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01. Memo	From D. Allan Bromley to John Sununu Re: Robert White of NAE (1 pp.)	7/3/91	(b)(6)	

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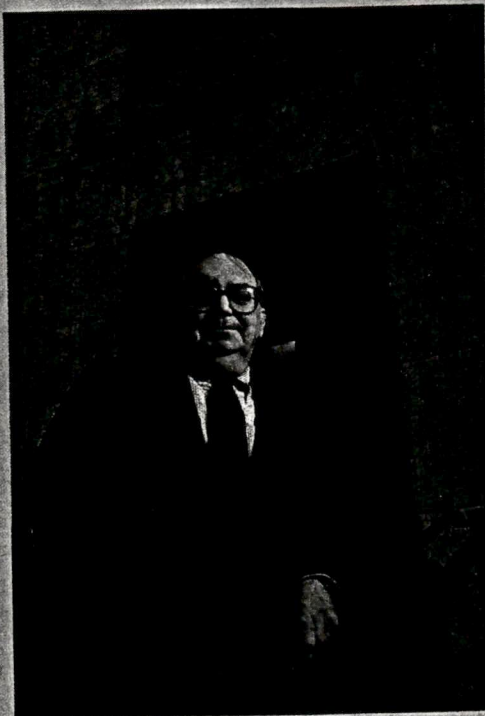
The Crisis in Science Funding

AN INTERVIEW WITH ROBERT M. WHITE

Is this the best of times, the worst of times, or what? An alien visitor trying to make sense of today's scientific funding situation would be excused some Dickensian confusion. President Bush's proposed 1992 budget would devote \$76 billion to civilian R&D—an increase of 13 percent (not accounting for inflation). National Science Foundation spending would rise 18 percent, to \$2.7 billion. The National Institutes of Health, which funds most of the country's biomedical research, would get a 7 percent increase in its basic science budget. Such growth is conspicuous in a budget that is otherwise mostly flat or shrinking.

But prominent voices from the scientific community are calling for more radical increases to deal with what they describe as a crisis. Nobel laureate physicist Leon Lederman, president of the American Association for the Advancement of Science (AAAS), has pronounced the U.S. scientific enterprise "sick," and has prescribed as a remedy the doubling of federal spending on R&D. Based on an informal survey of academic scientists, Lederman says a malaise has descended upon the research community. He paints a picture of financially struggling researchers who feel that the glory days of U.S. science are past.

Such demands have raised a firestorm of controversy. Congressman George Brown (D-Calif.), chair of the House Committee on Science, Space, and Technology, downplayed Lederman's report of malaise. "You could easily document the same level of despair among other groups," he told a recent



The President of the National Academy of Engineering says that more than money is needed to fix what ails the research enterprise.

meeting of the AAAS. Politicians, he warned, "no longer regard unlimited federal funding as a birthright for scientists."

Robert White, president of the National Academy of Engineering since 1983, remembers fondly the days when money was plentiful. In 1950, fresh out of MIT with a doctorate in meteorology, he worked at the Air Force Cambridge Research Lab. "I had my own laboratory at a young age," he recalls. "I had as much money as I could possibly want to spend. It's hard to believe that there were actually times like that."

White says that despite the outraged demands of many scientists today, support for R&D remains generous, and has risen faster than inflation over the past two decades. Overall U.S. spending on R&D, says White, "dwarfs the investments in science and en-

gineering research of our major trading partners." Still, he says, today's more constrained budgetary climate should lead the research community to rethink its approach to funding.

White served from 1963 to 1977 as chief of the U.S. Weather Bureau and then as the first administrator of the National Oceanic and Atmospheric Administration. Before his election to the NAE presidency, he headed a 50-university consortium that operates the National Center for Atmospheric Research.

Technology Review senior editor Herb Brody talked with White at his Washington office about the perceived crisis in science funding, and about the proper role of R&D in an industrial economy.

TR: How do you support your contention that research in this country is, overall, pretty well funded?

WHITE: In 1990, both the public and private sectors spent \$150 billion for the support of R&D across the board, not just on academic research. That's a 61 percent increase over the preceding decades in constant dollars. And even if you discount the very large fraction of the R&D expenditure by the federal government for defense, the amount is still larger than any of our industrial partners or competitors. The country has over 200 research universities, and 35 of them have research budgets exceeding \$100 million. Government laboratories have also grown remarkably. Additional resources of course would help. But I have seen no clear justification for requesting a doubling of the funds for R&D.

TR: If we have a burgeoning research community, and we spend more money than any of the countries we do business with, why do so many people feel so many scientists feel so threatened?

WHITE: The problem is simple: In academia, where the problem is acute, we appear to have too many scientists and engineers chasing too few research dollars. It is evident in statistics that indicate the low success rate that scientists and engineers have in getting their work funded. Almost all fields have suffered significant drops in the proposal success rate. At the National Institutes of Health, less than one in four approved applications actually receives support. The question is, are there too many scientists and engineers, or is there too little money?

TR: Well, which do you think?

WHITE: Some of both. It's quite clear we're going to have to live in a constrained federal budget environment. That means we're going to have to adjust the other side of the equation. And that side of the equation is

the production rate of scientists and engineers who follow careers in academic research.

TR: You have compared the production of academic researchers to the fable of the sorcerer's apprentice.

WHITE: Yes. In the Disney movie *Fantasia*, a sorcerer's apprentice sets in motion a multiplying army of brooms carrying buckets of water that become a flood. In a way, the same thing has happened here: the nation has loosed a flood of scientists and engineers who seek careers in academic research. Over the decade from 1977-1987, the number of doctoral scientists and engineers in academic research and development increased 65%, from approximately 94,000 to 155,000. This is a phenomenal increase.

TR: And this has gotten out of control?

WHITE: At any given time a faculty member may have about five doctoral students under his or her tutelage. Assuming that two complete their work each year, then even if only one-third of the graduates go into academic research, there is about a 15-fold replication over a teaching career of 20 years. Faculty members train many students in their own images. And many of these students aspire to remain in academia, doing research and teaching. Each seeks funding support and funding is unable to keep pace. That fundamentally constitutes the problem.

TR: What should these PhDs do instead?

WHITE: One would think that if we're producing scientists and engineers at the PhD level, we have a marvelous opportunity to upgrade the quality of our science and engineering staffs in industry and government laboratories. Government laboratories are having a very difficult time attracting top-level talent. And the economic effectiveness of many industries is large-

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ly dependent on their technological capabilities. So there are outlets for scientists and engineers other than to continue doing research in academia.

TR: Can't PhDs often get more money working for industry than for a university? What further incentives are needed to get them to leave academia?

WHITE: Industry does not actually pay much of a premium for PhDs. In fact, over a working lifetime in industry, a scientist or engineer with a doctorate doesn't make that much more than one with a master's degree. This suggests that the economic incentives are weak. Industry and government might take this opportunity to upgrade its entire technological work force.

TR: You faced that choice personally, didn't you—you got a meteorology PhD, and then left academia. What persuaded you to make the move?

WHITE: Well, my professor, Henry Houghton, sat me down—he was a wonderful human being, head of the Department of Meteorology at MIT—and we had a long talk. He said the department was not going to be hiring many people, but that there was a big world out there with great opportunities for people well-trained in meteorology. He advised me to make a move and set out on a different kind of career. I was a little upset by that, because I had my eyes set on staying in academia. But it was good counsel.

TR: So more professors ought to be nudging their students out of the ivory tower?

WHITE: Yes, but you have to have the receptors out there. There has to be some place where the young PhD can go and get a rewarding and exciting job.

TR: I can see why an excess of PhDs in academia would be bad news if you are one of them. But it would seem to be great for the nation—it becomes a buyer's market for research talent, and the taxpayer is the buyer.

WHITE: That's true—especially if scientists and engineers put their minds toward advancing the economic effectiveness of this nation. Many universities are quite prepared to do that. MIT is a good example, trying to combine its manufacturing program with its management school in its Leaders for Manufacturing program. And you see that happening at universities across the board. Many universities recognize some of the central problems in this country, and they are seeking to help. This great pool of trained people that we've been producing is a marvelous opportunity for us to begin to increase technological capabilities across the board, whether in government agencies or in industry.

TR: Since industry benefits from doing R&D, companies would seem to have an incentive already to hire more scientists and engineers. What further incentives are needed?

WHITE: I think industry has to recognize that they need to build up their R&D capabilities. Obviously, some industries invest substantially in R&D. But you can find many industrial sectors that have invested minimally—the construction industry, for example, and machine tools. As a result, U.S. industry loses market share. The U.S. machine tool business lost much of its market share because of a failure to conduct R&D and to exploit R&D that had been taking place at universities and elsewhere.

TR: You would think that these industries would have a market incentive to preserve themselves. Since that incentive seems not to have worked, what else should be done?

WHITE: There's no silver bullet. It is not solely a matter of R&D. We need economic policies that will encourage industry to make investments in R&D. And we need to improve the management of technology. The recent book by Daniel Roos and others at MIT—*The Machine That Changed the World*—documents beautifully some of these technology management issues. Also, government needs to play a larger role in the support of generic tech-

nologies important to our industry and the economic effectiveness of the country in the global marketplace.

TR: Do you think the government is starting to take on that role?

WHITE: Yes, I'm encouraged. I'm very pleased with what I see as a gradual change of view in the government—for example, the recent issuance by the White House Office of Science and Technology Policy of their first technology policy. I'm also pleased with some of the new directions in the proposed FY 1992 budget.

TR: Particularly —?

WHITE: I'm pleased that the high-performance computing initiative has received an increase of some \$150 million, or 30 percent, to help establish American preeminence in this field. Another good sign is the increase in the budget for the Advanced Technology Program in the National Institute of Standards and Technology, which provides grants for development of generic technologies. The NSF's investments in engineering and science and technology research centers have been additional steps in the right direction. We're beginning to see the emergence of efforts by the federal government to focus funding on areas of technology that are important to the long-range industrial health of this country.

TR: So it's an industrial policy?

WHITE: Hardly. We need to define our terms. Former Secretary of Defense Harold Brown, when asked how he would distinguish between an industrial policy and a technology policy, suggested using as an example the development of U.S. agriculture. In the early days, the government supported agricultural research and extension services—a technology policy. Government expenditures supported generic technologies that could be used by farmers to increase their productivity. Today, the federal government provides large subsidies for agriculture for a variety of reasons—to pro-

tect some growers against foreign competition, to ensure adequate income for farmers, and to achieve other national objectives. That's industrial policy.

TR: Focusing on specific areas of generic technology means either adding significantly to the overall budget, which you admit is unlikely, or taking money away from other areas.

WHITE: If we are to live with a constrained budget, some criteria for funding priorities need to be established. I'm suggesting that one important criterion has to be the contribution of R&D investments to the economic growth of this country. Accepting this criterion puts you in a position to rank investments, and would suggest focusing money on key technology areas.

TR: If you're going to focus on near-term economic effectiveness, that would seem to leave basic research out in the cold.

WHITE: I am not suggesting that economic effectiveness be the only criterion. We also need to ensure the education and training of talent, and we need to invest funds in the continuing search for new knowledge. Also, I am not drawing a distinction between basic and applied research. Let's take a generic technology field—say, optoelectronics. There are many basic optoelectronic phenomena that need to be better understood. So investments in basic science that can illuminate some of the fundamental processes would be enormously helpful. And historically, developments in practical technologies have often opened up whole areas of basic research. The invention of the steam engine helped the discovery of the laws of thermodynamics, not the other way around.

TR: Still, you would seem to have little use for fields of research with only weak connections to generally useful technology—astronomy, say.

WHITE: I don't say that at all. Every society has an obligation to make substantial investments in understanding the world

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about it—whether it's understanding the processes that govern the universe or fundamental human biology.

TR: But it seems inescapable that there will be winners and losers.

WHITE: There always are, even in today's allocation of resources. It is not a question of "either-or." Given the magnitude of the investment in R&D in this country, we should find it possible to focus more of our resources on areas that contribute more directly in the long run to our economic effectiveness.

TR: You've suggested creating a pool of funds by skimming 1 percent off the research budget of every federal research project.

WHITE: I was trying to illustrate what could be done by focusing even a modest amount of resources.

TR: One obvious area of enormous expenditure is defense. Sixty percent of the proposed R&D budget would be for defense. Is that too much?

WHITE: You have to realize that a lot of what the DOD classifies as "research" is not what most people would call research. A large fraction of it goes into procurement and prototyping. In fact, the Academies of Sciences and Engineering have told Congress that our public policy is being skewed because a large amount of R&D resources in the Defense Department is not what one would normally call research.

TR: Still, a large fraction of the country's R&D budget is funded by the military.

WHITE: True. Much Defense Department R&D is on "dual-use" technologies, which have civilian as well as military uses. If you look at this year's budget, there's DOD money for the high-performance computing initiative and for R&D in manufacturing, both of which are obviously dual-use. The Defense Department pumps \$1 billion a year into basic science. That's 50 percent

of the amount the NSF pumps in. A good chunk of this money goes to the universities. The Defense Department is now a big supporter of university research that is not tied to immediate defense needs.

TR: So the military is doing its share to keep research healthy?

WHITE: My view is that the Defense Department has a larger obligation than it is at present discharging to ensure the vitality of the academic research enterprise. It is one of the nation's biggest users of the output of R&D and of trained personnel, and so should be spending more money on academic basic research.

TR: You have expressed some concerns about the state of the competitive grants system for deciding where R&D money gets spent. Why?

WHITE: Our competitive grants system serves us very well. But there are some problems. For example, the peer-review system for giving out research grants is becoming overloaded.

TR: Why?

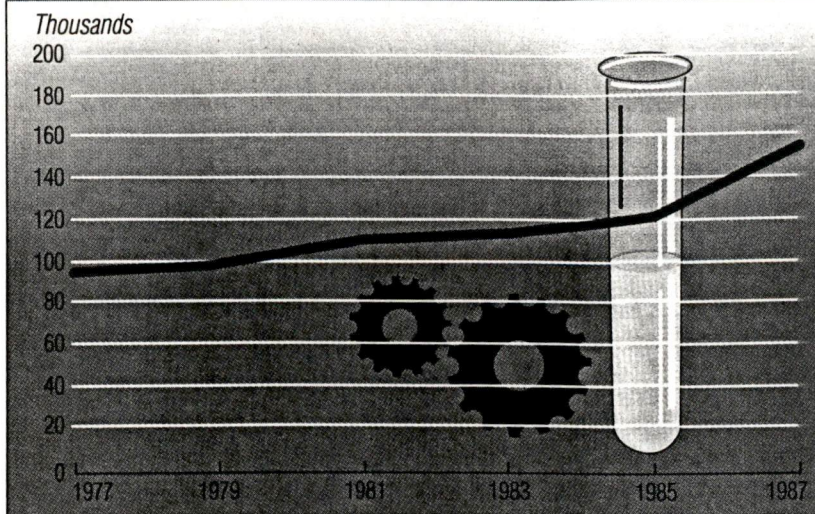
WHITE: There is an increasing number of proposals being submitted that need to be evaluated and peer reviewed. The probability of any individual proposal's success goes down. The logical thing for a grant seeker to do is to submit more than one proposal. That's what's happening, and a National Science Foundation report says the system is under stress.

TR: If the peer-review system is overloaded, is it still serving its function of making sure that funding goes to the most deserving people?

WHITE: Generally it is. One concern I have is that young investigators too often are unable to get funds for their work. The peer-review system disadvantages the young investigator who doesn't have a track record.

TR: How might we attack that problem?

PHD SCIENTISTS & ENGINEERS IN ACADEMIA



WHITE: The government should set aside federal money specifically for young investigators. Some of that is happening already; for example, the National Science Foundation gives out about 100 Presidential Young Investigator awards each year.

TR: But that's not enough?

WHITE: I'd like to see more. And that program requires matching funds. NSF provides some money, then the awardee has to obtain matching funds from industry or other private sources. Another remedy would be to provide institutional grants directly to universities, which could then allocate them to young researchers.

TR: Why would that help?

WHITE: The knowledge of who the promising young scientists and engineers are is much better at the local institutional level than at the federal level. Institutions could make sure that their bright young researchers get some initial resources—some seed money—which would give them the track record they need to compete for federal funding. On the other hand, some faculty members think institutional grants are not the way to go.

TR: What are they worried about?

WHITE: They're concerned that universities might divert the money to other research purposes—that the funds might go to inferior proposals unsuccessful in the federal grant process.

TR: What other suggestions do you have for revising the research funding system?

WHITE: The defense industry offers a useful model. Each year, defense contractors negotiate with the government a certain fraction of their overhead funds that can be used for independent research and development—IR&D. We don't do it for university contracts and grants. We ought to look into it.

TR: You have said that the R&D enterprise

is heading for a "shakeout," something like what industries go through. An industry shakeout usually means that weaker companies drop out of the market. What do you see happening in R&D?

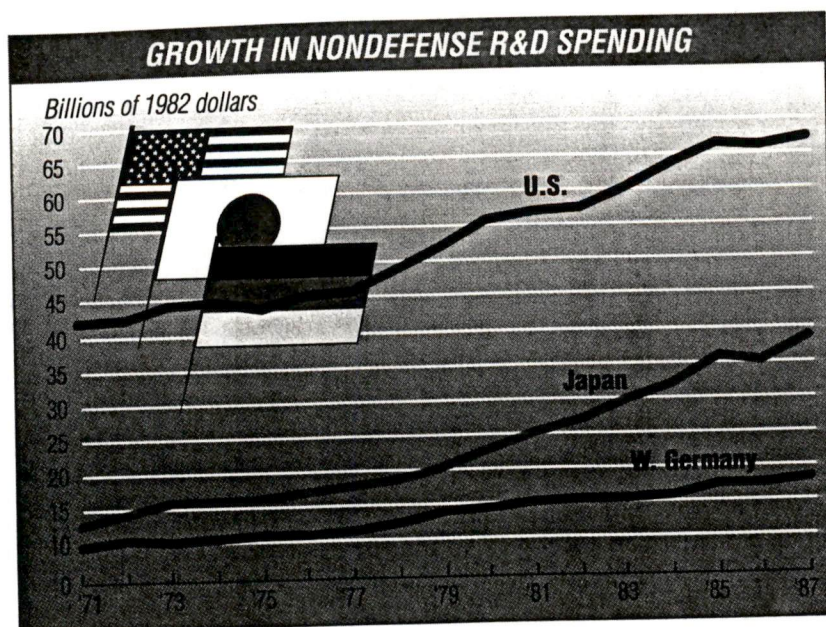
WHITE: If the federal competitive grant process is indeed merit based, and if funds are tight, then a shakeout is inevitable. Weaker proposals aren't going to get funded. And the universities will have to decide what they're going to do with those people in the academic community who aren't competitive in acquiring funding—universities don't have enough resources to carry them for long.

TR: Will only the best and richest universities be able to keep doing research?

WHITE: Certainly the best, but not necessarily the richest. We have a very large number of universities that maintain a broad spectrum of R&D programs. The quality of the R&D varies from field to field. It may well be that a university recognizes that one of its departments is not competitive and decides to focus its resources on areas of strength. When you have a shakeout in industry, you take a look at what your strong and weak lines of business are. You preserve the good—in fact you may build up and strengthen those areas with comparative advantages. I hope we will manage the shakeout wisely so that what we preserve are the strong elements of our R&D enterprise, wherever they may exist.

TR: How will this shakeout come about?

The growing number of academic researchers is straining the federal funding system. A shift into industry, says White, would both relieve stress on the federal R&D budget and help focus research on economically important areas.



Despite complaints from the scientific community, federal support for R&D has been growing steadily and far exceeds that of our economic competitors.

WHITE: It's going to be up to individual universities, deans, department heads and boards of trustees. I've been at universities where they have closed down departments and opened new departments—all as a function of estimates of what was important, what they could do well, and what they couldn't do well.

TR: One of the options a university has is to turn directly to industry to get funding.

WHITE: Yes, that's happening more and more.

TR: Isn't there a threat to academic independence if universities become key elements in economic development?

WHITE: As far as I can see, and from what our studies at the academies indicate, there have been few distortions of the R&D enterprise in universities as a result of industry support. I think industry has approached support of university R&D in a statesmanlike and open way. Universities have been jealous of their independence and academic freedom and are careful not to allow the availability of funds to torque their R&D programs. But the danger exists. If there is a serious shakeout, there will be a temptation to torque research programs to acquire funds. Then you have a problem.

TR: And what do you do about it?

WHITE: That's a matter that each university administration must cope with in its own way. Some universities see themselves as important elements in economic development, others are much more concerned that they remain independent places for education and training of students, and for the conduct of basic research.

TR: An international issue also arises: If the university is an element of a program to make the country more economically competitive, then it hardly makes sense to share its research with, say, the Japanese. Doesn't that subvert the principle of open communication among researchers?

WHITE: I understand that there are concerns in some parts of Congress about access of industrial competitors, like Japanese corporations, to R&D that has been supported largely by taxpayer money. That issue has especially been joined at MIT. My view is that as long as the principles of academic freedom are observed, and as long as the research program is not torqued, and as long as there is no favored access for foreign corporations, the country benefits from support of our universities by foreign corporations. It's more important for the country to have an intellectually vibrant university system than it is to try to build walls around the university. That doesn't make any sense for a university. The information it produces is available to anyone through the world pool of knowledge.

TR: Many research scientists and engineers believe that too much money is going into "megaprojects" like the superconducting supercollider (SSC) and the Human Genome Project. Do you think the balance ought to shift back in favor of individual researchers?

WHITE: I think the big-science, little-science issue has been blown out of proportion. Many of the big-science activities have been proposed by individual scientists because they needed to do frontier research. The SSC, the astronomical observatories,

and the planetary space probes are good examples. Where did the proposals for these big-science activities originate? They came from individual scientists who said, we want to work at the cutting edge of science, and we need the following facilities to do that research. Who do you think uses the telescopes? It's the individual investigators. I happen to be very familiar with the National Center for Atmospheric Research in Boulder, Colorado. That's a big center. It serves hundreds of individual university scientists who couldn't do their work otherwise, whether it's the use of an aircraft, or a very large scale computer, or a field observing system.

TR: But it is, as you've said, a zero-sum game: if you're putting money one place, it follows that you're not putting it somewhere else.

WHITE: Not in the past. The budget for individual investigators has been going up and the budget for big-science projects has been going up, too. Scientists and engineers out there would probably like to see a higher rate of growth for individual scientists than they have.

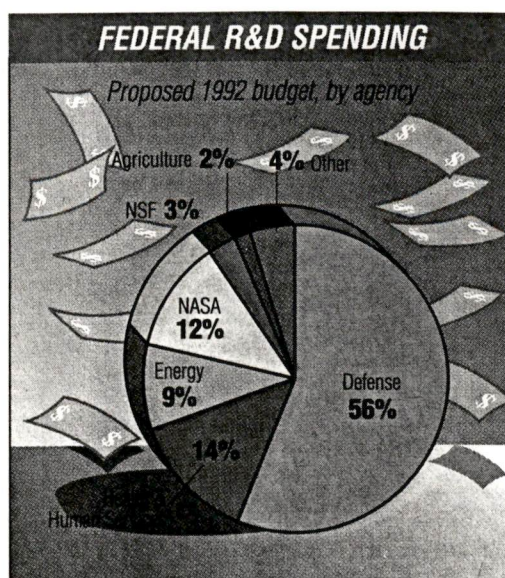
TR: Do you think the growth of "pork-barrel science" is changing the image of science in this country?

WHITE: I worry about that. With the growth of lobbying groups, and with one discipline taking on another discipline, the scientific community is in danger of looking like just another special pleader for funding.

TR: Isn't that what it is?

WHITE: But science and engineering are held in special regard because of the recognition that investments in research and development have paid off handsomely for the nation in improved health care, higher standards of living, jobs, and economic growth generally.

TR: You think research is losing that special stature?



The nation would spend \$76 billion for R&D in fiscal 1992 under the administration's proposed budget, an increase of 13% over 1991. Defense research

would continue to dominate the funding picture, but NASA, NSF, and the National Institutes of Health would see big gains.

WHITE: Yes, there is that danger. We have an obligation to justify our requests for funds more specifically. It is not sufficient to claim entitlement to as much money as is necessary to support every good scientist in the country because we contribute so much to the understanding of the world and to long-term economic development.

TR: When you say justification, you mean economic payback?

WHITE: Yes, in the long run, investments in research and development have to have an economic, social, or defense payback. Science and engineering research, like any other activity in this country, has a social purpose, and it must justify expenditures in ways that can be understood and lead to the social and economic betterment of the country. In using the term "social payback," I also mean that all societies have an obligation to make an investment in the search for understanding of the natural processes of our universe—the search for knowledge for knowledge's sake. ■

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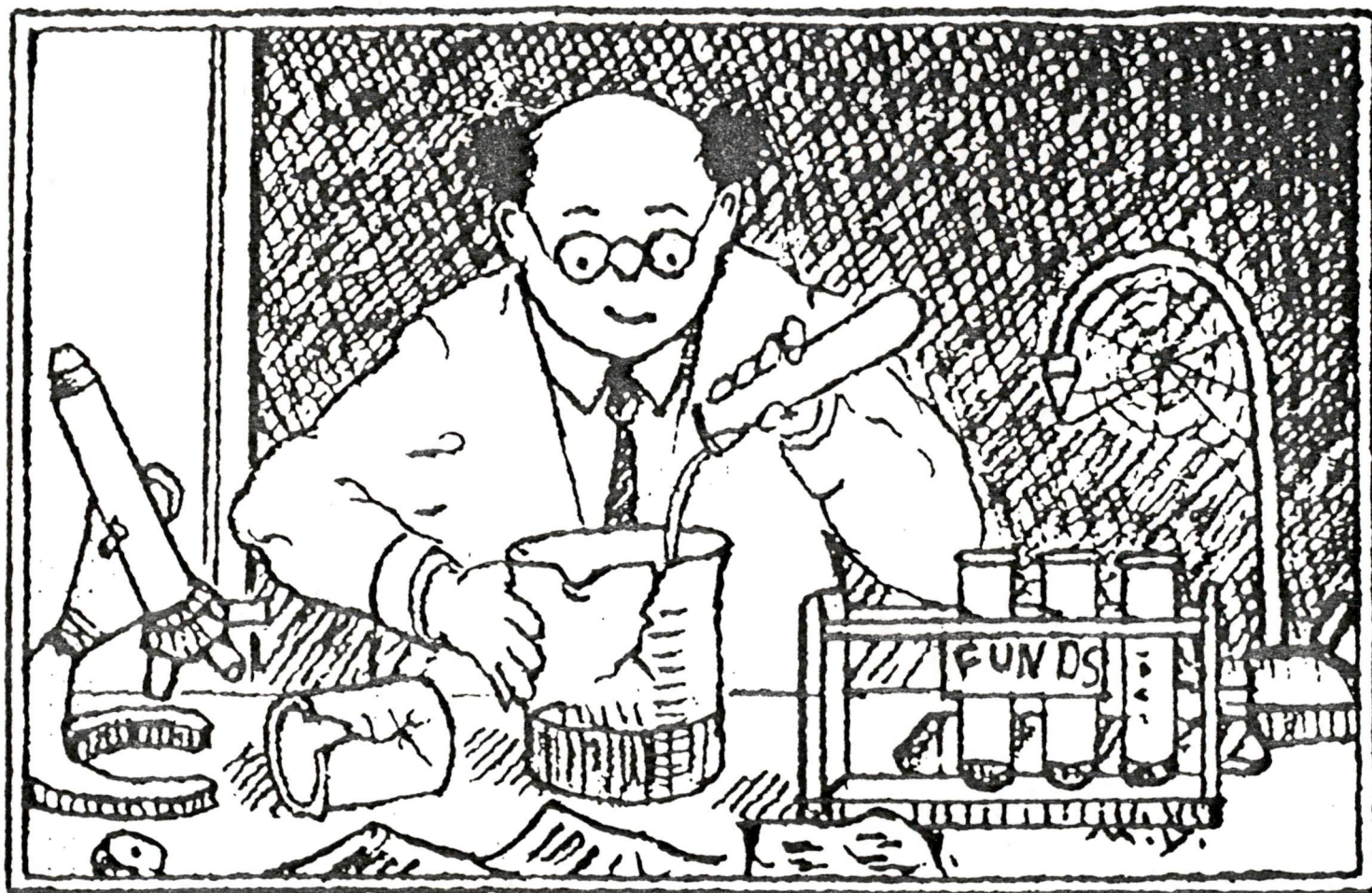


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THE NATION

Science shouldn't get low priority, even in this era of deficits

Its practitioners are more than just another special-interest group

By Frank Press

In laboratories at Boston University, in faculty meetings at Tufts and wherever scientists gather from Harvard Square to Hawaii, there is growing apprehension about the future of American science. Physicists have difficulty obtaining support to conduct experiments on emerging fields such as superconductivity or new energy sources. Postdoctoral students seeking cures for diseases have less than a 1-in-4 chance of winning a grant from the National Institutes of Health. Researchers studying global warming wonder how to keep their own labs warm.

Leon Lederman, a Nobel laureate in physics and current president of the American Association for the Advancement of Science, recently wrote of "a depth of despair and discouragement that I have not experienced in my 40 years of science." He quoted many scientists, including one at MIT who said, "The history of the past decade is one of continued harassment over money, lost opportunities due to inadequate support, and a stifling of imagination due to money worries. If US scientists must continue to stand by and watch as our best ideas are carried forward by groups from abroad, our nation cannot hope to escape a rapid decline."

Yet do the facts justify such distress?

President Bush has submitted a budget with stronger support for science than any in recent memory. He proposed that federal spending on civilian research and development increase by 13 percent to \$76 billion. Basic science research spending is slated to rise 8 percent, to \$13 billion. The House Budget Committee recently approved a 17 percent increase for the National Science Foundation.

The matter of priorities

Coming at a time of unprecedented deficits, these and other initiatives show that political support for science is strong. Even ex-

cluding research and development targeted at defense needs, American science is well funded when compared with other industrial countries.

Is the scientific community being ungrateful in asking for more while states such as Massachusetts face severe budget deficits and a host of social problems? Have we reached the limits of scientific growth?

I believe, emphatically, that we have not. The scientific community does not present a problem of too many mouths to feed for science-funding agencies. Rather, it is an enormous national resource, one that is the envy of other nations. Strengthening science, even at a time of tight budgets, is not merely defensible but essential. As one looks beyond the immediate problems of the Persian Gulf or the recession in New England, the United States will depend more than ever on the contribution of its scientists, engineers and other technical experts.

Last month, the White House released a list of 22 areas of technological development that it deemed "critical to the national prosperity." All of the fields - materials processing, optoelectronics, biotechnology and the like - are based on science. Expecting the nation to compete in them without a strong scientific enterprise is like asking the Red Sox to play without Roger Clemens; it's possible, but it's no way to win a pennant.

The economic indispensability of science is outpaced only by its vitality. Before I came to Washington, I taught geophysics at several universities, including MIT. I never imagined then the extraordinary advances that would occur across so many disciplines.

Everyone, whether a software designer in a Route 128 firm, a soldier who used high-tech weapons in the Persian Gulf or a teenager enjoying a new CD player, has been affected by these changes.

What the scientific community can do

Given this extraordinary record and set of opportunities, the cries from our laboratories should be painful to anyone who cares about not only science but the future of the country. Continued negativism could transform young scientists into a dispirited generation. To paraphrase Harvard Business School, we risk talking our way into scientific decline.

This need not occur. It is possible to reinvigorate the scientific community without spending vast new sums. But changes are needed in how science is funded and organized - and scientists themselves need to do a better job of explaining to the public why they are not just another interest group looking for a federal handout.

For all its troubles, the US scientific community remains the world's leader in most disciplines. Statistics from the Institute for Scientific Information suggest that the quality of US science, as measured by citations per paper, actually is increasing relative to other nations. Foreign researchers seek to join our facilities and companies. Americans win more than their share of Nobel Prizes and other honors.

Why, then, are so many scientists finding it difficult to obtain support? One reason simply is that there are more of them competing for resources. The number of academic scientists and engineers has doubled over the last 20 years. But then, so has the nation's real economic growth. We need so many researchers to attack the growing complexity of science. In fact, we need more. Modern science is nourished not just by the scientific cream in places like Boston and Cambridge but by the larger body of scientists who perform experiments and gather data for all to use. With increasing frequency, these scientists on the next tier are the first to observe, measure and make the breakthrough.

So cutting back on the number of researchers is not the answer. And neither is there much hope of reducing the cost of research. New electron microscopes and other equipment are expensive. Many laboratories and research facilities already are in urgent need of modernization, and graduate students must be paid adequately.

What does make sense is to set priorities more clearly, both within and across disciplines. The federal government supports research through a variety of agencies and programs. This approach has worked well over the years, providing scientists with diverse sources of support for unconventional ideas. Yet it also has made it difficult for policy makers to set overall priorities, especially when more than one agency is involved. Decisions about, say, AIDS research and space travel are made separately. Policy makers and scientists need better systems for looking at the entire picture and deciding where national needs and scientific opportunities are greatest. Our academy and others have suggested ways of accomplishing this.

Choices must be addressed

A more rational approach is especially important to assure that new megaprojects do not overwhelm less-visible research by smaller teams and individual scientists. Initiatives such as building a superconducting supercollider or mapping the human genome have the potential to produce findings of historic significance. And from a political perspective, they also may be funded with "new money" that otherwise might not be available to scientists. But tradeoffs do exist between large and small projects, as well as between beginners and more-established scientists, people and facilities, and among different research sites. These choices should

be addressed more squarely.

A recent report by the country's astronomers shows that scientists are willing and able to help make these choices. Under the leadership of John Bahcall of the Institute for Advanced Study at Princeton, the astronomers developed a detailed list of priorities based on scientific importance, timeliness and cost-effectiveness. They identified which telescopes and other new research tools were most important and emphasized the need to sustain existing labs and observatories.

Applying this approach to a larger community - to all of physics, for example - will be more contentious. But addressing priorities is an obligation scientists must assume. We may even wish occasionally to recommend priorities across a number of disciplines, especially when dealing with such matters as training, facilities, equipment and levels of research grants. Some scientists worry that participating in this process will pave the way for politicians to constrain overall levels. As one colleague put it to me, "None of us is smart enough to play God." But we scientists do know more than anyone else about what is happening in our community, and we owe it to the taxpayers to help allocate resources effectively.

Unfortunately, even the most rational allocation will be inadequate at current funding levels. What's needed is a doubling of the science budgets not only of the National Science Foundation, as has been proposed by the administration, but of all the agencies and departments of the federal government that depend on science. The constraints of the federal budget agreement make this difficult to achieve quickly, but it can and should be done no later than the end of the decade. The cost next year would be about \$2 billion more in the science budget - not much in the budgetary scheme of things.

Clearer priorities and a modest budget increase would go a long way toward easing the current anxiety within science. There is no reason for us to be self-absorbed or defeatist at a time of extraordinary opportunity. Recent incidents involving alleged scientific misconduct or misuse of research funds clearly require a responsible and decisive response from the scientific community. Yet we should not talk our way into scientific decline or let others do so without our objection.

The nation shares our vision that science can improve the human condition. It accepts that an investment in research pays off in greater wealth and provides new resources to address social problems. It understands the serendipitous nature of our work. Eighty percent of Americans believe they will benefit from developments in science and technology, according to a 1987 survey.

The case on behalf of science is a powerful one, and it is one the American public will accept with enthusiasm. So, whether along the Charles River or elsewhere around the country, the scientific community need not despair about its future. With a more rational system for setting priorities, a modest increase in funding and continued public support, we can continue to unlock secrets of nature and lay the groundwork for new medicines, technologies and industries. Science has not reached the limits of growth; fortunately for all Americans, it's just hitting its stride.

Frank Press is president of the National Academy of Sciences.

THE WHITE HOUSE

April 5, 91

Dear John:

Within the law, it would appear that the proposed declassification of the Snake River Sockeye has resulted from a process that has touched all the requisite bases and had the benefit(?) of a whole cadre of experts. I do not believe that the process

Dear John:

THE CHIEF OF STAFF
has seen

Within the law, it would appear that the proposed declassification of the Snake River Sockeye has resulted from a process that has touched all the requisite bases and had the benefit to a whole cadre of experts. I do not believe that the process is open to attack.

But this episode would seem to raise significant questions regarding the underlying regulations, rules, and definitions on which the process is based. Although I am certainly no ichthyologist it seems to me that the definition of "endangered species" are far too broad.

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

April 3, 1991

MEMORANDUM FOR D. ALLAN BROMLEY

FROM: NANCY G. MAYNARD 
SUBJECT: Sockeye Salmon - Science Background

I am forwarding herewith a very useful package of materials I just received on the scientific justification for listing the Snake River Sockeye Salmon as an endangered species.

As we discussed this morning, the key points to the issue are: (1) if the population is reproductively isolated (genetically distinct) from the rest of the population and (2) if the species represents an important component in the evolutionary legacy of the biological species. The Snake River Sockeye Salmon qualifies on both counts. I have attached, for your information and reference, a copy of the "Status Review for Snake River Sockeye Salmon" by Waples and Johnson. (Tab A) This paper presents the scientific basis for listing the species as endangered and includes references.

In addition, I am including some material on the very extensive process by which this listing takes place. Of most relevance to the quality of the scientific part of the review is a listing of the individuals involved in the review process. There are 4 groups involved in the review (individuals listed in Tab B):

- * 1. Biological Review Team (BRT) - Comprised of NMFS personnel with technical expertise. Reviews available scientific information, reports on the status of species under review, and provides recommendations to the ICC.
- 2. Technical Committee (TC) - Comprised of technical experts representing outside interests from throughout the Pacific Northwest. Reviews and comments on available data.
- * 3. Peer Review Group (PRG) - Comprised of experts from academic and research institutions to review information and NMFS technical determination. (Bios listed in Tab B)
- 4. Internal Coordinating Committee (ICC) - Comprised of NMFS NW Region to ensure that all policy and legal concerns are addressed.

An interesting aspect of this species is that evidently the Snake River Sockeye Salmon is a particularly important group of the Sockeye because, of all Sockeye populations, they swim not only the longest distances, but also reach the highest altitude (above sea level) to spawn. This could imply that they might be evolutionarily the most "fit" group of the species. Under the survival of the fittest assumption, you could conclude that human intervention has unwittingly interfered with an evolutionary trend toward the strongest of that particular species.

STATUS REVIEW FOR SNAKE RIVER SOCKEYE SALMON

by

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SUMMARY

To be considered for protection under the U.S. Endangered Species Act (ESA), a group of organisms must qualify as a "species" as defined by the ESA. The NMFS Species Definition Paper (Waples 1991) provides a framework for evaluating the petition for Snake River sockeye salmon (*Oncorhynchus nerka*) in this context. However, a lack of key information precludes a definitive determination at critical points of the decision process. This is particularly true for the first key question that must be addressed, Are Snake River sockeye salmon and kokanee distinct gene pools? This question is inherently tied to the question, Are post-Sunbeam Dam sockeye salmon in Redfish Lake direct descendants of the original (pre-1900) sockeye salmon gene pool, or have they recently been produced by the kokanee gene pool? The Biological Review Team unanimously agreed that there is insufficient information at present to determine with any reasonable degree of certainty the origin of the current sockeye salmon gene pool. After some discussion, the team reached a strong consensus that, in this instance, our obligation as stewards of the resource requires us to proceed under the assumption that recent sockeye salmon in Redfish Lake are descended from the original sockeye salmon gene pool. Therefore, as stipulated in the Species Definition Paper, the anadromous (sockeye salmon) component of *O. nerka* was considered separately from the nonanadromous (kokanee) component in determining whether an ESA listing is warranted.

Available information indicates that Snake River sockeye salmon meet both of the criteria necessary to be considered a "species" under the ESA: They are reproductively isolated from other sockeye salmon populations, and they represent an important component in the evolutionary legacy of the biological species. Given the extremely low numbers in the remaining population, the threshold question is not really an issue. Therefore, the decision to treat Redfish Lake sockeye salmon as

distinct from kokanee leads to a recommendation by the NMFS Biological Review Team to list the "species" as endangered. Although no adult sockeye salmon were observed in Redfish Lake in 1990, a declaration of extinction would be premature because other year classes may return through at least 1993. Research opportunities for 1991 may provide information pertinent to this petition. If further research indicates that Redfish Lake sockeye salmon and kokanee are not reproductively isolated (and therefore should be considered as a unit for ESA purposes), additional information will need to be developed to determine whether the combined unit is a "species" and, if so, whether it is threatened or endangered.

ACKNOWLEDGMENTS

The status review for Snake River sockeye salmon was conducted by the NMFS Northwest Region Biological Review Team (BRT). The extensive public record developed pursuant to this petition and discussions of that record by the ESA Technical Committee formed the basis for the review. Members of the BRT for sockeye salmon were: David Damkaer, Thomas Flagg, Elizabeth Garr, Orlay Johnson, Robert Jones, Conrad Mahnken, Gene Matthews, Gerald Monan, Michael Schiewe, Merritt Tuttle, Robin Waples, John Williams, and Gary Winans.

INTRODUCTION

Sockeye salmon (*Oncorhynchus nerka*) are native to the Snake River and historically were abundant in several lake systems in Idaho and Oregon. In this century, a variety of factors (including overfishing, irrigation diversions, obstacles to migrating fish, and eradication through poisoning) have led to the demise of all Snake River sockeye salmon except those returning to Redfish Lake in the Stanley Basin of Idaho. Following recent declines in that population as well, the Shoshone-Bannock tribe of Idaho petitioned the National Marine Fisheries Service (NMFS) to list Snake River sockeye salmon as an endangered "species" under the U.S. Endangered Species Act (ESA). To determine whether such an action was warranted, NMFS formed a Biological Review Team to review the status of Snake River sockeye salmon. This document reports the results of that status review and summarizes recommendations of the Biological Review Team regarding the ESA petition.

THE QUESTION OF EXTINCTION

It has been suggested that a full status review of Snake River sockeye salmon is not appropriate because the population is functionally extinct. The fact that no adult sockeye salmon were observed in Redfish Lake in 1990 lends support to this view. However, there is no provision in the ESA for declaring a "species" extinct until the last individual perishes. Redds (nests) of adult sockeye salmon were observed in Redfish Lake in 1988 and 1989 (Hall-Griswold 1990). Assuming a predominantly 4-year life cycle [typical for Redfish Lake sockeye salmon in the past (Bjornn et al. 1968)], adult returns may occur through at least 1993. Thus, although adult returns for the past 3 years have been minimal, we cannot make a determination that anadromous *O. nerka* are extinct in the Snake River. However,

if no adults return through fall 1994 (allowing for the possibility of some 5-year-old spawners), then such a determination would probably be warranted.

THE QUESTION OF "SPECIES" UNDER THE ESA

Two key questions must be addressed in determining whether a listing under the Endangered Species Act is appropriate:

- 1) Is the entity in question a "species" as defined by the ESA?
- 2) If answer to 1) is yes, is the "species" threatened or endangered?

The ESA of 1973, as amended in 1978, allows listing of "distinct population segments" of vertebrates as well as named species and subspecies. The Species Definition Paper for Pacific salmon (Waples 1991) stipulates that a salmon population will be considered "distinct" for purposes of the ESA if it represents an evolutionarily significant unit (ESU) of the biological species. A population (or group of populations) can be considered an ESU if it a) is reproductively isolated from other conspecific populations and b) represents an important component in the evolutionary legacy of the biological species.

Anadromy/Nonanadromy

For the sockeye salmon petition, the question of population distinctness is complicated by the presence in Redfish Lake of two forms of *O. nerka* (sockeye salmon and kokanee). The Species Definition Paper states that if both anadromous and nonanadromous forms occur together, it first must be determined whether the two forms share a common gene pool. If so, they should be considered as a unit in ESA evaluations; if the two forms are reproductively isolated, they should be considered separately. Application of the framework in the paper suggests the decision tree for the sockeye salmon petition shown in Figure 1.

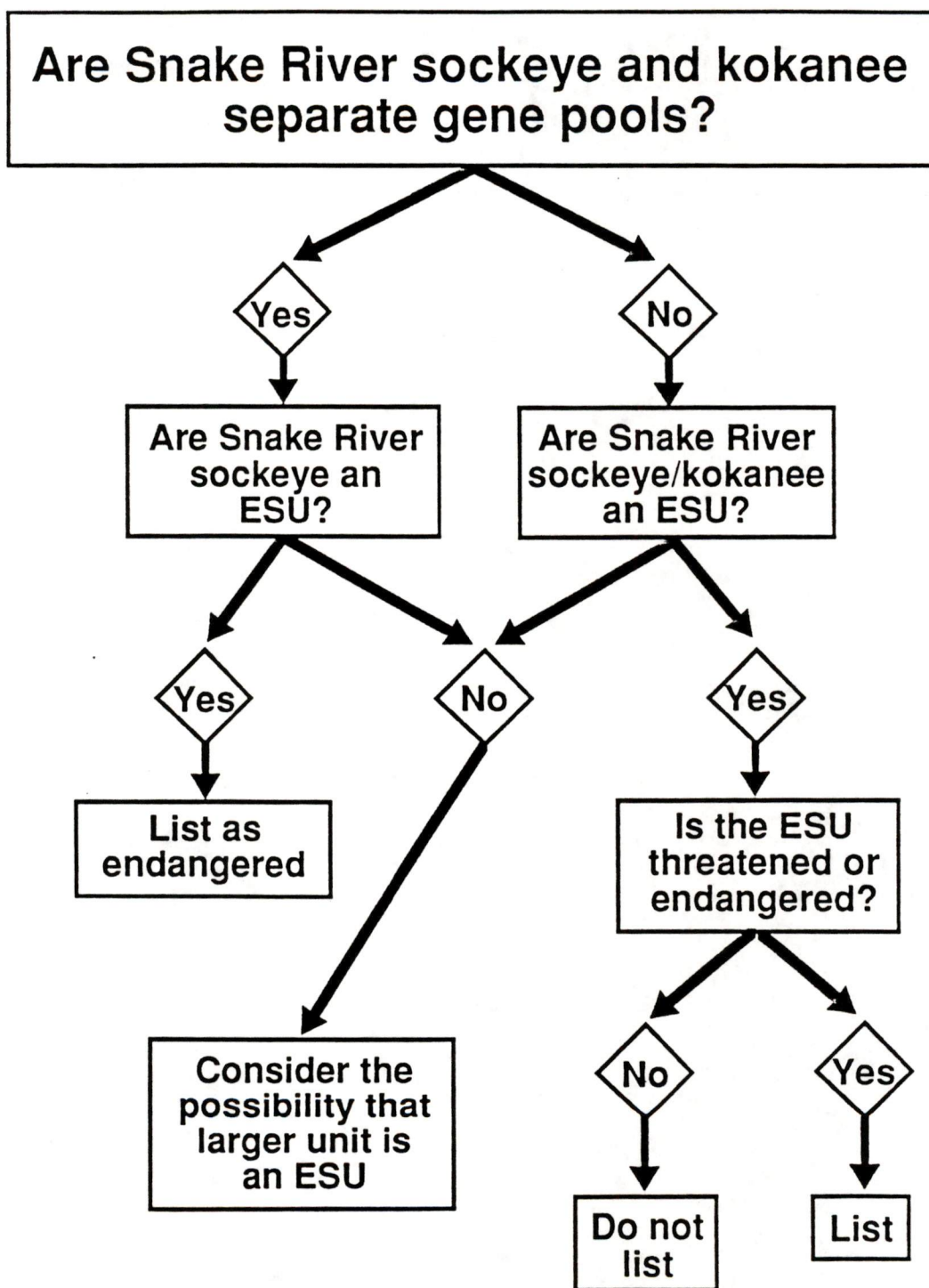


Figure 1.-- Decision tree that results from applying the framework of the Species Definition Paper (Waples 1991) to the petition for Snake River sockeye salmon.

The following information is relevant to the first key question that must be addressed in the decision tree: Are Redfish Lake sockeye salmon reproductively isolated from Redfish Lake kokanee?

A. Both sockeye salmon and kokanee are native to lakes in the Stanley Basin, including Redfish Lake. Historical records (Evermann 1896) indicate that in Alturas Lake, both forms spawned in the inlet stream, with kokanee generally spawning farther upstream and sockeye salmon spawning nearer to the lake. Evermann also recorded observations of sockeye salmon spawning in August in Redfish Lake. Recent observations at Redfish Lake indicate that kokanee continue to spawn in the inlet (Fishhook Creek) in August/September, but sockeye salmon spawn later (generally October) and only along the shores of the lake (Bowler 1990).

B. Recent studies (Foote et al. 1989b) show that sockeye salmon and kokanee that spawn sympatrically can be very different genetically. Substantial genetic differences were found in spite of occasional spawning between the two forms and viability of hybrids through early life-history stages in culture (Foote et al. 1989a; Wood and Foote 1990). Foote et al. (1989b) found significant allele frequency differences between sockeye salmon and kokanee in each of the lake systems they studied that had both forms. In their study, Foote et al. (1989b) also found that the magnitude of genetic divergence between the two forms increased with distance upriver from the ocean. An electrophoretic survey conducted for this status review by NMFS also found substantial genetic differences between sockeye salmon and kokanee in the Okanogan and Shuswap river/lake systems (Monan 1991).

C. Studies of other salmonid species have shown genetic differentiation between anadromous and nonanadromous forms that occur in the same river/lake systems (Skaala and Naevdal 1989; Vuorinen and Berg 1989).

The Biological Review Team concluded it is likely (but has not been conclusively established) that prior to 1900, sockeye salmon in Redfish Lake were reproductively isolated from kokanee.

Influence of Sunbeam Dam

The present day relationship between sockeye salmon and kokanee in Redfish Lake is uncertain. No sockeye salmon were available for genetic or other analyses to compare with the kokanee that were sampled in the fall of 1990. Recent sockeye salmon in Redfish Lake may be descended directly from the pre-1900 sockeye salmon gene pool. Alternatively, Sunbeam Dam may have caused extinction of the original gene pool, and recent sockeye salmon in the Stanley Basin may be due to strays or transplants, or they may represent an anadromous form recently derived from the kokanee gene pool. The following are facts regarding Sunbeam Dam:

A. The dam was built in 1910 on the main Salmon River, about 20 miles downstream from Redfish Lake. The dam was too high for salmon to surmount by leaping.

B. A wooden fish ladder was constructed in 1912, but contemporary reports suggested that the ladder functioned poorly, if at all, for fish passage (Chapman et al. 1990).

C. A concrete fish ladder was completed in 1920. After initial structural problems were rectified, sockeye salmon and other salmonids were observed passing above the dam in that year (Pearson 1921). Apparently, concerns

about fish passage persisted in subsequent years (Chapman et al. 1990), but, apart from the eyewitness accounts discussed below, there is no firm evidence regarding the effectiveness of the second ladder in the period 1921-34.

D. A diversion tunnel existed for at least part of the period 1910-34 and may have permitted passage of some species in some years.

E. The dam was partially blown out by dynamite in 1934, allowing passage of fish. Passage was further improved by removal of additional parts of the dam in subsequent years.

F. Eyewitnesses recently interviewed recall seeing sockeye salmon spawning in Redfish Lake in 1927, 1928, 1929, 1930, 1933, 1934, 1935, and 1938 (Jones 1991). Parkhurst (1950) reported adult sockeye salmon in the lake in 1942, and runs were abundant in some years in the 1950s (Bjornn et al. 1968). No information about sockeye salmon abundance in Redfish Lake is available for the period 1943-53.

Post-Sunbeam Dam sockeye salmon

A number of hypotheses have been suggested to explain post-Sunbeam Dam sockeye salmon in Redfish Lake. It was apparent from discussions in meetings of the ESA Technical Committee that there is a diversity of opinion on this subject in the scientific community. Arguments for and against each of the hypotheses can be summarized as follows:

- 1) Enough sockeye salmon were able to pass above Sunbeam Dam to sustain the run, either over the inadequate ladder or through the diversion tunnel.

Supporting arguments:

- a) Passage of sockeye salmon in 1920 indicates that adults were present at the base of the dam 10 years after its construction, including the period during which fish passage was deemed least likely. The improved ladder completed in 1920 should have allowed easier passage in subsequent years.
- b) Several eyewitnesses recall seeing adult sockeye salmon moving through the ladder and spawning in Redfish Lake between 1927 and 1933, and others recall that sockeye salmon were speared in nearby Decker Creek in 1927 and 1928 (Jones 1991).

Counter arguments:

- a) The concrete ladder was not built until 1920; prior to that time, the only possibility for passage was through a diversion tunnel of uncertain utility. The wooden fish ladder installed shortly after completion of the dam was destroyed by the first high water. Fish passage through the diversion was considered difficult or impossible (Chapman et al. 1990).
- b) Eyewitness accounts related 60+ years after an event may be unreliable. Perceptions of "big" and "little" (e.g., in differentiating sockeye salmon from kokanee) may be distorted by the passage of time, particularly if the eyewitness was a child at the time of the observation.
- c) Even if a few sockeye salmon passed the dam between 1910 and 1934, it was not enough to maintain the run.

2) Sockeye salmon continued to spawn in the river or in refuge lakes below Sunbeam Dam during the years the river was obstructed, and descendants of these fish recolonized the lake after removal of the dam.

Supporting arguments:

- a) Riverine spawning sockeye salmon are present in many areas throughout the range of the species (Foerster 1968).
- b) There are lakes downstream from Sunbeam Dam (e.g., Sullivan Lake) which might have served as temporary refugia.
- c) Irrigation for cattle and farming changed the hydrology of central Idaho. It is possible that prior to this period, there were other lakes or deep pools available for marginal sockeye salmon spawning.

Counter arguments:

- a) Rearing habitat for sockeye salmon is not ideal (perhaps not even suitable) anywhere immediately below Sunbeam Dam.
- b) If refugia were used, why aren't sockeye salmon currently observed in these areas?

3) Redfish Lake was reseeded after partial demolition of Sunbeam Dam by sockeye salmon straying from elsewhere.

Supporting argument:

Straying has been documented in sockeye salmon, as in other species in the genus.

Counter argument:

It is necessary to postulate a substantial number of strays that fail to home accurately by an enormous distance (over 700 river miles from Lake Wenatchee to Redfish Lake). No evidence has been presented to indicate that Columbia River salmon stray any substantial distance up the Snake River.

4) Post-Sunbeam Dam sockeye salmon are the result of introductions of unknown origin.

Supporting argument:

Idaho Department of Fish and Game (IDFG) has records of kokanee plants into Redfish Lake each decade beginning in the 1920s (Bowler 1990). Unrecorded plants involving sockeye salmon may also have occurred. Sockeye salmon eggs from Babine Lake, British Columbia, were introduced into nearby Alturas and Stanley Lakes in the early 1980s.

Counter argument:

The recent stocking of sockeye salmon eggs is not thought to have produced any returning adult fish (Hall-Griswold 1990). In any case, these transfers are too recent to explain the resurgence of sockeye salmon in Redfish Lake dating to at least 1942 (Parkhurst 1950) or earlier (eyewitness accounts). There is no evidence to support the speculation that sockeye salmon were introduced into Redfish Lake between 1934 and about 1950, and no one has strongly advocated this position.

5) Post-Sunbeam Dam anadromous *O. nerka* originated from the seaward drift of kokanee from Redfish Lake or other Stanley Basin lakes.

Supporting arguments:

- a) Kokanee have successfully outmigrated and returned as sea-run adults in other lake systems (Foerster 1947; Mullan 1986).
- b) In some years, *O. nerka* juveniles outmigrated from Redfish Lake in numbers higher than can plausibly be explained by the number of spawning sockeye salmon (Bjornn et al. 1968).

c) Juvenile kokanee migrate out of nearby Alturas Lake (Bowler 1990), and Bjornn et al. (1968) suggested that anadromous *O. nerka* found in Alturas Lake in 1964 were derived from kokanee.

d) If the original sockeye salmon gene pool became extinct as a result of Sunbeam Dam, recent anadromous fish must be derived from the kokanee gene pool because other explanations for their existence are not plausible.

Counter arguments:

a) Although it has long been known that kokanee can produce anadromous fish, the number of outmigrants that successfully return as adults is typically quite low. In fact, there appears to be no evidence that kokanee anywhere have naturally produced a sustained run of sockeye salmon. Thus, if kokanee were responsible for post-Sunbeam Dam anadromous *O. nerka* in Redfish Lake (a run that numbered over 4,300 adults in 1955), it would be an unprecedented occurrence for the species.

b) The relatively poor performance of anadromous kokanee may reflect genetically-controlled life-history differences between sockeye salmon and kokanee that are likely to influence survival in the ocean and during migration (Foote et al. 1989a; Wood and Foote 1990). If this is so, particularly poor performance might be expected from kokanee facing the long migration required for anadromous fish from Redfish Lake.

c) Other Snake River kokanee populations (e.g., Dworshak Reservoir) regularly produce outmigrants without any records of the return of adult anadromous fish (Bowler 1990).

d) In the year with the greatest excess of outmigrants in comparison with estimated sockeye salmon production, kokanee outmigration may have been influenced by release of hatchery kokanee into Redfish Lake (Bjornn et al. 1968).

e) Currently, Redfish Lake kokanee spawn in Fishhook Creek in August, whereas sockeye spawn only in the lake and primarily in October (Bowler 1990). For the "seaward drift of kokanee" hypothesis to be tenable, therefore, it is necessary to postulate substantial shifts in time and place of spawning.

6) The present gene pool is a mixture resulting from hybridization of kokanee and sockeye salmon that failed to outmigrate.

Supporting arguments:

a) In some lakes, kokanee and sockeye salmon remain sympatric and spawn in the same locations at the same time (Ricker 1940; McCart 1970; Foote 1987; Foote and Larkin 1988).

b) Kokanee males may "sneak in" on spawning sockeye salmon pairs and may fertilize sockeye salmon eggs (Hanson and Smith 1967; Foote et al. 1989a).

c) Although Foote et al. (1989b) found significant genetic divergence between sockeye salmon and kokanee in each system they examined, they also found that sockeye salmon and kokanee from the same system were more similar to each other than either was to the same form in a different drainage.

d) McCart (1970) showed that crosses between kokanee males and sockeye salmon females produce viable offspring in culture.

e) In many lakes, a percentage of sockeye salmon (principally males)

fail to outmigrate, thus becoming resident fish. Residual sockeye salmon have many kokanee characteristics but may be phenotypically distinct (Foerster 1968).

Counter arguments:

- a) There are observed protein electrophoretic differences between some sympatric sockeye salmon and kokanee populations which could not persist if hybrids had any appreciable degree of reproductive success (Foote et al. 1989b).
- b) Kokanee and sockeye salmon spawning in the same lake system often are spatially and/or temporally isolated.

Discussion

These six hypotheses suggest three general scenarios for post-Sunbeam Dam sockeye salmon in Redfish Lake: Scenario A--the original sockeye salmon gene pool persisted (Hypotheses 1 and/or 2); Scenario B--the sockeye salmon came from somewhere else (Hypotheses 3 and/or 4); and Scenario C--recent anadromous fish are derived from the kokanee gene pool, either directly or through hybridization (Hypotheses 5 and/or 6). We rejected Scenario B because Hypothesis 3 (straying) was considered implausible given the distance from possible seed populations, and there seems to be no evidence to support Hypothesis 4 (stock transfer). Arguments can also be made against each of the remaining hypotheses; however, the post-Sunbeam Dam existence of an anadromous run of *O. nerka* in Redfish Lake is not in doubt, so they must have come from somewhere. In the judgment of the Biological Review Team, Hypotheses 1 (limited passage) and 5 (seaward drift of kokanee) were considered the most likely, but we could not completely rule out Hypotheses 2 (spawning below the dam) or 6 (hybridization of sockeye salmon and kokanee) as possible sources for the post-Sunbeam Dam sockeye salmon. The team

unanimously agreed that there is insufficient information at present to determine with any reasonable degree of certainty which (or what combination) of these events actually occurred.

The Biological Review Team thus faced a difficult problem: a decision whether the sockeye salmon petition is warranted is required by law by April 1991, but there is insufficient information for a definitive determination of the first key question in the process. After a lengthy discussion, the team reached a strong consensus that, because we cannot conclude with any certainty that the original sockeye salmon gene pool is extinct, as stewards of the resource we are obliged to make a conservative decision in this circumstance. The team was not unmindful of the implications of this decision, and we do not suggest that a lack of information should always result in a conservative decision in ESA evaluations. However, a factor that weighed heavily in these considerations was the irreversibility of the likely consequences of taking the alternative course. That is, if we were to assume that recent anadromous *O. nerka* in Redfish Lake were derived from kokanee and this assumption proved wrong, the original sockeye salmon gene pool could easily become extinct before the mistake was realized.

Species Determination

An affirmative answer to the question, Are Snake River sockeye salmon and kokanee separate gene pools? places us on the left branch of the decision tree. Focus is now on the sockeye salmon gene pool, and in particular on the question, Are Snake River sockeye salmon an ESU? The NMFS Species Definition Paper (Waples 1991) provides two criteria that must be met if a population is to be considered an ESU (and hence a "species" as defined by the ESA). Information relevant to these criteria can be summarized as follows:

A. Reproductive isolation

- 1) Redfish Lake sockeye salmon represent the last anadromous forms of *O. nerka* in the entire Snake River system.
- 2) The nearest extant sockeye salmon populations are in the Wenatchee and Okanogan river/lake systems in the upper Columbia River, over 700 river miles away.

B. Evolutionary significance

- 1) Redfish Lake supports the southernmost sockeye salmon population in the world. Sockeye salmon returning to Redfish Lake also travel a greater distance from the sea (almost 900 miles) and to a higher elevation (6,500 feet) than do sockeye salmon anywhere else in the world. In contrast, sockeye salmon in the Wenatchee and Okanogan river/lake systems spawn at elevations more than 4,000 feet lower. Furthermore, these upper Columbia River populations are in a different ecoregion domain (Humid Temperate Domain) than is Redfish Lake (Dry Domain) (Bailey 1980). Collectively, these data argue strongly for the ecological uniqueness (with respect to sockeye salmon) of the Snake River habitat and make it likely that the population contains unique adaptive genetic characteristics.
- 2) Electrophoretic studies of sockeye salmon throughout North America and Asia typically have found substantial genetic differences between sockeye salmon stocks from different river systems (e.g., Utter et al. 1984; Foote et al. 1989b; Monan 1991). Furthermore, a recent study (Monan 1991) demonstrated that samples of kokanee from Redfish and Alturas Lakes are genetically similar to each other but quite distinct from samples from other lakes in Idaho, Washington, and British Columbia.

These data suggest that sockeye salmon from Redfish Lake are genetically distinct from other sockeye salmon populations.

Available information thus indicates that Redfish Lake sockeye salmon are reproductively isolated from other sockeye salmon populations, and there are several good reasons for considering them to be an evolutionarily important component of the biological species *O. nerka*. Snake River sockeye salmon therefore qualify as a "species" as defined by the ESA.

Alternative Scenario

Because of the uncertainty regarding the origin of recent anadromous *O. nerka* in Redfish Lake, we also considered the implications of following the right branch of the decision tree (sockeye salmon and kokanee share a common gene pool) under the assumption that Hypotheses 5 or 6 are correct. Under this assumption, the two forms (sockeye salmon and kokanee) should be considered as a unit, and the relevant question becomes, Are Snake River sockeye salmon/kokanee an ESU? The following data are germane to this question:

A. Introductions of kokanee into Stanley Basin lakes (including Redfish Lake) have occurred many times, beginning in the 1920s and continuing through the 1980s (Bowler 1990). Sources of many of the plants are unknown, but known sources include Anderson Ranch Reservoir, Idaho; Lake Pend Oreille, Idaho; and Flathead Lake, Montana. Sockeye salmon eggs from Babine Lake in British Columbia were planted in Stanley and Alturas Lakes (but not in Redfish Lake) in 1980-83.

B. Recent electrophoretic analyses by NMFS show that kokanee from Redfish and Alturas Lakes are genetically similar to each other but as a group are

very distinct from other kokanee populations from Idaho, Washington, and British Columbia, including populations known to be sources for kokanee transfers into Stanley Basin lakes (Monan 1991). Kokanee in Alturas Lake are very distinct genetically from the Babine Lake sockeye salmon that were planted there in the early 1980s (Monan 1991). We thus have no evidence that kokanee or sockeye salmon planted into Stanley Basin lakes have had a permanent genetic influence on the kokanee stock.

C. If kokanee in Redfish Lake are producing anadromous fish that return to spawn, they apparently are the only kokanee population in the Snake River drainage that is doing so.

The genetic distinctness of kokanee from the two Stanley Basin lakes suggests a strong degree of reproductive isolation from other kokanee populations. A determination regarding evolutionary significance with respect to other *O. nerka* populations would require a more detailed study, but it seems reasonable that if we assume Redfish Lake sockeye salmon/kokanee are essentially a single gene pool, then they may represent an ESU (or part of an ESU comprising, perhaps, the Stanley Basin lakes). Is such an ESU threatened or endangered? Considering only abundance, the answer is probably not. The most recent abundance estimate for Redfish Lake kokanee is about 25,000 fish of all ages. This estimate, however, has a large variance, and the kokanee population may be vulnerable if predatory species are introduced for sport fisheries (Bowler 1990).

For anadromous/nonanadromous units, however, the threshold question is somewhat more complex. Following the guidelines of the Species Definition Paper, we must consider whether loss of a trait (e.g., anadromy or nonanadromy) would compromise the genetic characteristics of the population that make it an ESU.

Specifically, in the present case, would extinction of the anadromous form represent an evolutionarily important loss to the "species"?

Several outcomes are possible. If Redfish Lake sockeye salmon/kokanee were determined to be an ESU primarily on the basis of characteristics of the kokanee form, and this determination did not depend on the existence of an anadromous form of *O. nerka*, then the potential loss of the anadromous form would probably not constitute a threat to the ESU. However, if Redfish Lake sockeye salmon/kokanee were determined to be distinct solely (or primarily) because of the presence of the anadromous form, then potential loss of a trait that makes a population "distinct" (i.e., a "species" under the ESA) should be a legitimate ESA concern.

Again, there is not enough scientific information for a definitive determination of this issue. A trait that is important in an evolutionary sense must have a genetic basis. It seems likely that there is some genetic basis for anadromous behavior in kokanee, but this has not been clearly demonstrated. Expression of the trait seems to be controlled at least in part by environmental factors. Assuming the phenomenon does have a genetic basis, it is not clear whether the trait would be lost if no anadromous fish were to return, and if so how quickly it might be lost. Foerster (1947) showed that kokanee from Kootenay Lake retained the ability to migrate to sea and return as adults (albeit in small numbers) when forced to do so, in spite of being landlocked for thousands of years. On the other hand, it has been suggested that kokanee in Wallowa Lake in Oregon (a Snake River drainage) may have lost the ability to produce truly anadromous fish within about 20 years of the erection of barriers to adult returns (Oregon Department of Fish and Wildlife 1990).

In principle, these questions are amenable to scientific study. In practice, a substantial research effort would probably be required for a minimum of 5-10 years before any meaningful results could be anticipated.

THRESHOLD DETERMINATION

If Snake River sockeye salmon are an ESU, a decision to list as endangered seems inescapable given the records of few remaining fish. As noted above, an extinction determination would be premature at this time.

RESEARCH OPPORTUNITIES FOR 1991

The following research activities may help to formulate a recovery plan (if necessary) and may provide answers to some of the important questions relating to this petition.

- A. Juveniles outmigrating from Redfish Lake (April-May)
 - 1) Use PIT tags to study time of downstream arrival at dams.
 - 2) Perform genetic analyses for comparison with Redfish Lake kokanee sampled in 1990.
- B. Adults returning to Redfish Lake (July-September)
 - 1) Hold in net-pens until spawning (October).
 - 2) Perform genetic analyses on carcasses after spawning.
 - 3) Use part of progeny from spawnings in captive brood-stock program; remainder would be released into the wild.
 - 4) Cryopreserve male gametes for use in future years.

The PIT-tag study may yield information that will allow effective use of protective measures. Genetic analysis of outmigrating *O. nerka* may show they are distinct from the resident kokanee, lending strong support to the hypothesis that another gene pool (presumably the ancestral sockeye salmon gene pool) persists in Redfish Lake. Inability to find genetic differences between 1991 outmigrants and

kokanee sampled from the spawning grounds in 1990 would be consistent with the hypothesis that anadromous fish have been produced by the kokanee population. However, such a result would also be consistent with the hypothesis that no sockeye salmon outmigrated in 1991 but some remain at sea and may return through 1993. That is, fish outmigrating in 1991 might be kokanee that would never return as adults [as apparently occurs, for example, at Dworshak Reservoir (Bowler 1990)].

If an adequate number of returning adults are sampled without finding any appreciable differences from Redfish Lake kokanee, an answer of "not reproductively isolated" to the first key question is probably warranted, indicating that the right branch of the decision tree should be followed. This conclusion is based on the observation that sympatric sockeye salmon and kokanee can be quite different genetically, so we would expect to find genetic differences if the original sockeye salmon gene pool still exists.

Implementation of the suggested research plans is contingent on several factors. All field work must be coordinated with the appropriate state and federal agencies, and necessary permits must be obtained. Careful consideration should be given to the risks of handling juvenile and adult fish and the consequences of removing a sample of 50-100 juvenile outmigrants for genetic analysis. The benefits and risks of a captive brood-stock program should be discussed and carefully considered. Finally, funds to conduct the research, including personnel to staff the collecting weirs over extended periods of time, must be made available.

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**MEMBERSHIP OF GROUPS ASSEMBLED BY THE NORTHWEST REGION TO ADDRESS
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Administers all Regional actions.

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Gary Smith	- Deputy Regional Director
Merritt Tuttle	- Regional Protected Species Coordinator
Charles Karnella	- F/PR2
Pat Montanio	- F/PR2
Karl Gleaves	- GCF
Doug Ancona	- GCNW
Bill Robinson	- Chief Fisheries Management Div.
Gerald Monan	- Northwest Fisheries Science Center
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Rob Jones	- Environmental and Tech Services Div.

BIOLOGICAL REVIEW TEAM (BRT)

The BRT is comprised of NMFS personnel with technical expertise. The BRT reviews available scientific information, reports on the status of species under review, and provides recommendations to the ICC.

Northwest Fisheries Science Center

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TECHNICAL COMMITTEE (TC)

The TC is comprised of technical experts representing outside interests from throughout the Pacific Northwest (Enclosure 1). The TC was developed by NMFS to ensure that all available scientific information relevant to species under review is provided for the NMFS Administrative Record.

PEER REVIEW GROUP (PRG)

The PRG was developed to review information and NMFS technical determinations (Enclosure 2). The PRG is comprised of recognized authorities in the biological sciences.

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LISTING COLUMBIA RIVER SALMON UNDER THE

ENDANGERED SPECIES ACT

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**QUESTIONS AND ANSWERS FOR NOAA'S PROPOSED LISTING
OF THE SNAKE RIVER SOCKEYE SALMON AS AN ENDANGERED SPECIES**

QUESTION: What Will NOAA do if it appears that the Snake River sockeye are extinct? Will the agency take conservation measures until it is proven that the species is extinct?

ANSWER: We will not know if Snake River sockeye salmon are extinct until five years after the last redd was observed ($1989 + 5 = 1994$). Should no fish return by then, the population can be considered extinct. At that time, listing would no longer be appropriate.

The agency will take protective and conservation measures until it is proven that the sockeye population is extinct. If the population is listed as endangered, these measures will include prohibitions on taking, recovery actions, and Federal agency consultation requirements as required under the Endangered Species Act (ESA). Even with a "proposal" to list, NMFS is prepared to take actions in 1991 to capture, preserve and propagate all returning Snake River sockeye. NMFS proposes to build a capture weir at Redfish Lake to receive returning sockeye. They would further construct holding facilities to preserve and protect these fish until they could be spawned and to rear the progeny to maturity.

Even if no sockeye salmon return in 1992, the agency would be prepared to conduct the above efforts through 1994. Because this species has a four to five year life cycle, and there is evidence of sockeye redds (2) in 1989, it is prudent to assume that adult sockeye may return to Redfish Lake through 1994. If there are no sockeye returning by November 1994, the Snake River sockeye may be considered extinct. Both adults and juveniles would be genetically sampled to further aid in species identification.

QUESTION: Why didn't NOAA act sooner? Why isn't the agency using the emergency provisions of the ESA?

ANSWER: The Northwest Region independently initiated a Status Review of Snake River sockeye salmon early in 1990,

prior to receiving the petition. The sockeye population had remained at low but seemingly stable levels until a dramatic decline in the adult fish count at Lower Granite Dam occurred at in the fall of 1989.

Regarding the implementation of emergency provisions of the ESA, the Northwest Region has evaluated those factors that pose adverse impacts to Snake River sockeye salmon and concluded that the immediate promulgation of emergency regulations is unnecessary. However, should over-harvest or adult and juvenile migration issues not be resolved in 1991, emergency listing may be necessary.

QUESTION: Are the salmon fisheries in the Pacific Northwest still in good shape? If so, why? If hatcheries have been successful in maintaining the commercial fisheries, why is the agency protecting wild runs?

ANSWER: In general, the key production stocks (many wild and hatchery populations) are in good condition. However, some of the weaker wild populations have suffered from mixed stock harvest. Wild populations are generally the only populations that qualify for protection under ESA; consequently, hatchery fish can not be regarded as a substitute for petitioned populations. This reasoning stems from one of the purposes of the ESA, which is "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved." Thus, self-sustaining populations in the wild are key to achieving this purpose.

QUESTION: Why didn't the Administration propose to fund the Columbia River salmon hatchery in the 92 budget?

ANSWER: The Administration believed that other entities had the responsibility to fund the hatchery program because other entities (hydropower producers) were responsible for the initial declines in salmon abundance.

However, sockeye salmon hatcheries do not exist under the Columbia Fisheries Development Program, which is financed by NMFS. Sockeye hatcheries had generally failed prior to the time when the original Program hatcheries were constructed; consequently, none were built for sockeye. There have been no new hatcheries constructed under this program for several decades.

QUESTION: Will the commercial and recreational salmon fish catch be impacted by listing under ESA?

ANSWER: Yes, if there is a listing the fisheries could be impacted. The recreational salmon catch is negligible, as is the ocean harvest. However, commercial fisheries for sockeye salmon by Indians and non-Indians could be impacted primarily on the mainstem of the Columbia River. Short term forecasts of 1991 abundance of Columbia River sockeye indicate that a fishery is unlikely. Consequently, listing would have little impact that year. There are no forecasts of abundance for subsequent years.

QUESTION: Will NMFS now undertake its own review of all the subspecies of salmon with respect to status of wild salmon stock?

ANSWER: Not in the short term. NMFS will complete the status reviews for the other four stocks of salmon that were petitioned on June 7, 1990. Those reviews are our first priority. Our second priority will be to make a final determination regarding sockeye. NMFS resources are fully committed at this time in completing these tasks.

QUESTION: What is the recovery plan process?

ANSWER: NMFS has an excellent process in place with the Technical Committee (widespread outside membership), the Peer Review group (representatives from academic institutions), and our own scientific staff. In addition, these groups are likely to receive and evaluate information produced by the Hatfield Salmon Summit process. It is our belief that an additional recovery team would simply represent more bureaucracy and would not aid in recovery planning.

cc: KML
DIG
PARRISH
KORRELL

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

July 24, 1991

Dear Mr. McMillan:

Thank you for your letter of May 9, 1991, asking for comments on EPA's risk assessment regarding environmental tobacco smoke (ETS). While I have not had the time or opportunity to study in detail the risk assessment procedures applied by EPA in this instance, I am pleased to comment upon them based on such understanding as I have acquired.

With regard to your question: Did EPA follow its own guidelines in performing the risk assessment? If yes, do the data support the conclusions?

A review of the potential of ETS as a human carcinogen involves certain factors which are unique to it and properly must be weighed in the determination.

- ETS is a mixture of components, several of which are known human carcinogens, and others of which are known animal carcinogens as well.
- Mainstream smoke, which contains most, if not all, the components of ETS, is a constituent of ETS and is recognized to be a known human carcinogen for the person smoking.
- EPA has in the past reviewed and supported an assessment of ETS by the National Research Council whose report, "Environmental Tobacco Smoke: Measuring Exposures and Assessing Health Effects" (1986) involved a comprehensive analysis of physical-chemical properties and exposure assessment as well as in-vivo and in-vitro toxicological assays. The report concluded, with regards to lung cancer: "Considering the evidence as a whole, exposure to ETS increases the incidence of lung cancer in nonsmokers."

As I am sure you are aware, the 1986 EPA Guidelines for Carcinogen Risk Assessment basically outline two different assessments: (1) a Hazard Identification Assessment based on a weight-of-evidence approach which "contains a review of the relevant biological and chemical information bearing on whether or not an agent may pose a carcinogenic hazard;" and (2) a Dose-Response Assessment, Exposure Assessment and Risk Characterization, "the first step of the analysis needed to make such estimations is the development of the likely relationship between dose and response (cancer incidence) in the region of human exposure."

With respect to (1) the Hazard Identification Assessment, EPA might have produced an evaluation of the toxicology and carcinogenicity of each of the biologically active constituents of ETS, a formidable undertaking. Or, EPA might have focused on the well established carcinogenicity on the human lung of active smoking and pointed out the similarity of constituents between mainstream and sidestream smoke in declaring ETS a Group A carcinogen.

2

Given the evidence presented in three authoritative reports in 1986 (the NRC report, the U.S. Surgeon General's Report, "The Health Consequences of Involuntary Smoking," and the World Health Organization's report on "Tobacco Smoking"), EPA decided to conduct its risk assessment as an update to these three reports. Each of these reports judged ETS to be causally associated with increased lung cancer in humans. EPA sought to quantitate the effects under natural environmental circumstances.

From analysis of existing and new data, EPA concluded that its results were consistent with those of the three earlier reports. The overall results, adjusted for potential confounders, indicated increased risk in humans due to ETS. Additional elements needed for a finding of "sufficient evidence in humans," as described by the guidelines, are discussed in the draft risk assessment and addressed.

With respect to (2) the dose-response assessment and the exposure assessment, the EPA chose to project population impact based upon the epidemiological studies done at environmental exposures. With this approach, a mathematical dose-response extrapolation model and extensive exposure assessment would not be required, as I understand it. The approach seems reasonable to me. Thus, EPA used a methodology which estimated population risks directly, rather than relying upon estimates derived from a dose-response or exposure model.

With regard to your follow-up question: In light of relevant data that are generally available, what is your opinion of the lung cancer risk posed by exposure to ETS?

In general, we concur with the SAB report of the Scientific Advisory Board. Although there were some difficulties in applying the 1986 guidelines, the methodology does not seem sufficiently flawed to invalidate the findings that ETS should be classified as a Group A carcinogen.

I appreciate your interest and I hope that my response furthers your understanding of the problem.

Sincerely,



D. Allan Bromley
Director

The Honorable Alex McMillan
Member
U.S. House of Representatives
401 Cannon House Office Building
Washington, DC 20515

THE WHITE HOUSE
WASHINGTON

July 12, 1991

THE CHIEF of STAFF
has seen

MEMORANDUM TO JOHN SUNUNU

FROM: D. ALLAN BROMLEY *Allan*
SUBJECT: WORKSHOP FOR DEVELOPMENT OF A WESTERN
HEMISPHERE INSTITUTE FOR GLOBAL CHANGE
RESEARCH

You recall that the concept of a regional global change institute was proposed during the White House Conference on the Science and Economics of Global Change last April. During the President's very successful Latin American trip last December, I had the opportunity to discuss the proposed institute, along with other science, technology and environmental issues with senior officials in Brazil, Uruguay, Argentina, Chile, and Venezuela. The meetings resulted in a good exchange of views and enthusiastic support for the institute concept in each of the five countries visited.

I asked the Committee on Earth and Environmental Sciences of the Federal Coordinating Council for Science, Engineering and Technology (FCCSET) to plan and host a scientific workshop. It will provide a forum for discussion of the concept of a regional global change institute by the countries in the Western Hemisphere.

The workshop will take place in San Juan, Puerto Rico from July 15 to July 19, 1991 and I shall participate in its initial sessions. We have had an excellent response to the workshop from the countries in the Western Hemisphere and expect a successful workshop. I shall give you a report on the outcome of the workshop as soon as it is available.

THE WHITE HOUSE
WASHINGTON

July 12, 1991

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D. ALLAN BROMLEY *Allan*

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July 8, 1991

To : Dr. Bromley

Re: Your report to me of July 2nd

1. Read it with interest.

2. I think it is important that Dept. Of Education stay informed on any deliberations having to do with Education. Maybe Lamar Alexander sould send over a representative when education is on you agenda. This is good stuff and I want to be sure that evryone knows what you are doing on, for example, math and Science. Just a thought !!

cc: John Sununu

CB /

FROM THE PRESIDENT

THE WHITE HOUSE
WASHINGTON

July 2, 1991

91 JUL -5 PM 1:35

MEMORANDUM FOR THE PRESIDENT

FROM: D. ALLAN BROMLEY *Adm*

SUBJECT: Your Council of Advisors on Science and Technology

Mr. President, I would like to summarize the current activities of your Council of Advisors on Science and Technology.

Since February 1990, the President's Council of Advisors on Science and Technology (PCAST) has met 12 times and held 5 discussions with you. During our meetings, you indicated a number of topics you would like PCAST to consider. Also, the Council has had extensive discussions with various senior officials within the Executive Office of the President, including the Vice President, Michael Boskin, Robert Gates, Michael Deland, and Roger Porter, to help better understand the Administration's goals and how the PCAST could be most helpful. Further, the Council talked in detail with many agency and department heads including James Watkins, Richard Truly, Donald Atwood and others to get their views on how the PCAST could be responsive to you and the Administration.

Mr. President, as Chairman I can report that the PCAST has been listening and is working intently on addressing many issues raised during these discussions. Seven of the most important are briefly described below. Each has been given to separate, ad hoc, discussion groups within PCAST for further discussion and at an appropriate time we would look forward to reporting to you on these deliberations.

The first issue is mathematics and science education. The importance of this issue was touched upon in nearly every PCAST discussion. Council member Peter Likins, President of Lehigh University, has taken the lead in this area with the goal of (1) providing an extragovernmental perspective on the work of governmental groups, including the Committee on Education and Human Resources of the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET); and (2) undertaking specific studies to address such relevant questions such as: how best to approach the very serious problems in US precollege education, are undergraduate and graduate enrollments in engineering and the sciences appropriate society's needs and the talents of our population? Are Ph.D. recipients likely to be available to meet demands for faculty in engineering and the sciences in the coming decade? How can enrollments in these areas best be altered?

A second issue involves the global environment and natural resources. Council members Thomas Lovejoy of the Smithsonian, David Packard, and Nobel laureate Norman Borlaug, are taking the initiative to: identify areas of potential interaction and collaboration with the private sector in global change research; provide private sector input on societal needs that can be served by further scientific research in the areas of natural resources, and earth and environmental sciences; and identify areas in need of further study in order to protect biological diversity and minimize the impact of human populations upon it.

International economic competitiveness is a third issue for PCAST focus. As with mathematics and science education, maintaining our science and technology base was pointed to by Administration officials as crucial to increased U.S. economic competitiveness. Council member Ralph Gomory, President of the Sloan Foundation, was asked to lead a group considering the areas of new technology, product improvement, and the technical workforce. Ralph will then work to identify ways to enhance the partnership between the government and the private sector with the goal of improving our competitive position internationally.

The war in the Gulf, among other things, demonstrated and confirmed the vital link between technology and national security. In your statement, **National Security Strategy of the United States**, you acknowledge that the economic and military strength of the United States rests on technological superiority. I have asked Council member Sol Buchsbaum, Senior Vice President for Technology System at AT&T Bell Laboratories, and Johnny Foster, Chairman of the Defense Science Board, together with David Packard and others to define and discuss the role science and technology are expected to play vis-a-vis national security during the decade of the 1990's and beyond in a vastly changed world environment. They will examine how effectively science and technology frontiers are being integrated into our national security activities; identify gaps or deficiencies, and where appropriate, propose alternative mechanisms and approaches.

Because of its promise for improved health care and American quality of life, and because the global market holds many promises for American industry, the area of bioscience and corresponding biotechnology is a fifth PCAST topic. Council member and Nobel laureate Daniel Nathans, Professor of Molecular Biology and Genetics at Johns Hopkins University School of Medicine will chair this effort. Daniel and his group will provide information to PCAST on: ways to enhance the transfer of biotechnology from Federally supported laboratories and University groups to American industry and how to encourage private sector leadership; ways to provide private sector input on current and possible future governmental policies that will enhance basic research in the life sciences and long term research and development by the biotechnology industries.

A sixth area of PCAST focus is on research megaprojects in the sciences. Council member John McTague, Vice President for Technical Affairs at Ford Motor Company, is taking the lead with Harold Shapiro, President of Princeton University. They are examining the relative roles of megaprojects, both of the large-scale, single facility type such as the Superconducting Super Collider and the multi-investigator, multi-facility type such as the Human Genome Project, with the smaller individual

investigator-initiated science projects. They will examine the potential for greater international cooperation in the megaprojects, and suggest the most appropriate fora - governmental and scientific, national and international - in which such cooperation could be further discussed and coordinated.

A seventh topic being addressed by the PCAST is high performance computing and communications. Your Presidential Initiative in the 1992 budget in this very important area laid the groundwork for maintaining and extending U.S. leadership in both the research and education communities. Here, Sol Buchsbaum is taking the lead to build upon current Federal activities and to explore ways to encourage the private sector participation and leadership that will maintain and ensure future U.S. competitiveness in this field.

The Council is pleased to respond to the challenge you have given it in examining these issues, and values the opportunities it has had thus far to provide advice. We look forward to providing you with additional private input on each of these seven areas and on others of importance to you and your Administration.

THE WHITE HOUSE
WASHINGTON

July 8, 1991

THE CHIEF of STAFF
has seen

d MEMORANDUM FOR THE PRESIDENT

FROM: D. ALLAN BROMLEY *Am*
SUBJECT: OP-ED PIECE FOR THE WASHINGTON POST

Enclosed herewith is a piece entitled "Science and the Space Station" that will appear in the Wednesday issue of the **Washington Post**. I have written it in an attempt to respond to some serious misunderstandings in the scientific and engineering communities regarding the rationale for the station and its relation to your continuing and generous support for investing in the Nation's future via a strong and vital science and technology enterprise.

Enclosure

THE WHITE HOUSE
WASHINGTON

SCIENCE AND THE SPACE STATION

by
D. Allan Bromley
The Assistant to the President
for
Science and Technology

Since he became President, George Bush has sought to cast the annual budget negotiations with Congress in a new light. He has emphasized investments in the future -- in education, preventive health care, the transportation infrastructure, environmental protection, the exploration of space, and scientific research. In fact, George Bush has given stronger support to science and space than has any President during the past two decades.

Congress also recognizes the importance of investing in science, technology, and space, and it has taken a number of steps to increase those investments. But the tight fiscal climate created by the need to reduce the deficit has presented both the Congress and the Administration with difficult choices. The whole point of last fall's budget agreement was to encourage priority-setting. As the budget season progresses, we must keep in mind the consequences of the choices Congress makes in setting its priorities for the nation's future.

One difficult choice for the Congress involves Space Station Freedom. Earlier this month a House Appropriations Subcommittee voted to eliminate funding for the space station. The full House later reversed the subcommittee's decision on space station, but chose to offset station by freezing all of NASA. Although space science funding would continue to constitute about 20 percent of NASA's activities -- as recommended by the Augustine Commission -- needed growth in NASA programs requested by the Administration would be lost.

The opponents of the space station have presented the tradeoff as being between space and science, but the Administration does not believe that the debate should be cast in these terms. The debate is not between science and the space station. Nor is it between big science and little science. It is between investments in the future and current consumption.

The Administration believes that its budget strikes a careful balance between our current needs -- including our commitments to veterans and the plight of the homeless -- and future investments. By funding the Veterans Administration and HUD at levels higher than the increases requested by the Administration, the House is tilting this balance and contributing to a long-term decline in future investments by the federal government.

Unfortunately, many scientists and engineers have accepted the mistaken premise that the tradeoff is between manned space flight and science. Space Station Freedom has never been primarily a science project, just as the Apollo program was not primarily a science mission. Rather, the space station is our initial permanent step into space, the critical next chapter in a grand story of exploration that will take humans away from the home planet into an endless frontier.

Indeed, there is one form of scientific research that can be done only with a permanent, manned outpost in space: the life sciences research essential for the next step in human exploration of space and beyond. We need to know how humans can adapt to the harsh and unforgiving environment of space and to prolonged weightlessness. A major scientific effort, involving substantial numbers of astronauts in space, will be needed to understand the physiological and behavioral changes that occur in space and to devise methods for coping with them. Much work needs to be done to carry out such a program. Scientists and engineers need to work constructively with NASA, the Administration, and Congress toward this end.

Like the scientific returns, the technological return from the station are impossible to predict but are certain to be rich. The Apollo program offers a good analogy. When the National Academy of Engineering recently picked the top ten engineering projects of the past quarter century, the Apollo program ranked first, ahead even of the microprocessor and communication satellites. The Apollo program also represented the first time in the history of our species where a quantum leap in both science and technology took place without the impetus of a global war.

Those who argue that money saved from the station will go to research and development overlook the pressures being exerted on Congress. The point missed is that the probability of funding both science and space is maximized when the two stick together as part of one, future-oriented coalition. As Budget Director Richard Darman said in testimony before the House Committee on Science, Space, and Technology, "The reality is that appropriators will tend to do exactly what the station-killing committee has proposed to do: give no more to science than in the President's budget; reduce station to zero; and reallocate every single dollar thus 'saved' to non-science."

Killing the space station would also threaten our ability to succeed in funding areas of science and technology far removed from space. The public supports scientific research and manned space exploration for two primary reasons: because it believes that these investments pay off, and because of the intellectual excitement and adventure that these activities provide. Space exploration has captured the imagination of much of the American public, especially our youth. In the 1960s the Apollo program inspired many young people to become scientists and engineers, even if they did not work directly in the space program. To attract the next generation of scientists and engineers, and to promote science and technology much more broadly in our society, a manned space program is essential as part of a balanced space exploration program.

The House's decision to save the space station has set the stage for more positive actions by the Senate. But the Congress now faces a choice: By expanding only one third of one percent of our GNP on NASA we can embrace a new age of exploration. Or we can choose to spend the money on the political system's insatiable consumption habits, thereby closing the door on space -- the next great frontier--and on America's leadership on it. The choice, to me, seems clear.

8

THE WHITE HOUSE
WASHINGTON

July 1, 1991

THE CHIEF of STAFF
has seen

MEMORANDUM FOR JOHN H. SUNUNU

FROM:

D. ALLAN BROMLEY

Alan

SUBJECT:

OP-ED PIECE ON SPACE STATION FREEDOM

Attached is a draft op-ed piece on Space Station Freedom that I plan to submit to the Washington Post. I would very much appreciate it if you could review the draft and return your comments to me by the end of the day Wednesday, July 3. Thank you for your help.

Attachment

DRAFT

[July 1, 1991]

SCIENCE AND THE SPACE STATION

by D. Allan Bromley

Since he became President, George Bush has sought to cast the annual budget negotiations with Congress in a new light. He has emphasized investments in the future -- in education, preventive health care, the transportation infrastructure, environmental protection, the exploration of space, and scientific research. In these last two areas in particular, George Bush has given stronger support to science and space than has any President for the past two decades.

Congress also recognizes the importance of investing in science, technology, and space, and it has taken a number of steps to increase those investments. But the tight fiscal climate created by last year's budget agreement has presented both the Congress and the Administration with difficult choices. As the budget season progresses, we must keep in mind the consequences of those choices for the nation's future.

One difficult choice for the Congress involves Space Station

Freedom. Earlier this month a House Appropriations Subcommittee voted to discontinue funding for the space station and allocated funds saved primarily the Department of Housing and Urban Development, the Department of Veterans Affairs, and the Environmental Protection Agency. The full House later reversed the subcommittee's decision, but at the price of freezing funding for many science programs within NASA. Although space science funding would continue to constitute about 20 percent of NASA's activities -- as recommended by the Augustine Commission -- needed growth requested by the Administration would be lost.

The House presented the tradeoff as being between space and science, but the Administration does not believe that the debate should be cast in these terms. The debate is not between science and the space station. Nor is it between big science and little science. It is between investments in the future and current needs.

The Administration believes that its budget strikes a careful balance between these needs -- including our commitments to veterans and the plight of the homeless -- and future investments. By funding the Veterans Administration and HUD at levels higher than the increases requested by the Administration, the House is tilting this balance and contributing to a long-term decline in future investments by the federal government.

Unfortunately, many scientists and engineers have accepted the mistaken premise that the tradeoff is between manned space flight and science. Groups and individuals have written to the

Congress to oppose the Space Station, believing that money taken from the station will instead go largely to research and development. This belief reflects an incomplete understanding of the Space Station's objectives and of the Congressional appropriations process.

Space Station Freedom has never been primarily a science project, just as the Apollo program was not primarily a science mission. Rather, the space station is our initial permanent step into space, the critical next chapter in a grand story of exploration that will take humans away from the home planet into an endless frontier.

Even though the space station is not primarily a science project, it will make possible much excellent science. In particular, there is one form of scientific research that can be done only with a permanent, manned outpost in space: the life sciences research essential for the next step in human exploration of space and beyond. We need to know how humans can adapt to the harsh and unforgiving environment of space and to prolonged weightlessness. We need to find out how to identify and minimize harmful effects and how to counteract them when they occur.

Whether humans can adapt and perform well over extended periods of time may be the critical question that determines whether human exploration of space is possible. The experience of Soviet cosmonauts in extended space flight has pointed toward potentially serious problems: decalcification of bones, loss of

muscle mass, changes in cardiovascular function, and behavioral changes that may be psychologically or physiologically based. A major scientific effort, involving substantial numbers of astronauts in space, will be needed to understand the physiological and behavioral changes that occur in space and to devise methods for coping with them.

Much work needs to be done to carry out such a program. Scientists and engineers need to work constructively with NASA, the Administration, and Congress toward this end.

Other forms of scientific research will be done in the weightless environment provided by the station, including experiments involving protein crystallization, phase changes, combustion, and materials research. This research does not, by itself, provide a compelling rationale for building the station. But any time a new technique becomes available in science -- in this case, a microgravity environment -- new and exciting uses are invariably found for that technique.

Like the scientific returns, the technological returns from the station are impossible to foresee today but are certain to be rich. The Apollo program offers a good analogy. When the National Academy of Engineering recently picked the top ten engineering projects of the past quarter century, the Apollo program ranked first, ahead even of the microprocessor and communication satellites. The Apollo program also represented the first time in the history of our species where a quantum leap in both science and technology took place without the impetus of

a global war.

Those who argue that money saved from the station will go to research and development overlook the pressures being exerted on Congress. As Budget Director Richard Darman said in testimony before the House Committee on Science, Space, and Technology, "The reality is that appropriators will tend to do exactly what the station-killing committee has proposed to do: give no more to science than in the President's budget; reduce Station to zero; and reallocate every single dollar thus 'saved' to non-science."

Lobbying by some scientists against the space station has pitted discipline against discipline, scientist against scientist. Scientists do not further the cause of science by attacking a project so closely linked to science and technology. In lobbying against the space station, scientists have circled the wagons and are shooting inward.

Lobbying against the space station also threatens funding for areas of science and technology far removed from space. The public supports scientific research and manned space exploration for two primary reasons: because it believes that these investments pay off, and because of the intellectual excitement and adventure that these activities provide. Space exploration has captured the imagination of much of the American public, especially our youth. In the 1960s the Apollo program inspired many young people to become scientists and engineers, even if they did not work directly in the space program. To attract the

next generation of scientists and engineers, and to promote science and technology much more broadly in our society, a manned space program is essential as part of a balanced space exploration program.

The House's decision to save the space station has set the stage for more positive actions by the Senate. But the Congress now faces a choice: By expending about a third of a percent of our GNP on NASA we can embrace a new age of exploration, or we can choose to close the door on the next great frontier and on America's leadership on that frontier. The choice, to me, seems clear.

8

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

JUNE 27, 1991

MEMORANDUM FOR D. ALLAN BROMLEY

FROM: VICKIE V. SUTTON 

SUBJECT: ACID RAIN RESEARCH

THE CHIEF of STAFF
has seen

With this memo, I am forwarding to you three copies of "Assessment of the Theory and Hypotheses of the Acidification of Watersheds" produced for the U.S. Department of Energy by Edward C. Krug. This study responds to the question concerning pre-industrial levels of surface water acidification and the effect of watershed disturbance on acidification.

The report lays out an alternative theory of acid rain, suggesting that acidity in lakes is not controlled by geological runoff, but rather by near surface runoff from highly acidic, organic rich soils and peats and lichens. The observed effects of acidity in surface water is due to the qualitative shift from organic acidity to mineral acidity, rather than quantitative changes in acidity. He suggests that this more comprehensive theory of surface-water acidification be incorporated into the mathematical models used to predict changes in surface water chemistry.

Krug states in the Executive Summary:

"Paleolimnological studies indicate that approximately 90 percent of currently acidic (pH < 5.5) surface waters examined in the northeastern U.S.A. and southern Norway were naturally acidic (pH < 5.5) in pre-industrial times. Many surface waters of 'sensitive' watersheds in areas of the world not receiving acidic deposition are naturally acidic . . ."

The dynamics in surface water acidity over time has also been explained by the changing land-use hypotheses of Rosenqvist (1978; 1980). Several studies are cited by Krug (p. 3-168) presenting paleolimnological data indicating that specific acidic surface waters in pre-settlement times (pre-1600's) experienced higher pH excursions when forests were cleared. In the 1800's when land abandonment was occurring, the lakes began to return to their natural, acidic level. Historical records are consistent with this data, indicating the absence of fish during settlement periods.

I have also attached a recent conference paper on this subject presented by Krug on June 6, 1991, a Washington Times article, and a brief biography of Edward Krug for your information.

Please let me know if you would like anything further.

ACID RAIN, FORESTS, AND FISH

Edward C. Krug, Ph.D.
Director of Environmental Projects
Committee for a Constructive Tomorrow (CFACT)

GLOBAL ENVIRONMENTAL CRISES: SCIENCE OR POLITICS?

A CATO Institute Conference
June 5-6, 1991, The Capital Hilton Hotel, Washington, D.C.

513 Kerry Drive
Winona, MN 55987

@ June 6, 1991

ACID RAIN, FORESTS, AND FISH

By: Edward C. Krug

TO FOOL THE PUBLIC

Creating "crises" in the name of a "just cause" is the historically-proven method for acquiring power. The crisis and the just cause are instruments created to torture the public into signing over control to the "knowing elite". This process is also called the "creative use of hysteria" by the Sierra Club: a member of the collective group of political organizations known as the "Environmental Party". While the last thing that responsible leadership wants in a time of **real** crisis is hysteria: hysteria is precisely what Party leaders want and need.

Hysteria has worked very well for them. The Environmental Party has grown to be more than 4 times larger than the Democratic and Republican parties combined! Accordingly, everybody is an environmentalist. Mickey Mouse, Ronald McDonald, and President Bush are all self-avowed environmentalists. The "green giant" is something to be feared.

Acid rain is illustrative of the creative use of hysteria. Acid rain is a manufactured crisis. Party activists screeched long and hard that acid rain is creating an aquatic silent spring. Key agents within the scientific community and government fabricated "facts" to lend authority to the assertions that the sky is falling. For example, in 1980 the EPA asserted that the average lake in the northeastern United States was acidified 100-fold in the last 40 years by acid rain. Not to be outdone, the National Academy of Sciences claimed that acid rain would double again this damage by 1990.

Some of our leadership was responsible enough to take the time to figure out that the public perception of "We were going to lose all our lakes and half our forests" was based on unfounded assertions, as Senator Moynihan (D-NY) told 60 Minutes (Dec. 30, 1990). But rather than deal with the attempt by the Environmental Party to co-opt our political system, the Senator and others chose to establish a massive national acid rain research program (NAPAP) an action which, unfortunately, could only have the effect of legitimizing the claims of disaster.

Such an inception - typical of programs set up to research alleged catastrophes such as pesticides, ozone depletion, and global warming - is a brilliant Party strategy for discrediting science and government. Researching something that is, in the public mind, a "crisis" automatically earns ill will. After all, 'Why wait to do research on something that we know is an horrendous crisis?'

And the subsequent research results on the issue invariably do not turn out as "expected". Regarding acid rain, NAPAP researched the lakes of the Adirondacks - the area of the Northeast most likely to have the well-advertized massive lake acidification. We found that the average Adirondack lake is less

acidic now than prior to the Industrial Revolution - not 100-fold more acidic as claimed by the EPA. And we found no measurable change in the acidity of lakes over the last 10 years, despite the assertions of the National Academy of Sciences that yet another 100-fold increase in acidity would occur by 1990.

So then we scientists were accused of watering down our research results to appease political pressures. Yes, there were political pressures. But they were pressures to support, not oppose, the basis of the program's existence - in this case that acid rain is an environmental catastrophe.

The result of this brilliantly-devised setup is that science and government are discredited. The eco-saboteurs emerge unscathed and triumphant - the heirs to the public trust.

And so we now live in the Age of Non-Reason. Virtually all scientific research is funded by government and industry yet surveys show that, at most, only 15 percent of all Americans believe the information they receive from industry or government. On the other hand, 68 percent believe the faith assertions of the political activists.

Recently, even Science magazine (our most prominent scientific journal) reported and sided with key Party agents within the scientific community in criticizing NAPAP for actually having the gaul to do real science (Roberts, 1991).

POLITICAL SCIENCE

Science is important to the Environmental Party, not as science but as the ultimate tool of political persuasion "because of the almost 'religious' belief which people have developed about the objectivity - and thus the certainty - of the results of science" (Schaeffer, 1976, pp. 200).

However, the results of acid rain "science" have been anything but objective. The Norwegian national acid rain program established the research perspective of the subsequent national programs in the U.S., Canada, and Europe. The enabling legislation of the Norwegian national program (Nr. 172/1974) mandated that "the aim of the project is to provide material for negotiations in order to limit the emission of SO₂ in Europe" (Rosenqvist, 1990). You can read this legislation as "upon this conclusion our facts are based!" Scientists who were willing to make up facts to support this preconceived conclusion about acid rain were handsomely supported. Scientific objectivity was rewarded with ridicule and ostracism in a process of the selection of the least fit.

As the Norwegian program was ending in 1980, President Carter called acid rain one of the two environmental crises of the century and started NAPAP at \$ 10 million/yr for 10 years.

Thus, the inception of NAPAP was hardly scientifically objective either. And, at \$ 10 million/yr, NAPAP was merely window dressing to provide the appearance of scientific credibility for the claims of environmental disaster.

Remember, NAPAP was supposed to be investigating the sources of acid rain, its atmospheric chemistry and transport as well as its myriad claimed effects such as: visibility, effects on crops, effects on forests, effects on lakes, effects on buildings, effects on human health. Then you take all of these effect and research areas and divide them among all of the participating agencies: the U.S. Park Service, the USGS, the U.S. Forest Service, the TVA, the USDA, NOAA, NASA, the national laboratories, Department of Health and Human Services, Department of Energy, Department of Commerce, and (last but not least) the Environmental Protection Agency - and you see that \$ 10 million/yr will hardly pay the salaries of the administrative paper pushers, let alone support any meaningful research.

NAPAP was originally set up to put a rubber stamp on the false claims of disaster. It was not set up to do science.

This changed with President Reagan. Under enormous political pressure, by 1984 the President was ready to accede to the demand for an expensive crash program to stop acid rain but only if the scientific experts would agree with the accepted belief that if acid rain is not stopped within 5 years there will be an "aquatic silent spring".

Armed with the truth, Bill McFee of Perdue University and I, enabled the committee to tell EPA Administrator Ruckelshaus on February 2, 1984 words to the effect that, "It is our scientific opinion that - contrary to popular belief - the world will survive for another 5 years. Accordingly, we believe that NAPAP should be continued." And by gosh we were right! It is 1991 and the world still has not come to an end!

President Reagan's response was to increase NAPAP's budget ten-fold to around \$ 100 million/yr so that it could finally get around to doing meaningful scientific research on acid rain. With the new budget, NAPAP also got a new Director: a world-class scientist by the name of Kulp.

This made the Environmental Party furious. NAPAP became distinct from all other national acid rain programs - it was evolving into a scientific entity rather than remaining a creature of environmental politics. Since NAPAP was no longer likely to rubber stamp the claims of disaster the Party would discredit NAPAP with the help of its powerful allies in the media and government which, most importantly included the EPA. The EPA was NAPAP's lead federal agency.

Thus NAPAP was not able to produce perfectly objective science. However, we must commend NAPAP for performing much better than we have any right to expect - NAPAP was overwhelmingly besieged from both within and without.

The Environmental Party's criticism of NAPAP and its vehement objections to the establishment of a "NAPAP" for global warming are badges of honor.

ACID RAIN

A Rose By Any Other Name

Bias was insured from the beginning with the selection of the pejorative term - acid rain. How can something called "acid rain" be anything but bad?

Nevertheless, the nitrogen and sulfur "contaminants" of acid rain are essential macronutrients - elements required in large amounts to sustain all forms of life on earth. It is a well-kept secret that European and American acid deposition monitoring networks started out of the national agricultural experiment stations. Agricultural experiment stations have been sampling and analyzing atmospheric deposition of N and S for more than one century not as contaminants but as free fertilizer, literally "manna from heaven".

The world's first national acid rain program (Sweden) determined the principal effect of acid rain was improvement of crop yield and crop protein content.

In the United States, acid rain is fertilizing 300,000,000 acres of eastern forest. But rather than incur ridicule by reporting that the fertilizing acid rain benefits 99.9 percent of the forest, it was reported that acid rain may be damaging 0.1 percent of our forest - fertilization of high altitude forest by acid rain may be increasing cold damage by making forest grow too long into the winter.

In the EPA-managed lakes program, the pressure to show damage was even greater. In assessing forest damage, we used the full amount of forest on which acid rain is falling to come up with the 0.1 percent damage estimate. But not so with lakes. Rather than use the full value of 200,000,000 acres of lakes receiving acid rain, only the approximately 2,000,000 acres of lakes most likely to be acidic were considered.

Statistics was used to exaggerate the acid-lake problem 100-fold.

The principal effect of acid rain was to increase regional levels of sulfate in water but not the acidity of water. What sulfate principally did was to increase concentrations of calcium and magnesium in surface waters - the effect of which is to improve fish survivability in dilute water by increasing ionic concentration. Calcium and magnesium are also nutrients and their leaching (along with that of other nutrients) may also be improving lake nutrient (trophic) status and food supply.

Weird Science

And then, a theory was developed to support the preconceived conclusion that acid lakes are essentially the result of acid rain. A recent example of the use of this theory to say that acid rain is principally responsible for acid surface waters is a paper published in the May 24 issue of Science by a group of EPA "scientists" (Baker et al., 1991).

The fabricated acidification theory is ridiculously non-scientific. If we were in second grade and the teacher was pouring water through peat moss and we insisted on answering that he was pouring water through lime-bearing gravel, we would get a

zero. Moreover, we would then be led by the hand to the school psychologist for examination.

However, in 1984 a National Academy of Sciences panel of world-class acid rain scientists was lauded for precisely that answer. They reported a "scientific consensus". Because acid lakes and streams receive their water principally as runoff through highly acidic peaty soils and associated acidic vegetation (such as Sphagnum mosses) - which have little in the way of mineral substances to remove acid - but slight additions of acid were asserted to result in tremendous increases in acidity (large decrease in pH) of runoff. Since lime-bearing gravel can only produce alkalinity and not acidity, acid rain was asserted to be responsible for the acid lakes and streams.

Such strange science fails the reality check. The existence of peat moss is impossible to reconcile with acid rain theory. But peat moss does exist and it is the diagnostic of "sensitive" watersheds. Unfortunately, acid rain is not a typical scientific discipline where the reality of peat moss would instantly disprove the theory.

Furthermore, acid rain theory predicts that soils can not impart acid to water. That soil scientists measure soil acidity by mixing soil in water and then measuring the acidity that soil imparts to water is yet another "silver bullet" in the heart of the acid rain theory.

Three categories of NAPAP research also invalidate acid rain theory. One, isotope-dated lake sediments indicate that acidic lakes "were relatively common in the Adirondack Mountains and New England before the Industrial Revolution."

Two, laboratory and watershed experiments support the sediment research by showing that "clean rain" on acid soils gives acid runoff that resembles soil pH. This should be no surprise to soil scientists as we use 2.5 to 5 volume ratios of water-to-soil to measure the pH of materials like peat moss. This is equivalent to a flood of biblical proportions - 10-to-20 inches of instantaneous rainfall on 4 inches of peat moss.

Acid rain has little or no measurable effect on the acidity (pH) of runoff (Figure 1). Again, this should not be a surprise to soil scientists. Materials like peat moss are well buffered acids containing about 100,000 times the pH measure of their acidity (e.g., Brady, 1974, p. 384).

Three, the magnitude of acid-dead lakes and streams in areas of the world having acid soils but not acid rain dwarfs that of areas supposedly "devastated" by acid rain. In the Amazon basin, a river the size of the Mississippi, the Rio Negro is naturally acid-dead. The naturalist and explorer Alexander von Humbolt wrote about these "rivers of hunger" nearly 200 years ago, definitely pre-dating industrial activity in the jungles of the Amazon.

About 3.5% of lakes in "sensitive" watersheds of the eastern U.S. are too acidic to support viable sport fisheries ($\text{pH} \leq 5.0$). In Australia and New Zealand there are "sensitive" watersheds similar in character to those in the eastern U. S., southern

Norway, and eastern Canada. Anywhere from 28% to 79% of the surface waters in these Southern Hemisphere locations are acid-dead. There is no acid rain here. The World Meteorological Organization and others monitor the atmosphere and precipitation here to see what clean atmosphere and precipitation actually looks like (Krug, 1989).

Any one of these facts is enough to be the proverbial "silver bullet" through the heart of the acid rain theory. That a whole bandolier of such silver bullets has been shot into the heart of the theory and the theory still lives illustrates that acid rain theory derives its life from something other than science.

Again, we must credit the post-1984 NAPAP for its shift toward being scientific. In the text of NAPAP reports, for example, on page F-16 of NAPAP's 1989 Annual Report aquatic effects chapter, the popular acidification theory is discredited and my acidification theory is reported as the new international scientific consensus on surface water acidification - although the wording is so arcane (perhaps deliberately so) that one would have to be a scientific expert in the field to feel certain about it. Unfortunately, these scientific findings remain buried as they have been censored from summaries and briefing papers used to advise decision-makers and other interested parties.

The informed public is still being misled to believe that the extent of acid lakes is 100-fold greater than it actually is and that acid lakes are essentially the result of acid rain.

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WARREN BROOKES

Scientific McCarthyism at the EPA?

Last Friday, William Rosenberg, deputy administrator of the Environmental Protection Agency, issued a formal apology to environmental scientist Edward Krug for having attacked his professional credentials, after Mr. Krug's appearance on the CBS' "60 Minutes" report on acid rain Dec. 30.

That CBS report charged that Congress and the administration had ignored the findings of the \$540 million National Acid Precipitation Program (NAPAP) that could have saved the nation \$5 billion to \$8 billion a year and still reduced sulfur dioxide (SO₂) emissions.

CBS' lead witness was NAPAP Director James Mahoney, who admitted that while acid rain was a problem, NAPAP had found no crisis and that the rhetoric on acid rain was "overblown."

It then interviewed Mr. Krug, who was trained at Rutgers University, where he graduated with highest honors in environmental science and subsequently received his Ph.D. A number of Mr. Krug's research articles on aquatic acidification led to his selection by the Energy Department in 1988 to do a big study on "The Theory and Hypothesis of the Acidification of Watersheds." He also served as a peer reviewer for NAPAP.

Mr. Krug's research showed aquatic acidification was not solely or even primarily related to acid



rain, and removing SO₂ would not make large differences in lake acidity. He told CBS: "We know the acid rain problem is so small that it's hard to see."

EPA, which spent nearly two years forcing NAPAP to cast its findings in more crisis language, was furious. Instead of attacking Mr. Mahoney or NAPAP, Mr. Rosenberg

went after Mr. Krug: "It is unfortunate that CBS chose Dr. Krug as its only scientific expert on acid rain, because Dr. Krug has limited scientific credibility even in the limited area of surface water acidification." ("Only"? What about Mr. Mahoney?)

These statements, along with a sham ex post facto "peer review" of Mr. Krug's DOE report, done by an EPA contractor more than a year after its publication, constituted an apparently vicious attack on a well-qualified scientist simply because he disagreed with the EPA. It has essentially barred him from employment in any research that has government funding.

Mr. Krug says Mr. Rosenberg's attack "clearly represents libel and slander," and argues that "the circumstances surrounding this so-called peer review prove malice with forethought." The Center For Individual Rights has agreed to help him sue EPA.

When we brought this matter to EPA's attention, last week, Mr. Rosenberg sent a formal apology Federal Express to Mr. Krug that said: "We did not intend to question your reputation as a scientist, and regret and apologize that the words used may have given that impression. I understand for example that you are widely published and have been an active consultant to NAPAP."

Mr. Rosenberg called this column to emphasize that "we never intended to hurt Ed Krug professionally, and I agree that the language we used was unfortunate. We have a basic disagreement on the issue, but

that did not justify the way we expressed it." Nor did it justify a retroactive sham "peer review" of Mr. Krug's DOE study that had already received praise from five official peer reviewers in 1989, including Swedish scientist Erik Eriksson, considered the "father of acid rain" who called it "a thorough study," and warned that the whole area of acid rain suffers from "a lack of classical scientific methodology." He found Mr. Krug's "highly critical review" to be "most welcome for sifting evidence from the sea of loose speculation often found."

Indeed, much of that "loose speculation" has emanated from EPA. Mr. Rosenberg himself is not a scientist, and his EPA appointment was due mainly to his relationship (sharing an office) with President Bush's pollster, Robert Teeter. Furthermore, when the NAPAP study was first featured in my series and editorials in the Detroit News, Mr. Rosenberg told its editorial board words to the effect, "We know acid rain is not that big a deal when it comes to lakes and forests. The big issue is health effects." Yet EPA had formally concluded in March 1988 that [n]one of the available laboratory data support the notion that steady long-term exposure to acid sulfates at levels [characteristic of the United States] produce any measurable health effects."

Mr. Rosenberg was just as ill-informed about Mr. Krug, who is the only NAPAP scientist to have published an invited review on acid rain

in Science. Not only was Mr. Krug a regular consultant to EPA and to NAPAP itself, but in 1987 he was chosen as conference organizer of the Acid Rain Symposium at the American Association for the Advancement of Science annual meeting in Chicago.

In short, Ed Krug is a first-rate working scientist now being frozen out in a field that unfortunately depends heavily on EPA-controlled or influenced funding.

When we brought this to his attention, House Energy and Commerce Chairman John Dingell, Michigan Democrat, was furious, stating categorically that "Rosenberg has no credibility in this House, I wouldn't even let him in my office. I will certainly look into this matter."

Sen. Daniel Patrick Moynihan, New York Democrat, who had told CBS' "60 minutes," "It's good news to find out that you don't have a devastating problem," is now reviewing this matter as a result of a letter from Dr. S. Fred Singer, professor of environmental science at the University of Virginia, who charged that "such tactics do not bode well for other environmental debates."

It was apparent from our conversation that Mr. Rosenberg now genuinely regrets his excessive attack on Mr. Krug, though he remains a loyal supporter of the administration's acid rain program whose SO₂ reduction could have been done at no cost to the economy or the environment — had it just paid attention to NAPAP.

Warren T. Brookes is a nationally syndicated economics columnist.



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

APR 26 1991

OFFICE OF
AIR AND RADIATION

Dr. Edward Krug
513 Kerry Drive
Winona, MN 55987

Dear Dr. Krug:

It has come to my attention that you are concerned about statements made by EPA regarding the December 30, 1990, episode of "60 Minutes" on acid rain. I am advised that you have expressed concern that your professional reputation may have been affected by these statements.

This is to assure you that our comments to CBS regarding the "60 Minutes" program on January 4, 1991, were intended to express concern about the balance of views presented on the program and were not a direct reference to your professional competence. The comments were made within the context of our concern that the scientific evidence presented by "60 Minutes" did not reflect a balanced debate of the issues.

I want to make it clear that we did not intend to reflect on your professional stature but were trying to respond to the way "60 Minutes" characterized the severity of the acid rain problem. It is our position that the acid rain program, overwhelmingly passed by the Congress and reflected in the Clean Air Act Amendments of 1990, is a measured response to a variety of ecological problems, including those related to aquatics, forests, manmade materials, visibility and human health.

While you have differing views on the issue, we did not intend to question your reputation as a scientist and we regret and apologize that the words used may have given that impression. I understand, for example, that you are widely published and have been an active consultant to the National Acid Precipitation Assessment Program and the Department of Energy.

If you are interested, I would be pleased to meet with you personally to discuss the matter.

Sincerely,

A handwritten signature in cursive script that reads "William G. Rosenberg".

William G. Rosenberg
Assistant Administrator for
Air and Radiation

Edward C. Krug

Edward C. Krug is director of environmental projects at the Committee for a Constructive Tomorrow. He formerly served as associate professional scientist for the Illinois State Water Survey at the University of Illinois and assistant soil scientist at the Connecticut Agricultural Experiment Station. Krug is a frequent lecturer, and his many articles on acid rain and the relationship between soil and water acidity, the chemical effects of watersheds, and related subjects have appeared in Science, Nature, The Journal of Hydrology, The Journal of the Air Pollution Control Association, and Policy Review. He earned his doctorate in soil science at Rutgers University.