

Mr. Chairman, this concludes my remarks. I am happy to respond to questions Members of the Committee may have.

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Chairman **BOEHLERT.** Thank you very much Dr. Baron. Dr. Keeler?

STATEMENT OF DR. GERALD J. KEELER, PH.D., ASSOCIATE PROFESSOR OF CIVIL AND ENVIRONMENTAL ENGINEERING, UNIVERSITY OF MICHIGAN

Dr. **KEELER.** Thank you very much. It's my pleasure and honor, as well, to be here today, to be able to talk to you about something I've been spending a lot of time on for the last decade. In one way it's kind of ironic that I started my scientific career and did my doctoral research on understanding the sources of acid deposition in the Eastern United States, and 15 years later find myself again looking at a contaminant problem, and trying to understand the sources of mercury, and finding out that, in fact, the same sources are responsible for both sets of problems.

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I noticed here that in order to try to be bipartisan geographically I show a side of the Western United States in my presentation and will quickly transform to the Eastern, Southern, and Mid-West region. And I will see if I can move on.

Why is mercury important? Well, mercury is a human and ecosystem risk, and it has become a very high priority, both with the public, and has been recognized as a high priority environmental problem at both the state and Federal agencies.

It's a dangerous toxin, especially dangerous to children and fetuses. At this time we do not have a complete understanding of all of the health effects of mercury.

Mercury in fish may also have a disproportionate effect on low economic status groups. There are native Americans who are dependent upon fish in their diet. And this is something that has become more and more obvious as research has gone on.

At present 39 states have issued fish consumption advisories for mercury. Glibly, I have been told that the other states have not checked to see if they have mercury in their fish.

The warnings for fish are, at this point, affecting both recreational and commercial fisheries across the country, so this is not an isolated problem. The problem is not a new one. In Florida, over a decade ago, public concern over the deaths of two Florida panthers, and the extremely elevated levels of mercury in Everglades fish, prompted people to try and understand why mercury in fish in Florida was elevated. At that time the atmosphere was not implicated as a very likely source—it was more thought to be the urban runoff, agricultural runoff, or perhaps a natural process involving weathering of peat.

Today, however, we have a better appreciation. After a decade of scientific research, we now know that over 95% of the mercury that's entering the Everglades ecosystem is the result of atmospheric deposition. This understanding is not limited to the state of Florida and the Everglades. A recent study performed by EPA, in which my group was looking at the atmospheric inputs, found that over 90% of the atmospheric, over 90% of the mercury loading to Lake Michigan was also from atmospheric sources, so that tributary inputs were a much smaller, of smaller significance.

So the atmosphere is now recognized as the dominant pathway by which mercury gets into, is sent to the ecosystems. Although we have made great strides in understanding how important the atmosphere is, the link between the deposition of mercury and what we find in fish is not as well established.

This diagram would take a long time to go through, so I won't do that, but the box on the bottom illustrates the complexity of the biogeochemical cycling of mercury, and as Professor Driscoll eluded to, mercury transforms from an elemental form and a mercuric chloride form into a methyl form, which is what is the form that bioaccumulates up the food chain.

But this link is not as well known. Recent research has been done looking at estimating how much of the atmospheric deposition reductions would reduce mercury's fish tissue concentrations. And what we have found is basically a linear reduction in the amount of mercury in fish would be seen proportionate to the amount of decreasing deposition. So there is hope there.

So, what do we know about mercury? We now know that present, our present understanding of the forms of mercury emitted from sources of all types is inadequate. We need to have a better handle on the forms emitted from all types of sources, both fossil fuel, municipal waste incinerators, and others; as this controls the fate of mercury in the environment.

Mercury is emitted in different forms, and these forms then control where the mercury is deposited. This Mercury II form that's been noted on here is a form that readily deposits in the ecosystems. And we believe that this form controls the local and regional deposition.

In the United States the studies that we have performed suggest that emissions of Mercury II, or this reactive mercury compound is what is responsible for much of the local and regional contamination we see in both Florida and the Great Lakes region.

Today we have a very limited ability to be able to compare observations to modeled results. This slide was meant to illustrate that the current number of MDN sites is inadequate, and we need to increase our funding so that we can have better funding for better spatial resolution, and better temporal resolution, so that we can better link atmospheric deposition to ecosystem processing.

And I guess I, my time is up.

Chairman **BOEHLERT.** Well, you can add a little bit more.

Dr. **KEELER.** Okay. The last two points. In terms of the science questions, one of the important science questions we have now is that we know that mercury is both locally, regionally, and globally transported. And we need to be able to access how much of the mercury we see in different ecosystem is from each one of these different scales. The amount that comes from local deposition in the Great Lakes region could be completely different than the amount that comes from local deposition in the state of Florida, as well as out in the western part of the United States.

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We also need to better understand the importance of natural sources in the western part of the country. Natural sources could be a very significant input to the mercury burden and aquatic ecosystems; as well as we need to start understanding how area sources, such as mobile sources, may be contributing to the mercury burden you see in the environment.

And lastly, recent studies have shown that mercury is a significant problem in the Arctic, due to some extreme environmental conditions there, and in marine ecosystems, which will only hasten the problem in terms of fish contamination in those ecosystems.

I'll stop there.

[The prepared statement of Dr. Jerry Keeler follows:]

PREPARED STATEMENT OF GERALD J. KEELER

Gerald J. Keeler, Associate Professor of Environmental Health Science, Associate Professor of Atmospheric, Oceanic, and Space Science, University of Michigan, Ann Arbor, MI 48109; (734) 936–1836; *jkeeler*@umich.edu

The Problem of Mercury

In the US more of our surface waters are impaired for fishing due to mercury contamination than for any other toxic contaminant (US EPA). Fish consumption is most often the route of human exposure to toxic contaminants, and the U.S. Food and Drug Administration (FDA) routinely issues guidelines to states on levels that warrant closures of fishing waters to recreational and commercial fishing. Currently, thirty-nine states have mercury fish advisories, which likely impact both sport fishers and subsistence fishers (USGS). Other counties around the world, including our neighbor to the north—Canada, and several European countries also issue fish consumption warnings due to elevated levels of mercury in fish. The form of mercury found in fish is Methyl mercury (MeHg), which is a neurotoxin. Those most at risk for brain and nervous system damage are children and unborn babies of mothers who eat mercury contaminated fish during pregnancy. Subsistence fishermen, such as many Native American Tribes, are particularly affected by these bans on consumption of mercury-contaminated fish because of the problems associated with alternative foods. There are numerous Alaskan tribes that depend on fish and wildlife for their source of

food. Recent research has revealed that the Arctic ecosystem may be particularly at risk due to unusual meteorological conditions and atmospheric chemistry observed there that lends itself to greater deposition of mercury to the surface of the frozen ecosystem.

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Today the dominant source of fish contamination is believed to be emissions to the atmosphere from fossil-fuel burning power plants (primarily coal-fired), municipal waste incinerators, and other industrial sources. Some forms of the emitted mercury compounds (e.g., mercuric chloride) directly deposit to water bodies, or to the watershed where they runoff to the adjacent lakes and streams. To date we have a limited data set for the emissions of Hg in its various forms from the major emissions source types.

It should be noted here that in parts of the U.S. significant amounts of mercury reach surface and ground water due to indirect inputs such as urban runoff and leaching from mines and waste disposal sites. Elevated mercury concentrations have also been measured in the influent of municipal wastewater treatment facilities in urban areas that might accept discharges of industrial wastewaters as well as domestic waste.

Natural emissions of mercury to the atmosphere from abandoned mine tailings and from natural geological materials are also significant in parts of the western U.S. Understanding the magnitude of these natural emission sources is made more difficult due to the observation that previously deposited mercury can also undergo chemical transformations that convert it back to the elemental form that readily leaves the earth's surface (land and water) to re-enter the global background of mercury. The rate at which mercury is re-emitted from the surface varies with the type of surface, forest vs. farm field for example. Research to understand the factors that influence the rate of surface emission is ongoing and will meet a critical data need for the development of emissions inventories needed for sounds environmental management of impaired ecosystems.

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After it enters the environment, biological and chemical processes in the soil, surface waters, and sediments can transform mercury into methyl mercury (MeHg), the most toxic form of Hg, which taken up by plants and animals. The levels of MeHg tend to build up or bioaccumulate in organisms on up through the food chain. While mercury can transform from one chemical form to another, it does not degrade or disappear like some other persistent organic pollutants.

Mercury and Acid Deposition

The problems of acid rain and mercury contamination are closely linked. Research has revealed that the levels of Hg in fish tissue tend to be higher in more acidic water bodies. The same sensitive ecosystems that have been the recipient of acidic compounds from the burning of fossil fuels also receive elevated concentrations of mercury and other toxic trace elements. With the Vice President's announcement of an energy policy that continues to focus heavily on fossil fuels, there is some urgency to understand the linkage between atmospheric emissions from these sources and the risks to humans and the environment. Research aimed at understanding the sources and cycling of mercury in the environment will also help us in

understanding the fate and risks from the other 15 "pollutants of concern" identified in the *Third Report to Congress* of the Great Waters Program. Since the atmospheric fate and transport of mercury is so inter-twined with the chemistry of atmospheric acids and ozone, federal agencies should aim to develop integrated high-temporal and spatial monitoring sub-networks in select ecosystems that have comparable aquatic and biological monitoring.

Environmental Monitoring

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The importance of high quality monitoring data for development of sound environmental policy can not be understated. At present, the proper balance of long-term atmospheric deposition monitoring sites and integrated process level research sites does not exist. While there are currently several national monitoring networks for acid deposition (NADP/NTN, CASTNet, AIRMoN) as well as the National Air Monitoring Stations (NAMS) and State and Local Air Monitoring Stations (SLAMS) for assessment of the National Ambient Air Quality Standards, there is not a national effort to properly assess the trends in ambient mercury or the dry deposition of mercury, which can equal the deposition of mercury deposited by precipitation. Several states have initiated weekly mercury monitoring as part of the NADP sub-network referred to as the Mercury Deposition Network (MDN). However, the spatial coverage at present is not adequate to assess emissions trends or to assess the efficacy of reduction programs. The highest deposition (wet and dry) is found in and downwind of our large urban areas where there are, at present, few monitoring sites. Support from the federal government will be required to improve the spatial coverage as well as to improve the quality of the monitoring equipment presently being utilized. Current efforts by the US EPA and USGS need to be expanded to allow for a continued improvement of monitoring networks and utilization of modern technological breakthroughs in microelectronics that are now becoming more widespread. Improvements in monitoring methods will also be required for attainment of the goals of the Bi-national (U.S.-Canada) and Tri-national (U.S.-Canada-Mexico) environmental programs and action plans.

Source Attribution

The question of whether one can determine the source or source types contributing the Hg in a particular water body or in the fish in a particular lake is one asked often. Monitoring conducted for source allocation would require the use of short-duration measurement techniques that are now available as well as event-based wet and dry deposition methods. The use of proper techniques and complete chemical and elemental characterization of the deposition samples allows the estimation of the contribution of mercury from the major sources (See Dvonch et al., 1999, ES&T for more details). Detailed measurements that axe needed for determining source-receptor relationships can also be used to better understand the basic processes that are controlling the fate of mercury emissions from various sources in different regions of the U.S.

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A well-defined network of monitoring sites together with the chemical and elemental characterization would allow for regional and national assessments of the major sources contributing to the mercury deposition. This network would provide the needed data to track changes in mercury deposition and assess

the efficacy of regulatory programs. Funding for the development and implementation of this type of network would also need to include both wet and dry deposition measurements. In addition, the enhanced deposition data would allow linkage to whole ecosystem studies tracking changes in the biological and physical environment.

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Chairman **BOEHLERT.** Thank you very much, thank all of you very much. I only wish, I said to Dr. Mimikakis, counsel, that I wish this were on CNN. Not that I want to get our lovely faces on CNN, but it's important to get your message on CNN, because of all the real frustrations Mr. McHugh and I particularly experience, when we talk about acid deposition, and mercury, and destroying lakes and forests. I say, you guys up in upstate New York, why don't you get your act together and solve the problem?

When I first came here, one of my campaign pledges was to do something about the problem of acid deposition. I was an instant success—it only took me 8 years to get something going. But I can recall vividly

initially people saying to me, don't you understand you're a national legislator now, that is a New York problem, particularly a northern New York problem. And I keep talking, and they finally conceded, well, it's a regional problem. Why don't you get together with the people in Ohio and Indiana, and work something out? And we kept talking and talking, and John McHugh joined me, and we kept talking, and finally people are beginning to appreciate, thanks to not so much our rhetorical excellence, but thanks to Dr. Cowling—works that you're doing, and the reports like Dr. Driscoll's, your latest, the true dimensions and magnitude of the problem are appreciated.

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The biggest frustration I have is not being able to convince others that I don't have a, just a self-interest, a parochial interest in this. And that's why I want to give as high a visibility as I can to people like you, distinguished scholars, who talk about the magnitude and dimensions of the problem, and so that my colleague, Mr. Udall, it didn't take any convincing of him, appreciates that the problem affects his constituents in Colorado. And our friends in Florida begin to appreciate, hey, you've got problems down there, too. So, thank you very much for the excellent testimony.

Let me ask a couple of questions. I notice from EPA's budget for '02 they talk about that additional monitoring sites are needed. Boy, do we all agree on that. But of course the agency doesn't seem to ask for any additional money for these new monitoring sites.

What kinds of additional monitoring do you think the Federal Government should do, and why?

Dr. Cowling, do you want to address that?

Dr. **COWLING.** There are some items in his testimony that I think are worth considering. In the NADP, the question of upgrading the collection device that is used for precipitation. That's one thing. And working further at the business of adding dry deposition estimates to the wet deposition measurements that we can make quite reliably. That's another thing that would be very beneficial.

And, as our mercury friend has mentioned, we need an updating of the mercury network—many more sites in other parts of the country. We have 227 precipitation chemistry monitoring sites. How many do we have on mercury? Thirty something. Those are illustrations of needs.

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Chairman **BOEHLERT.** You have already anticipated my next questions. What additional systems for mercury monitoring do we need? Dr. Keeler?

Mr. **KEELER.** Over the past 2 years there has been a significant improvement in technology, both for testing emissions from various types of utilities, and in fact all stacks, as well as our ability to speciate mercury, as I had mentioned briefly. The form of mercury that's in the atmosphere is what controls whether it deposits quickly nearby the plant, or whether it gets transported long distances.

We now have the ability to measure all of these forms, both in the gas phase, and the particle phase, as well as in the aqueous media.

This technology is new; it's in the process of being rigorously evaluated, both by EPA, and by groups like my own. And that technology needs to be implemented and put at some small number of research grade sites across the country, in different areas that have very different source combinations, as well as different meteorology. But the technology is there to do that, now. We have also developed new generation precipitation systems that allow automated precipitation collection, which should lower the cost of the operation, but also provide much more relevant and readily available data. And so I guess I would make a plea to the Committee to make sure that the latest technology is being used in terms of any future network developments.

But the technology is finally there. It's just a matter of getting the funding in place to implement the technology.

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Chairman **BOEHLERT.** Let me ask, and I'm going to adhere to the time limit for the Chair, as well as everyone else. Let me ask all of you to ponder this for a moment.

What would you say are the two or three top research needs for acid rain and nitrogen deposition and mercury?

Dr. **COWLING.** I'd like to mention that the U.S. Geological Survey operates more of the total number of sites in NADP than I, than any other, and the EPA has an important number, but the number, it is not just EPA who runs NADP, there is the State Agricultural Experiment Stations, there's the NOAA sites, there's the U.S. Geological Survey Sites, and it's important that we maintain the mutual commitment among these different agencies to do their part in order to have an adequate database in all parts of the country.

Chairman **BOEHLERT.** Dr. Driscoll, do you have any comments you would care to make? And I want to ask Dr. Baron to tell us about her budget a little bit.

Dr. **DRISCOLL.** Just in terms of research needs, I think it's important to point out that the problems that we have been talking about are very much inter-related, and we have been studying them in isolation, but there are a lot of linkages between acid rain and mercury, nitrogen, as well as something we haven't talked about, which are climatic disturbances in climate.

So I think looking at these interactions is a very important area of focus.

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Chairman **BOEHLERT.** Dr. Baron, as I recall, the budget is not too kind toward USGS, do you want to talk to us about that for a moment?

Dr. **BARON.** Well, sir, as a scientist way down on the totem pole of the U.S. Geological staff I really

can't talk about the budget, but I could give you a research need that I think is important.

We don't have nearly enough knowledge of the very interesting interactions that occur with nitrogen, or acid comes in and influences soil biota. These are fungi and bacteria that are essential for plant growth, and we don't know yet how they are being affected.

This indication in Southern California that we are seeing tremendous losses of this very important part of our soil structure, and that influences both plant interactions and susceptibility, and also insect outbreaks as well.

We need a lot more research, I think, on the ecological implications of not only nitrogen, but all these other combined affects.

Chairman **BOEHLERT.** Anybody else have anything?

Dr. **KEELER.** I would like to second Dr. Driscoll's comment about the intertwining of these pollutants. As I mentioned in the beginning, the mercury problem is one and the same as the acid deposition problem. What we've learned only in the last couple of years is that the chemistry that controls acid deposition is also very important in terms of mercury. So I would argue that we really need to make sure that we are integrating these problems together and looking at research that addresses these things simultaneously, and not just from an atmospheric point of view, or from an aquatic ecosystem point of view separately, but that these things should be done together. We should be looking at the atmospheric end of things together with the ecosystem effects. This is the only way that we can bridge that gap between the deposition and say the mercury content in fish.

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Chairman **BOEHLERT.** Thank you very much. The gentleman's time has expired.

Mr. Udall?

Mr. **UDALL.** Thank you, Mr. Chairman. I want to associate myself with your remarks about the affects of acid rain on all of us. Everyone seeing one of those cartoons with an out-house hanging over a river, and the comment is, well don't worry, we're up river from everyone else. And I think for many years we have also categorized our community as being upwind or downwind, but if you think about it, we're all downwind of each other.

Last month in Boulder, and in Colorado we had a yellow haze that covered Colorado for much of about 3 days, I think, Dr. Brandt. It turned out that the dust that was in the air, causing this haze, was from Mongolia. And it was a very powerful example of the fact that we are all downwind from each other, when you look at the globe in its entirety.

Picking up on Dr. Keeler's comments, I want to extend this question to the whole panel. We are talking about mercury and its persistent toxic compound has found its way into the food chain. Is acid rain accelerating the entry of any other toxics into the food chain?

Dr. **DRISCOLL.** One problem that I think Dr. Baron eluded to, which is quite important in terms of toxic affects, is aluminum. Aluminum is a component of soil, and as it turns out under most conditions, aluminum is retained in soil. But, in the presence of acid rain, it's mobilized, and aluminum is quite toxic to plants, and it's very toxic to fish and aquatic organisms.

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And there are a few other metals that have similar behavior, beryllium is another one, extremely toxic metal, mobilized under acidic conditions. And there are a few others that act like that.

Mr. **UDALL.** Any other comments on that? So aluminum is a material we should be aware of and be concerned about, I hear you suggesting.

Talk a little about greenhouse gases and their affect on acid deposition, and secondarily, what affect would restricting greenhouse gas emissions have on acid deposition?

I extend the question to the entire panel.

Dr. **COWLING.** Jill mentioned nitrogen. Nitrogen is one of those greenhouse gases. When it's in the form of NO. And it isn't just how acid rain affects these, but NO is a denitrification product of biologically available nitrogen.

So, so long as we continue to enrich the atmosphere and the biosphere with more and more nitrogen from power production, from food production, or from industrial sources, we will continue to have more and more nitrogen circulating in the atmosphere and the biosphere of the earth.

And the more of that that remains biologically available, the more we will have of the NO emissions. So one of the questions that we have as a nation, and maybe as a globe, is how much excess nitrogen, that's the term that Jill used. How much more than what is necessary for maintenance of an effective and enjoyable life, insofar as food supplies are concerned, and as far as energy use is concerned.

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Nitrogen is sort of the next element on the series of elements with which we need to be concerned.

Dr. **BARON.** I mentioned that nitrogen comes from combustion of fuels, well fossil fuels are also a major source of carbon dioxide. So, by cleaning up or reducing the emissions of one, it's very likely that we'll reduce the other. So there is a synergy there that would help us in both perhaps becoming more energy efficient, as well as reducing these emissions causing all of these problems.

Mr. **UDALL.** So there is a, very much a potential benefit you would see forthcoming, were we to do a better job of restricting the emissions of greenhouse gases?

Dr. **BARON.** If that opportunity were to arise, I think we would see benefits.

Mr. **UDALL.** Dr. Keeler, were you interested in commenting as well?

Mr. **KEELER.** Yes. Research that was conducted by colleagues of mine, at the University of Michigan biological station have been looking at the changing ecological structure and the force to the ecosystem there by enhancing the levels of CO in these chambers with plants, and then looking at how the plant, growth changes, the rate at which carbon sequestration by the plants changes, and so forth. And what they found was that the carbon moves differently in these plants that have elevated CO. Obviously plants like CO, so they doubled the CO. The plants grew bigger, but the leaf structure changed, and the amount of roots below the surface changed.

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What they found, though, is that while the leaves got bigger with the higher CO, they didn't have as much nutritional value to the micro-organisms eating the leaves, and so they had to work harder then, you know, using more energy to do it. So, they have now been able to track this over the last 15 years, and look at changes in the ecosystem structure moving up the food chain, and they are seeing some dramatic changes.

Now one of the things that we have just begun doing is, look at how do these toxic metals like mercury, that are also taken up by the plant material, change as the plant structure changes. Mercury likes to go with the organic carbon that's in the plants, and if climate change occurs and we have more CO, it may mean a faster mobilization of the mercury that's associated with the carbon, because it's moving out of the ecosystem quicker.

So there are some linkages between climate changing the ecosystem structure that will potentially exasperate, and say the amount of mercury that's in the aquatic ecosystems that are nearby. And these are things that we are trying to understand now, because we believe it's not if it's going to happen, it's when it's going to happen, and we need to be ready to do something about it.

Chairman **BOEHLERT.** I'd like to say thank you, but that's not particularly good news. The gentleman's time has expired.

The Chair recognizes Mr. McHugh.

Mr. **MCHUGH.** Thank you Mr. Chairman, and again thank you to the committee members for their hospitality here today.

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Both Dr. Driscoll and Dr. Cowling made reference to schematics which showed by color-code that the problem is getting better. What might we say to those who would turn those charts and say, things are getting better, why do we need to do anything else?

I wonder if either of you might want to comment on that?

Dr. **DRISCOLL.** Well, with respect to surface waters in the Adirondacks, we do see slight decreases in concentrations of sulfuric acid, but in terms of the constituents that fish and other aquatic biota like trees respond to, the acidity, the situation actually hasn't improved very much, if at all.

And if we extend the current rates of recovery, they would be over very long timeframes, many, many decades. So if we are concerned about these resources, and we want to accelerate that recovery, then our interests would be best served by having additional reductions.

Mr. **MCHUGH.** Dr. Cowling, would you like to add to that?

Mr. **COWLING.** I would just like to emphasize, in the context of the several remarks lately that multiple pollutants, multiple effects ways of thinking lead us to understand we are talking about one atmosphere with a whole lot of different kinds of processes going on in it. And although we are, our tendency is to deal with one problem at a time, as Charley was saying, we need to understand it's one atmosphere, it's our atmosphere, and we should manage that atmosphere from the standpoint of food production, from the standpoint of energy use, from the standpoint of mercury emissions. And the sources of these substances are the same. Basically, use of fossil energy, and feeding ourselves, are the principle sources of the nitrogen, the mercury, the sulfur that lead to the ecological problems that we face.

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Mr. **MCHUGH.** Thank you. Dr. Driscoll, you are one of the authors of the study that was conducted now under the auspices of the EPA and the office of Air and Radiation that studied the cost benefits associated with the provisions of Senate Bill S.172 that in my lay reading of it suggested pretty strongly that the benefits and avoided costs, health costs, environmental avoided costs, et cetera was considerably greater than the cost of implementation of those more strict standards.

That, I think, is a key part of any kind of approach that we have to take in this town politically, and to helping those, as the Chairman noted, in certain parts of the country who are being affected by this, and yet who continue to have questions about the efficacy of moving forward.

I wonder if you, or if your colleagues would like to comment upon what we stand to gain versus what would be required to be invested to make a difference.

Dr. **DRISCOLL.** I think you're correct. I think that the retrospective analysis, also from the 1990 Clean Air Amendments clearly show that the benefits greatly outweigh the costs, actually the best estimates of current costs are much much less than were projected, almost, you know, a factor of eight. And there are tremendous benefits, particularly on the health side, associated with inhalation of particles. And those states which benefit the most are those states with the highest emissions.

So there are hugh benefits on the health side.

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Mr. **MCHUGH.** Dr. Cowling, would you like to critique Dr. Driscoll's hypothesis there?

Dr. **COWLING.** I thought I did.

Mr. **MCHUGH.** Okay.

Mr. **COWLING.** John Tucki, Professor at Princeton, in Statistics, was a member of the Oversight Review Board, and one of the very important observations that he made was that all of the estimates of the costs of decreasing environmental emissions are much greater than the actual costs have turned out to be. And the number eight, and we had some very nice illustrations of this in the conference that we just finished. And about eight is right, eight is the number by which the costs are reduced. One-eighth is what we now paid for what it was estimated to be very substantial cost. But this eight fold difference, or five fold difference or something of that order is what Tucki had observed in many different ecological or environmental problems.

Dr. **KEELER.** If I could just make one point to that?

Mr. **MCHUGH.** By all means.

Dr. **KEELER.** We were talking about acid deposition, but these compounds that are emitted into the atmosphere and chemically react to form secondary particles are also causing us great expense in terms of health problems, respiratory disease, asthma, bronchitis, and so forth also are incredible economic costs to our nation. So, before they are removed by precipitation, these things are causing other, other problems as well.

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Chairman **BOEHLERT.** Coincidentally, just prior to you mentioning that Dr. Mimikakis gave me a report from the Harvard Center for Risk Analysis, and that is hardly viewed as a liberal area of thought on these issues. It does have a reputation for being rather conservative. And they are talking about the health benefits of emissions reductions from older power plants. And they studied nine plants in the Chicago area, and they conclude, "We estimate that the incremental increase of particulate concentrations attributable to these nine plants results in approximately 400 deaths per year." Then, later on, they talk about a study that found that, "if all power plants across the US reduced their emissions by 75%, approximately 20,000 premature deaths per year might be prevented."

Now this is addressing only the health benefits. They do observe in here that we would also have some benefits in reducing acid deposition. But that is rather significant. And that's why Bill Nye, the science guy, is a guy I kind of like, because he's the guy who does, we are in communication with him on a regular basis, and we're going to have him testify a couple of times here. But the, one of the reasons I like him so much is that he can take something very complicated and simplify it so that a lot of people can understand it. And that's, I'm trying desperately to find ways that we can contribute to the expansion, and hopefully the proliferation of information that is easily understood. Because I have to believe that if the average American really was able to appreciate what this problem is causing for him, or her, they would be writing their

Congress people and saying, hey, you'd better support those guys up on Capitol Hill that want to do something about this.

Thank you. Mr. Etheridge.

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Mr. **ETHERIDGE.** Mr. Chairman, thank you for those comments and for this hearing. Let me look at it a little broader viewpoint, and come back to a couple questions. Dr. Cowling, the answer is yes, I have been to Mt. Mitchell. I talked with Hugh Morton on a number of occasions, as I'm sure you have. A mutual friend who is quite concerned, and he is convinced it's all about acid rain. It would be kind of hard to convince him otherwise. But when you see the trees, not on a slide, but in person, you really do get an appreciation of how quick, and how damaging it is.

I would like to just have you just comment briefly, and not too much, so I can get to my real question. I am sitting here thinking, as we were talking, and the Chairman was making his comments, and as we teach children in school we talk to them about CO and the atmosphere, and how the trees transfer that into clean air, and I am not so sure a lot of our folks, that's about the extent of their understanding of the environment, unfortunately. And, but until they see the trees start to die, I'm not so sure they have a real understanding, or as the Chairman just indicated, they have a problem with their eyes, and they think it's allergies, but yet it's particulants in the air, or they have asthma or otherwise. They don't really understand how serious this issue can be.

And in your comments I hope you will touch on that, but let me get very quickly to a question, because all of this deals with quality of life, we are all so concerned about. And if you asked, do a survey, everybody is concerned about quality of life, it's top on everyone's agenda. And yet, when you get underneath that, it differs, and as we have, if we want to continue to have economic growth, as we're having in our part, especially in the Southeast, and let that be truly a positive quality of life, talk to me a little bit if you could about the oxidant study, where it is, and when that might be done, so we'll have some understanding of where we're headed?

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Dr. **COWLING.** And for those of you who aren't, as Bob Etheridge is, well informed about the Southern Oxidant Study, this is an alliance not unlike the National Atmospheric Deposition Program.

We have participation from NOAA, we have participation from EPA, we have participation from the Southern Company, private sector interest, we have participation from the Department of Energy, and we have a total of 40 universities and 42 governmental organizations that are working together, voluntarily, often bringing their own money, so it's like joining the church, and you have to tithe with the church in order to be a participant. That's true in NADP, it's also true in the Southern Oxidant Study. But we're currently involved, and I much welcome this question, actually.

Fourteen months ago EPA, which supports the university part of Southern Oxidant Study, was invited by

EPA to submit new proposals for another 5 years. We're 12 years old, going on 17, we hope. And we submitted them in March, and we're looking for response. And we've been told on a daily basis that we'll hear pretty soon.

And I would very much welcome any interest in, on the part of this committee or other committees of the House or the Senate that would ensure that—we have just finished 9 different field measurements programs. We have intended to commit ourselves thoroughly to analysis and interpretation of those 9 studies. And we are eager to get on with it. And the hold up on the university's part of the program, which holds this thing together, we do not run the program, we coordinate the activities that result in the products.

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And I would be happy to bring, for your interest, I will send to your office the recent compendium of outputs from, this is one of the major problems of field programs, we spend an awful lot of our money on the measurements and not enough money on the analysis and interpretation and translation of that into useful guidelines for management, and for communication with the public that needs to know about what we have found out. Like, for example, the greater ozone producing efficiency that we observe with small power plants, as opposed to large power plants. That's sort of counter-intuitive, and sort of outside the realm of policy.

But that's one of the most important discoveries that we have made. Ozone—or nitrogen oxides released in small, in small power plants will produce more ozone than if the same amount of nitrogen oxide were produced in a large power plant.

Mr. **ETHERIDGE.** I look forward to receiving that. Thank you.

Chairman **BOEHLERT.** Dr. Cowling, you indicated a preamble to your answer to that question that Mr. Etheridge was well-informed. I find from experience that he is usually well informed on a variety of issues.

He, as you know, is the former state superintendent of education.

Dr. **COWLING.** Yes.

Chairman **BOEHLERT.** The Chair is pleased to recognize the distinguished Chairman of the Sub-Committee on Research, Mr. Smith of Michigan.

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Mr. **SMITH.** Thank you, Mr. Chairman. Are you comfortable with the coordination between Agriculture and USGS, EPA? Is there some kind of structure for coordination of the research effort, the monitoring effort?

Dr. **BARON.** Certainly at our local level we are all working very closely together, and I'm happy to say that I'm preparing a paper with an Agricultural Research Service scientist for presentation at a meeting this summer. So there is a lot of coordination among the scientists who have questions.

Ecological research, atmospheric deposition research, these are not things that any one scientist can do by themselves, and we are lucky that a lot of us collaborate.

Mr. **SMITH.** So should there be more coordination at the Federal level, rather than just the local level?

Dr. **COWLING.** I would encourage more oversight, about cooperation, and cooperation extending into Bob Etheridge's realm of education, too. There are three of us here who are Professors, and I think that you probably do some teaching, too, Jill.

Mr. **SMITH.** Let me ask you another question. How many utilities have complied with Title IV of the Clean Air Act? Do we know this?

Dr. **COWLING.** Well yes, I'm sure there are other people behind us here could answer that, but I would say that most of them are. All of them.

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Mr. **SMITH.** Otherwise somebody would shut them down.

Has this additional cost in some ways impeded with the generation of electricity?

Dr. **COWLING.** Not to my knowledge.

Mr. **SMITH.** Is there a significant difference in the cost of compliance with Title IV, depending on the fuel, the burn—I assume if it's a coal generating plant, then the compliance cost is significantly higher than if they are using natural gas?

Dr. **COWLING.** Certainly the form, the type of fuel will influence the amount of emissions, and there are certain technologies, I'm sure that Charley Driscoll can probably answer these, he's an Engineer, probably better than I can.

Mr. **SMITH.** So maybe Mr. Driscoll could respond.

Dr. **DRISCOLL.** Well I think you're right. I think that there are different sources and different costs, and difficulty in compliance. There is, coal is a more dirty source than natural gas, so clearly there are costs associated with removal of sulfur, and other pollutants in those sources.

Mr. **SMITH.** Is natural gas minimal, in terms of its discharge?

Does acid rain, is it actually changing the pH of the soil, and is that measured—how much would it change the pH?

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Dr. **DRISCOLL.** Well there have been clear effects on soils, particularly in areas that are relatively

sensitive. For example, and area that I work at in New Hampshire, which is a forest service site, Harbor Brook Experimental Forest. We lost, we estimate 50% of the available calcium over the last 50 years to the acid rain.

Mr. **SMITH.** Another farm question, Mr.—Dr. Baron, you indicate that the nitrogen is partially, comes from agriculture from farms, from livestock. Is that measurable? Do we know what kind of percent that would contribute, and how would you measure that?

Dr. **BARON.** I don't know how you would measure it, but we have been working with estimates, based on processes of volitalization and processes of microbial activities in soil. Those estimates do suggest—I think that there are ways to measure it, I just don't know what they are.

Mr. **SMITH.** Dr. Cowling?

Dr. **COWLING.** Yes, I was just going to say, the amounts of nitrogen being emitted as ammonia in the state of North Carolina today is larger than the amount of nitrogen being emitted from all the power plants of North Carolina.

Chairman **BOEHLERT.** Say it again.

Dr. **COWLING.** The amount of nitrogen emitted as ammonia, which comes dominantly from agriculture operations, either through fertilizer conversion to ammonia, or as a result of the release of———

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Chairman **BOEHLERT.** Gas storage?

Dr. **COWLING** [continuing]. Gaseous, right; is greater today in North Carolina than the amount produced in combustion of fossil fuels in the state of North Carolina. It's not much different.

Mr. **SMITH.** Well, Mr. Etheridge is gone, but———

Dr. **COWLING.** No, he's here.

Chairman **BOEHLERT.** He's here.

Mr. **SMITH.** Why hasn't there been more improvement in the South?

Dr. **COWLING.** Well, nitrogen oxide emissions are not decreasing. Ammonia emissions are increasing. So there is more nitrogen in the atmosphere now than there was, or nearly the same amounts. So the lack of improvement is partly due to the fact that the Clean Air Act Amendments of 1990 were aimed partially at decreasing sulfur oxide emissions. And although there was some decrease in the amount of nitrogen oxides emitted under the provisions of Title IV, it is not nearly so pronounced as in sulfur. And nitrogen is more important in the Western than sulfur is.

So this is another aspect of the regionality of the air quality management challenges that we face.

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Mr. **SMITH.** Mr. Chairman, I would like the opportunity to submit some other questions in writing, if we could impose on the panel as to that much.

Chairman **BOEHLERT.** By all means. As a matter of fact, all panelists will be given the opportunity to submit questions in writing, and we would ask our guests to be as responsive in as timely a fashion as you possibly could.

Thank you, the gentleman's time has expired.

Ms. Jackson-Lee?

Ms. **JACKSON-LEE.** Thank you very much Mr. Chairman and the scientists and panelists combined that are here today, I thank you.

Let me just acknowledge the fact that this is an important hearing for the quality of life that we would like to pass on to our children. And I note that the title of the hearing is the state of the science and research needs for the future.

As I have been listening to you, it seems like you have a lot of knowledge, but the hearing suggests that we need to do more research. My question is, when will we know enough to be able to address this question of acid rain head on, if you will, even though I hear, as I have listened to some of the testimony, you believe we've made some progress.

Anyone want to answer? Do we have enough knowledge about acid rain to confront it head on? Dr. Driscoll?

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Dr. **DRISCOLL.** I'm a researcher, and I would always say we need to do more research. But I think we know a lot about how forest systems work, with respect to acid rain. Less so with respect to nitrogen, more so with respect to sulfur, very little with respect to mercury. But we know a lot about how sulfur moves through the system, and we have pretty good computer models, I think, that allow us to make reasonable predictions on what would happen, how the soil would respond, how the water would respond to hypothetical changes in inputs.

Ms. **JACKSON-LEE.** That leads me then to a component that we are supposed to be involved in, and that's legislation. Of course the 1990 Clean Air Act may have been referred to earlier in this hearing, helped us to regulate emissions. We are still having problems.

What do we need to do with that particular legislative initiative to improve how we can eliminate emissions sufficiently, or keep moving with the infusion of emissions. It probably differs, because we

differed our use, we differed what we are doing.

How do we make that legislation breathe in 2001?

Dr. **DRISCOLL.** Well, as we talked about previously, we've learned a lot since the 1990 Clean Air Act Amendments. We have seen, we have shown clear affects on soils where we didn't think there were any affects on soils 10 years ago.

We have demonstrated pretty, I think pretty convincingly that there are effects on trees, and we have been talking about all of these linkages associated with human health, the eutrophication of coastal waters, bio-diversity, there are a lot of subtleties to the problem that we know a lot more about.

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The 1990 Clean Air Act Amendments focused on sulfur controls in utilities, and I would say I think that if there are additional controls that would benefit the environment on a number of fronts, a number of issues.

I think it's also important to point out that once the 1990 Clean Air Act Amendments play out in 2010, about 55% of the sulfur dioxide emissions will be from utilities, the balance is from other sources. With respect to nitrogen from utilities, there is a smaller fraction, so there is transportation sources. And then there is ammonia agricultural sources, as Dr. Baron and Dr. Cowling have talked about, and we're just starting to talk about mercury.

So, there are a lot of things. And I think the 1990 Clean Air Act Amendments, it's been great, it's been a real success story, as far as I'm concerned. But I think there is a little bit more we can do.

Ms. **JACKSON-LEE.** Because of what we've learned. Dr. Cowling, so that means we need to add some of these other aspects of emissions?

Dr. **COWLING.** Yes. I think the other thing that we've learned from Title IV is the effectiveness of the idea of cap and trade. Putting a limit on how much is the total amount of a pollutant that is allowed, and then developing a trading mechanism, so that the maximally efficient processes for achieving those caps are actually implemented. It's up to the companies to make the choices about the means by which they can achieve the general decrease.

Ms. **JACKSON-LEE.** Lowering them.

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Dr. **COWLING.** The notion of cap and trade. It is a great success. It's being emulated in other countries of the world. We did something very significant in inventing another system than just limitations that are based on air quality standards, but are based on a maximum amount of the pollutant which could be emitted in the nation as a whole.

Ms. **JACKSON-LEE.** Let me just conclude by saying, Dr. Baron did you want to add something?

D. **BARON.** In Southern California, where nitrogen deposition is so severe, my research colleagues, who are actually with the USDA, have found that streams draining the San Bernardino Mountains are running 10 milligrams of nitrogen nitrate per liter as an average concentration. That's the Federal drinking water standard. Though we know that nitrogen deposition is very high in that part of the country, we know that these streams are running extremely high concentrations.

You ask if we know enough, it seems to me that—I don't know if anyone drinks that water, but they shouldn't.

Ms. **JACKSON-LEE.** Well, let me thank the Chairman very much. The only thing I could glean from what you have said, we have enough knowledge, and also that we can have a good economy, a good business, at the same time good quality of life, and good air, if you will. Thank you very much, Mr. Chairman.

Chairman **BOEHLERT.** Well, I'd like to identify with those remarks, Ms. Jackson-Lee.

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Ms. **JACKSON-LEE.** Thank you, Mr. Chairman, that gives me great excitement and comfort. Thank you for your leadership on these issues.

Chairman **BOEHLERT.** Thank you. Mr. Johnson?

Mr. **JOHNSON.** Thank you Mr. Chairman, members of the Committee, distinguished panel. Let me be just provincial for a moment. I guess my question would be two-fold. One is, how do you distinguish, and I am sure there are distinguishing aspects to this. The effect of acid rain on the Northeast vis--vis the rest of the, let's not say the rest of the country, let's say the Mid-West, because that's where I happen to be from.

Secondly, what degree of differences, if any, are there, with respect to the collective amalgam of knowledge regarding acid rain, in terms of its effect on the Northeast versus other areas of the country. It's sort of a two-fold question, and I'd just be glad to hear your response, I have no follow-up question.

Dr. **DRISCOLL.** Do you want me to take that? While I think all areas of the country are affected by acid rain, and acid rain affects a variety of resources. We talked about human health, we talked about forests, we talked about soils, we talked about fresh water systems, coastal systems. I think that depending on where you are in the country, the amount, the inputs vary. They are high in the eastern part of the country and lower in the west, but they are still significant in the west, and the resources that are affected vary across the country.

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So, in the Midwest some of the greatest benefits, and some of the biggest problems are associated with human health effects, but there are still lakes in the upper midwest that are impacted by acid rain, just like

we see in the Northeast.

Dr. **COWLING.** At this conference we just had a very fine report by one of the scientists from Wisconsin, and he was talking about seepage lakes. And seepage lakes are quite a different thing than non-seepage lakes.

We need to understand how the lakes work in order to manage them, and we don't have seepage lakes in the eastern part of the country, at least I don't believe we do, and so Wisconsin has a special challenge of managing its particular type of lake, where much of the water in the lake's body comes from the drainage from ground water, or the movement of ground water, rather than as precipitation inputs.

Similarly in Florida we have a different kind of lake structure. But, nevertheless, we have acidification processes, we have nitrogen deposition influences in all the different parts of our country. The Midwest is not immune to worry about these issues that are so often in the popular press regarded as Northeastern problems, as our Chairman was indicating.

Chairman **BOEHLERT.** I won't take this out of your time, Mr. Johnson, but I would point out we have passed out a study, a Harvard Study, to all the members of the panel, and it talks about the health benefits of emissions reductions from older power plants. And page three, I particularly call your attention to a study done at 9 power plants in the Chicago area, Chicago, Illinois; and we estimate that the incremental increase of particulate concentrations attributable to these 9 plants result in approximately 400 deaths per year. I would commend that to your attention. You still have a couple of minutes left.

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Mr. **JOHNSON.** I think the questions have been adequately addressed, and I appreciate it. Thank you.

Chairman **BOEHLERT.** Thank you very much. Mr. Grucci?

Mr. **GRUCCI.** Thank you Mr. Chairman. First let me commend you and the other members of the New York delegation for showing such great leadership in this, Congressman McHugh and Congressman Sweeney for bringing this issue to the forefront.

Coming from New York, and I come from the eastern end of New York, Long Island, we have a great body of water known as the Long Island Sound. Most recently the Long Island Sound has been experiencing a lobster die off, as well as other hard-shell deaths in the water, crabs, clams, et cetera.

What affect does, in your opinions, do you believe that the acid rain has on that particular issue. Or do you think there is something outside of acid rain that is causing the temperatures of the water to rise, or the oxygen level to be decreased, and the die off to be taking place?

Dr. **DRISCOLL.** I can respond to that. We have just completed a study, and if you like I can share with you a couple of papers that we have sent to journal articles, doing nitrogen budgets for Atlantic and Gulf Coast States, and including the Connecticut River System, and what we found on average in the Northeast, including for that system, is that a substantial fraction of the nitrogen coming in that contributes to low

oxygen concentrations is from atmospheric deposition, on the order of about 25%.

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Mr. **GRUCCI.** If I could get a copy of that I would appreciate it.

Dr. **DRISCOLL.** Sure.

Mr. **GRUCCI.** It is a huge, a huge concern of ours, not only because of the beauty of the Long Island Sound, but it is also an economic engine that drives a lot of the region of both Connecticut and New York, the border of the Long Island Sound, and it does have a very big impact. We need to resolve that issue and get the Long Island Sound back onto a healthy course again.

Dr. **DRISCOLL.** I might add that there has also been some very good work done on mercury affects in that area as well by colleagues at the University of Connecticut.

Mr. **GRUCCI.** I was going to ask you about that, the other levels other than nitrogen that have been measured has been sulfur levels and mercury levels, and do you see that as a potential problem for the health of the Sound, or is there certain levels that are acceptable?

Dr. **KEELER.** Coastal areas appear to be very susceptible to mercury deposition. We are just learning now that atmospheric chemical processing that happens in the coastal areas actually result in more deposition of the mercury to these areas. There is a lot of work that is just starting, looking at coastal zone management, and what they are finding is that not only is nitrogen elevated in the deposition, but also a lot of the other toxic compounds that come with the nitrogen and the sulfur, and mercury is one of those. So we always talked about the fish consumption advisories for the inland lakes. The coastal waters also suffer from the same deposition and the enhanced mercury concentrations.

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Much of our large sports fish that we catch off the coast are also very heavily laden with mercury. So this is very much a concern for all states that have coastal areas.

Dr. **COWLING.** Nitrogen also enhances the blooms of sometimes toxic algae, and I don't know personally whether that's a significant problem in the Long Island Sound, but it certainly is in other coastal regions further south.

Mr. **GRUCCI.** We have had in some of our inland bays the issue of red tide, brown tides, and it has had a dramatic affect on scallop fishing, for example.

You mentioned earlier about seepage, and it raised a question in my mind. Long Island is a sole source aquifer, all of our fresh drinking water comes from beneath the ground that we walk on.

Am I incorrect in believing that when the rain, the acid rains that fall from the sky percolate through the

ground that there is some sort of purification that is taking place as it migrates through the sand and ultimately hits the water table? Or am I incorrect in assuming that?

Mr. **KEELER.** Well, in general that's a correct principal, however, it depends upon the geological nature of the area for which you are talking about.

The arsenic problem, for example, in drinking water is one which the water that's percolating down through is actually picking up arsenic from the natural geological materials that are there. So the ground and the soils don't necessarily cleanse the pollutants from the soil, however other things may be scrubbed out and retained in the soil. So that depends upon the pollutant and the geological material.

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Dr. **DRISCOLL.** I am not specifically familiar with the aquifer problems in Long Island Sound, but I know in Europe there has been a lot of concern, and fairly well documented effects of elevated nitrate in drinking water supplies from atmospheric sources.

Mr. **GRUCCI.** Not being a scientist, and I'm going to ask you this question only from my own ignorance of the subject matter, and hopefully, you know, your answer will enlighten me.

If we did absolutely nothing, what happens to mankind?

Chairman **BOEHLERT.** The gentleman's time had expired, but I want an answer to that question. Thank you very much.

Dr. **COWLING.** I'd come back to this statement here, "Where there is no vision, the people perish." Well, that may be a very strong statement. There will need to be adjustments.

If we do not understand the relationship between human activities, energy production being one, and having so many of us who are eager to enjoy all of the amenities of modern life, we are going to face increasing problems of contamination of our environment, but more than is essential for a good life.

I think there is a degree to which we, as a nation, must wrestle with these issues, in making the choices in an ordinary sense about how to run the air conditioner, or what kind of a vehicle to use for transportation of the family.

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These are, these choices, if not informed by reasonable understanding of how ecosystem and nature interact, I mean how humans and nature interact, will lead inevitably to a decreased quality of life. And we can, if we are wise, make good choices, that will enable us to enjoy a reasonable and increasing standard of living. But it will take negotiation among all of us, if we are to ensure that there is an appropriate distribution of the wealth within our society, and an appropriate increase in the quality of life experiences for as many of our people as we could manage.

Chairman **BOEHLERT.** Thank you very much. For Mr. Grucci's benefit, I would just mention once again this study, and I would say 20,000 premature deaths per year might be prevented, provided all power plants across the United States lowered their emissions by 75%, this is Studies from the Harvard Center for Risk Analysis.

Read the study, but the point is this, the Harvard Study for Risk Analysis, some people might automatically assume, Harvard, isn't that a liberal think tank? I would point out that the Center for Risk Analysis has a pretty good reputation for being conservative in its approach to some of these topics.

So this is the type of information that is important to have on the public record.

The gentleman's time has expired.

The Chair recognizes the distinguished lady from, the gentle lady from Maryland, Mrs. Morella.

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Ms. **MORELLA.** Thank you Mr. Chairman, and I have always valued your involvement with the acid rain problem from the time you began Congress. And I remember at that time, too, in my state legislature concern.

Chairman **BOEHLERT.** You were a little girl then.

Ms. **MORELLA.** That's kind of you to say.

Let me ask the panel. First of all, I apologize I was at a government reform program meeting, which was going on at the same time. That happens around here, as you probably know. But let me be predictual too, and ask you about the affects of acid rain on the Chesapeake Bay, what remediation is necessary at this point, what progress has been made, and whatever else you would like to offer that would be of assistance. Obviously, I'm from Maryland.

Dr. **DRISCOLL.** Well, as we just talked about, there have been a number of studies concerning nitrogen inputs to Chesapeake Bay, and the values from these studies range somewhat, depending on who has done them, but I think in general the work has shown that atmospheric deposition contributes a significant amount, about 75% to that problem.

I should point out that there is all, there are a lot of good researchers in Maryland, working on the problem, and there are people who are working on mercury problems there, and finding some very interesting things.

So a lot of the things we have been talking about in other regions are certainly very relevant to Maryland.

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Ms. **MORELLA.** Would anyone else like to add anything else?

Dr. **COWLING.** Yes, I—the air shed that, from which the emissions come that fall in the Chesapeake Bay are very much larger, is very much larger than the water shed from which the pollutants come. And I don't know what the comparatives, it's 3 or 4 times as large. And it's important to understand that it isn't just down, I mean water flows downhill, but air can go over hills pretty well. And so the air shed is much larger than the water shed. So large sections which are not within the drainage basin contribute to it.

Ms. **MORELLA.** Contribute.

Dr. **COWLING.** Right.

Ms. **MORELLA.** How about acid rain on biodiversity?

Dr. **BARON.** There haven't been very many studies that I am aware of, but I do know of these studies in Southern California that have been looking at species, especially in native coastal sage scrub, which is a highly diverse series of plants, mostly endemic to that particular region. And they are seeing a loss of diversity, not just plants that are being directly influenced, but it's soil micro-organisms that are decreasing when you add particularly nitrogen, and I am sure when you acidify them the same thing occurs.

You also, then, see the cascading effects on insect and other animal populations, as well. But there is a study, there are the beginnings of research that is suggesting that acid rain and nitrogen deposition both decrease soil, or decrease bio-diversity.

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There is another series of studies I should mention from the Great Plains. Studies in Minnesota over many years, with experimental plots, where they add nitrogen to many, many different plots and look at the responses, and what they see is a dominance of a few species at the expense of many.

Ms. **MORELLA.** What about recovery time, too. Is there, to recover from whatever damage the ecosystem might occur.

And you wanted to comment, also, Dr. Driscoll.

Dr. **DRISCOLL.** If I could talk for a second on bio-diversity, and then I'll try to address your question about recovery. Also on the aquatic side there has been a lot of good work demonstrating the linkage between species diversity and acidification.

I'm from New York, and an area that is impacted is the Adirondacks, and in that region, in a lake that has neutral pH you might find 6 or 7 different types of fish, but as the pH goes down the diversity of fish populations decreased to the point that about a quarter of the lakes are fish-less lakes, so clearly they have been impacted.

In terms of recovery I think that the reductions that we have seen so far are very important, but because of

the inputs that have gone on for many, many years, there have been some changes to soils, for example, bases have been leached from soil, and sulfur has accumulated in soil well beyond what we might normally expect.

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And so, as we start the process of recovery, that sulfur starts to, from reducing sulfur, that's the sulfur that's in the soil starts to bleed out. That delays recovery. And the bases that need to redevelop, to redevelop soil, that need to be broken down from soil minerals, to redevelop soils, take many, many years to build back up. So you are talking about a relatively long period of time to get full recovery.

Ms. **MORELLA.** Thank you, Mr. Chairman, my time has expired.

Chairman **BOEHLERT.** Thank you very much. Part of the problem, I think, as we deal with these issues, is we tend to segment things too much. So, we have the Clean Air Act that deals with acid deposition, and we don't think of its impact on the Clean Water Act. And the Commerce Committee has jurisdiction over clean air, and the Transportation and Infrastructure Committee has jurisdiction over clean water, and we have to sneak in the back door, the Science Committee, because we deal with the R&D budgets, so we're not going to sneak in the back door. We're going to walk proudly to the front door, and we're going to let everybody know that we're determined to address this issue in a very responsible way. Not only as it deals with the air, but as it deals with the water, as it deals with the health impacts on the American citizenry.

The last time I checked the American people expect us to protect the water we drink and the air we breathe and the food we eat, and that's a pretty heavy responsibility, and I think we're up to it. And Doctor, we are going to do our best to demonstrate to one and all that we do have vision.

I thank all of you as serving as resources for this Committee, and we will call you probably more frequently than you care to be called for counsel and for guidance, and I can anticipate that the response will be one of cooperation and eagerness to be supportive of our activities. Because, quite frankly, with a couple of notable exceptions, we have three PhD's on the Committee. But most of us our just pretty darned good generalists, and we rely heavily on the input of experts like you.

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Thank you very much. This hearing is adjourned.

[Whereupon, at 5:15 p.m., the Committee was adjourned.]

APPENDIX 1: Witness Biographies

BIOGRAPHY OF CHARLES T. DRISCOLL

Charles T. Driscoll, Ph.D., is the University Professor of Environmental Systems Engineering at Syracuse University. Dr. Driscoll has worked on the effects of acid rain and mercury in New York and New England since the mid 1970's. His research interests include the chemistry of soils and drainage waters, environmental modeling, and the long-term biogeochemical patterns in forest and aquatic ecosystems. Dr. Driscoll served as Chair of the Gordon Conference on Forested Catchments, was designated by the National Science Foundation at a Presidential Young Investigator and has been honored with the Syracuse University Chancellor's Citation of Academic Achievement. He holds a Ph.D. in Environmental Engineering from Cornell University.

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BIOGRAPHY OF ELLIS COWLING

Ellis Cowling is a forest biologist at North Carolina State University who became a world leader in air pollution research. Beginning in 1975, he led a group of 200 scientists in creating the National Atmospheric Deposition Program (NADP). This network measures the amounts of nutrients and injurious substances transferred in rain and snow from the atmosphere to forest and agricultural land and surface waters at 200 research sites throughout the U.S. In some parts of our country, these substances are having positive effects on the productivity of crops and forests. In other parts, some of these same substances are having negative effects on forests, fish, and surface and ground water quality. Cowling will discuss how scientists and engineers in NADP (and in the Southern Oxidants Study which he now leads) are increasing scientific and public understanding about environmental change and the sustainability of ecosystems. As Chair of the session on Regional Impacts, he will also lead our discussion of how society can adjust the procedures by which air and water quality are maintained. Cowling has two earned pH degrees—one from the University of Wisconsin and the other from the University of Uppsala in Sweden. He has served as major professor for 66 graduate and postdoctoral students at Yale and at NC State Universities. He has been a member of the National Academy of Sciences since 1973.

BIOGRAPHY OF JILL S. BARON

JILL S. BARON, U.S. Geological Survey, Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, Colorado

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Jill S. Baron is an ecosystem ecologist with the U.S. Geological Survey, and a Senior Research Ecologist with the Natural Resource Ecology Laboratory at Colorado State University. She is principal investigator of along-term ecological research and monitoring program that works toward understanding Rocky Mountain

biogeochemical cycles, and the influences of land use, climate change, and atmospheric deposition on ecosystem processes. Her recent interests lie in applying knowledge of biogeochemistry and long-term processes toward ecosystem management of mountain environments, freshwater ecosystems, and human-dominated basins such as the South Platte River of Colorado.

Baron has received a number of achievement awards for her work from the National Park Service, the U. S. Geological Survey, and the USDA Forest Service. She is a member of the Ecological Society of America Governing Board and serves on the Science Advisory Boards for the Grand Canyon Research and Monitoring Center and the U.S. Geological Survey Research Grade Evaluation Advisory Committee. Baron has served on review panels for the National Science Foundation, for a USDA evaluation of Colorado State University's Water Resources Programs, and as an invited expert to the Science Advisory Board for EPA's Acid Deposition Effects and Nitrogen Bounding Study.

Baron received her Ph.D. from Colorado State University in 1991, and has undergraduate and master's degrees from Cornell University and the University of Wisconsin. She has received funding from the National Science Foundation, National Oceanographic and Atmospheric Administration, the Environmental Protection Agency, the National Park Service, U.S. Forest Service, and the U.S. Geological Survey. Her ecosystem training has encouraged her to apply many tools toward understanding ecosystem processes, including long-term monitoring, experimental work with nutrient additions and isotopic tracers, paleolimnological reconstructions of past ecological and biogeochemical conditions, and modeling.

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BIOGRAPHY OF GERALD J. KEELER

Dr. Keeler has been on the faculty at the University of Michigan (UM) in Ann Arbor since 1990. He holds a joint appointment in the Department of Environmental Health Sciences in the School of Public Health and in the Department of Atmospheric, Oceanic, and Space Sciences in the College of Engineering. He serves as the Director of the UM Air Quality Laboratory, an interdisciplinary research group which is internationally recognized as a leader in atmospheric mercury research. Professor Keeler has co-authored more than 40 peer-reviewed publications and numerous technical reports dealing with mercury measurement technology, sources, chemistry, transport, and deposition over the past decade.

Dr. Keeler's background is in Atmospheric Science. and Environmental Health. He received a B.S. in Physics and B.A. in Mathematics from Boston College in 1982, and M.S. and Ph.D. in Atmospheric Sciences from the University of Michigan, College of Engineering in 1985 and 1987, respectively. In addition, he completed a Post-Doc at the Harvard School of Public Health and was a Visiting Scientist at the MIT Nuclear Reactor Laboratory from 1987–1990.

Dr. Keeler served as a Technical Reviewer of the EPA Mercury Report to Congress. Prof. Keeler and his team are currently working on mercury projects in Florida, New England, Michigan, Great Lakes Region, and the Arctic.

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