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Science adviser to Bush criticized on ozone data

By Liz Bowie *MA*

A leading authority on ozone said yesterday that President Bush is receiving "abysmal" scientific advice from his science adviser, D. Allan Bromley.

"I don't recall in 17 years of science hearing a talk with so many errors," said Sherwood Rowland, who was the first to theorize that man-made chemicals called chlorofluorocarbons were destroying the Earth's protective ozone layer.

Speaking at an international conference of atmospheric scientists at the Stouffer Harborplace Hotel on Tuesday, Dr. Bromley said that the United States should move slowly in placing new controls on the production of greenhouse gases thought to contribute to global warming.

Dr. Rowland noted several examples of what he said were scientific inaccuracies in Dr. Bromley's speech, including his description of the chemical process that destroys ozone in the upper atmosphere.

"He is out of touch with the scientific community," Dr. Rowland said, adding that European scientists at the conference were appalled by the level of advice the president is receiving. Dr. Rowland is a chemist at the University of California at Irvine. Dr. Bromley is a former physicist at Yale University.

Mr. Edward S. Goldstein
Office of Policy Development
The White House
1600 Pennsylvania Ave.
Washington, DC 20006

Out of step?

Oryx's downsizing leaves many guessing if independent oil company has stumbled

By Maria Halkias

Staff Writer of The Dallas Morning News

The way management tells it, no one being laid off from Oryx Energy Co. should be too surprised.

At the end of its third year of existence, the nation's largest independent oil and gas company is shrinking but only "temporarily."

As Robert P. Hauptfuhrer, Oryx chairman and chief executive officer, sees it, the firm's "vision has been constant. The strategies have been basically the same.

"We've just had to accelerate our plans," he said in a recent interview. A significant restructuring announced in October that eliminates 1,000 jobs and accelerates the sale of assets will return Oryx to a position of growth by the end of next year, he said.

Nonetheless, employees are bitter. Outsiders are scratching their heads and Wall Street investors are taking a wait-and-see attitude toward a company that has failed to meet expectations.

"The antelope stumbles," one Wall Street analyst wrote recently about Oryx, named after the large straight-horned African antelope.

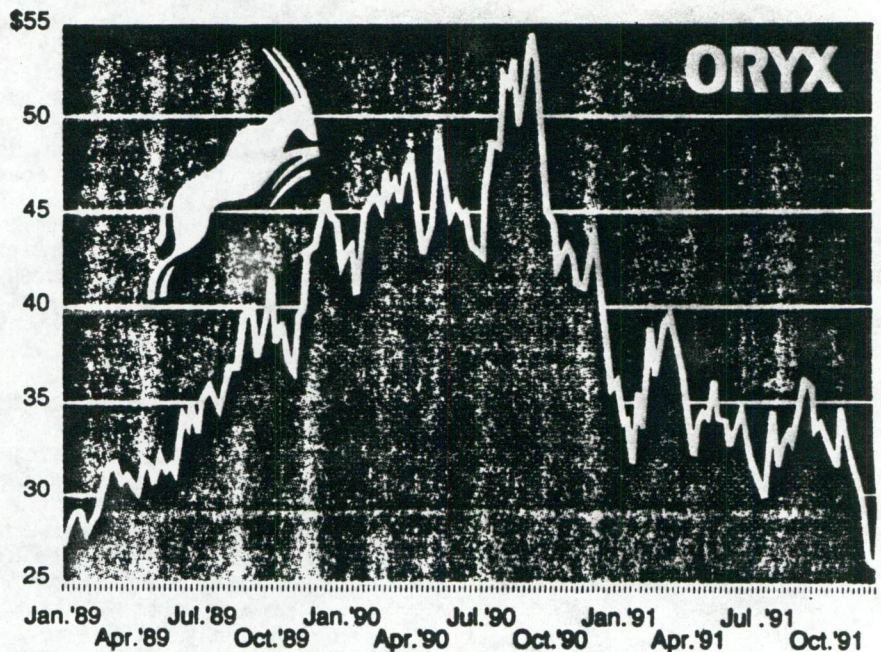
Since it was spun off from its former parent, Radnor, Pa.-based Sun Co., in late 1988, Oryx has experienced a hyperactive three years that included taking on large amounts of debt, in at least one instance, quicker than management had intended.

In late 1990, the company was set back

when its largest shareholder, the Glenmede Trust, said its Oryx investment violated its charitable trust covenants. It placed the \$1 billion stock holding up for sale. Management decided to borrow more money to repurchase the shares despite a stated strategy of debt reduction.

Glenmede's decision was one the company expected. The Oryx holdings represented a disproportionate share of the foundation's \$3.5 billion portfolio, and with a \$1.20 a share annual dividend the stock didn't produce the minimum return on investment required by the trust.

ORYX ENERGY STOCK PRICE



SOURCE: DRI / McGraw-Hill

But Oryx hoped it wouldn't have to deal with the prospect of a large chunk of its stock being placed in the market until much later, Mr. Hauptfuhrer said. "It was a divestment that was certain to happen at some time," he said.

The repurchase came at a time when Oryx's stock was trading at near a high in 1990, and Mr. Hauptfuhrer credits the company's successes with creating Glenmede's desire to sell.

In hindsight, that decision along with the collapse in already depressed natural gas prices in 1991 compounded problems for Oryx.

The company entered the international market, buying \$1 billion in assets from British Petroleum three years ago after it was divested.

"We started immediately working on trying to re-enter the international business," after the company was spun off with only domestic oil and gas reserves, Mr. Hauptfuhrer said. "We recognized if we wanted to grow — a primary objective — we had to look for reserves in some of the more promising basins, only a few of which remained in the United States."

At the same time, Oryx got Wall Street's attention by revealing its successful use of horizontal drilling technology, setting off a mini boom in the South Texas Austin Chalk. Oryx's stock price bounded to more than \$50 a share in late 1990 after initially trading in the mid-\$20s — aided by inflated oil prices following Iraq's invasion of Kuwait.

CONTINUED

Bush adviser rejects new limits on greenhouse gases

By Douglas Birch **4A**

A leading architect of the nation's science policy cautioned yesterday that the United States should continue to move slowly in placing new controls on the production of greenhouse gases thought to contribute to global warming.

"Our scientific understanding of climate change is far from certain," said D. Allan Bromley, the White

House science adviser, speaking at the opening of "Chemrawn VII," a five-day meeting in Baltimore of atmospheric scientists from around the world.

"Fundamental questions of great importance remain unanswered," said the former Yale physicist, addressing several hundred scientists at the Stouffer Harborplace Hotel. Too little is known about the chemistry of the atmosphere, he added, to take "drastic" action.

But some scientists at the conference said Dr. Bromley's remarks, which included a reference to recent tree-ring data that supports the warming theory, sounded less skeptical than previous White House pronouncements.

And Michael Oppenheimer of the Environmental Defense Fund predicted that President Bush would change his "intransigent" policy over the next year under pressure from other industrial nations and the presidential elections.

Dr. Oppenheimer said yesterday's resignation of White House Chief of Staff John H. Sununu would also help change the president's mind. Mr. Sununu is a vocal greenhouse theory skeptic.

Unlike most other developed countries, the United States has not moved toward limiting emissions of carbon dioxide, the most widespread greenhouse gas, from autos and power plants.

Scientists generally agree that agriculture, transportation and industry over the past 150 years have dramatically increased the atmosphere's load of certain gases that tend to trap the sun's heat.

But there is a dispute over whether those gases have already led to warmer global temperatures. Scientists also disagree over how far and how fast temperatures are likely to rise in coming decades and what the local effect of higher temperatures

would be.

Dr. Bromley cited recent evidence that ozone-destroying chlorofluorocarbons, once thought to be potent greenhouse gases, make no net contribution to warming.

"Preliminary" findings from research now under way, he said, suggest that another major greenhouse suspect, methane, may also have no net warming effect.

He stressed alternatives to emission controls on greenhouse gases, which he called the "lifeblood" of industry.

One was the construction of a new generation of safer and more reliable nuclear power plants. "The nuclear option in my opinion is the only technology available to us that can provide the large block of electricity that we require," he said.

Another was the creation of new "sinks" for greenhouse gases after they are released — such as a White House program to plant 1 billion carbon dioxide-absorbing trees a year on 1.5 million acres of vacant land.

And he said the United States should encourage Third World countries to use more efficient coal-burning power plant technology rather than try to impose "premature and likely ineffective controls on fuel use."

Dr. Bromley conceded that recent studies suggesting that people could adapt to greenhouse gas-induced warming with relative ease were controversial but said, "they provide a welcome balance to 'the sky-is-falling' rhetoric all too common elsewhere."

Some scientists at Chemrawn — an acronym for chemical research applied to world needs — were disappointed by Dr. Bromley's remarks. Glen E. Gordon, an atmospheric chemist with the University of Maryland, said the White House should shift its support behind energy conservation.

"Planting a billion trees sounds impressive," he said. But in terms of the amount of carbon dioxide they absorb, he added, the effects are "not all that significant."

Dr. Oppenheimer of the Environmental Defense Fund said it would be "imprudent to let uncertainties provide a barrier to action."

Information science may offer path to deeper laws of physics

70

Modern science is built around the idea of energy.

Energy transformations explain the motion and interaction of matter. One of Einstein's greatest insights was that matter itself is just energy in a special form.

But try to draw a picture of energy. You can't. You can only show the effects of energy. Energy is just a word, useful but abstract. As a physical concept, energy is a trick to make the books come out right in physicists' calculations.

Physicists have plenty of justification for using this trick. The universe is easier to understand if viewed in terms of processes involving energy — total energy remaining constant, although changing forms. But perhaps energy is not the only way of viewing reality, and perhaps other ways could lead to a deeper understanding.

Might not the universe work just as well if we described it with different equations and called what we were calculating by different names?

After all, science is just the art of making models of reality and using those models to predict how nature will behave. Often different models are equally successful at describing a given realm of reality.

In subatomic physics, for example, it is well known that sometimes the best model to use describes processes in terms of the interactions of particles. But often it is better to use a model that views those "particles" as waves.

Einstein showed that matter and energy are two different models for the same thing. He also showed that the Newtonian model of gravity — a force tugging on everything — was not as good a model as one in which gravity is viewed as a result of the geometry of space. Planets and satellites travel in their orbits not because something is tugging on them, but because they follow the natural distortions in space caused by the presence of matter.

As physicist Steven Weinberg has pointed out, though, Einstein's gravity can be viewed just as well as a force. The force model and geometry model of gravity are two equivalent ways of picturing nature.

It isn't entirely unreasonable, then, to suggest that the equations describing energy aren't the only way to understand the universe.

Some scientists, for example, like to view the universe in terms of information. Intuitively, information seems somehow less substantial than energy. But that may be only because energy is already in

control of our minds.

In a recent issue of *Physics Today*, computer scientist Rolf Landauer of IBM explored some of the issues linking the laws of physics to the manipulation of information by computers. Those laws are generally expressed in equations that imply infinite computational power — the ability to calculate pi to as many decimal places as desired, for example. But in exploring how to carry out such computations, it becomes clear that some need a computer with more memory than what is available in the entire universe.

Thus, Dr. Landauer concluded, today's laws of physics might not be the last word, but merely suggestive indications of how reality works. It may not be possible to calculate those laws as precisely as their form implies.

"I am proposing that the ultimate form of the implementable laws of physics requires only operations available (in principle) in our actual universe," Dr. Landauer wrote. Thus finding the ultimate laws of nature will require understanding more about the principles of information processing.

"Information handling is limited by the laws of physics and the number of parts available in the universe; the laws of physics are, in turn, limited by the range of information processing available," Dr. Landauer pointed out.

Physicist Wojciech Zurek points out, in another recent *Physics Today* article, that considerations of information transfer are also essential in understanding tricky phenomena of quantum physics.

The math of quantum physics implies the existence of parallel realities that we cannot detect. Information transfer between a system and its environment may have a role in resolving this quandary.

"Until recently, information was regarded as unphysical, a mere record of the tangible, material universe, existing beyond and essentially decoupled from the domain governed by the laws of physics," Dr. Zurek wrote in the October issue of *Physics Today*. "This view is no longer tenable."

Certainly the information view is not about to replace energy as the main way of describing nature. The utility and universality of energy ensure that any future science will have to incorporate or accommodate that part of current science. But perhaps puzzles in the scientific understanding of nature exist because nature can be described in many ways and we know only some of them. Energy is one approach, the standard approach. Information may someday be another — it is still in its infancy today. There may even be others, hidden from our view because of prejudices imposed by energy's successes.

**TOM
SIEGFRIED**

TALKING POINTS ON GLOBAL CLIMATE CHANGE

Current Status:

- Formal negotiations on a Framework Convention are now taking place under the auspices of the United Nations General Assembly. President Bush hosted the first negotiating session in Washington in February 1991.
- The next negotiating session will be held June 19 - 20, 1991. The Convention is expected to be ready for signature at the June 1992 U.N. Conference on Environment and Development in Brazil.
- A critical part of these negotiations will be the desire of some countries to achieve commitments on greenhouse gas reductions in the Convention.

U.S. Position:

- In these negotiations, the U.S. has championed a comprehensive approach to global climate change that incorporates all greenhouse gas emissions, and their sources and sinks. Each pollutant would be assigned a global warming potential (GWP) index in order to develop a common currency to analyze the impact of different actions.
- The advantages of this approach is emphasized in the Administration's "Action Agenda" released at the first negotiating session of the Framework Convention. This document summarizes the beneficial impacts of several recent U.S. programs including: (1) the Clean Air Act; (2) the phase-out of CFCs; (3) several DOE efficiency and renewable energy initiatives; and (4) an EPA rule to control VOC and methane emissions from landfills.
- Taken together, the "Action Agenda" predicts that these actions will cause U.S. greenhouse gas emissions to be at or below 1987 emission levels in the year 2000.
- The National Energy Strategy, if implemented as proposed, would further reduce emissions because of additional energy efficiency measures, and its increased emphasis on lower emitting fuels, such as natural gas, nuclear power, renewable energy, and the use of alternative fuels in the transportation sector.

- DOE estimates that the NES would allow us to hold greenhouse gas emissions to current levels beyond the year 2000.
- If the NES is not implemented, however, greenhouse gas emissions, as measured by the GWP, would increase significantly beyond 2000 due to increased coal use for electricity generation, and the growth of auto emissions.

U.K. Position:

- The U.K. has announced support for a 20 percent reduction in greenhouse gases by 2005 if other countries do the same. When this policy was developed, Mr. Heseltine advocated a more aggressive position of a 20 percent reduction by 2000.
- In preparing for the June negotiation session, the U.K. has shared the attached draft negotiation text with the U.S. In that text, the U.K. endorses what it describes as an "Incremental Comprehensive Approach," or a gradual phase-in of the U.S. comprehensive approach. We believe Mr. Heseltine will ask for support for this approach in your meeting. (See the attached article.)
- While the labels of this approach sound appealing, the U.K. proposal provides only lip-service to the U.S. approach because it would divide pollutants and sources/sinks into different categories: Annex A for pollutants and sources/sinks for which a GWP index and emission information is accepted; and Annex B for pollutants and sources/sinks where scientific uncertainties remain. Annex A would be controlled under the convention; Annex B would not.
- Nations would be invited to make commitments on emissions covered by Annex A. Scientific research would go forward on Annex B gases and sources/sinks, which would then be added to the Convention when knowledge and agreement permits.
- In the short-term, this approach would allow the U.K. to isolate those pollutants and sources which they believe should be controlled first. In the draft paper, the U.K. proposes that Annex A contain CO₂ and methane emissions from the energy and waste sectors.

- The U.K. also opposes the inclusion of greenhouse gas emissions covered under the Montreal Protocol, except to consider giving credit for countries which reduce emissions on an accelerated basis.
- The U.K.'s position on climate change is evident in the draft thematic papers prepared for the London Economic Summit. (These papers will form the basis of the Summit's final communique.) In the rewrites of the thematic papers, the treatment of climate change has consistently worsened. The latest draft references the use of several climate change "protocols" and excludes pollutants covered by the Montreal Protocol.

Britain to offer deal to US on greenhouse gas effects

By John Hunt, Environment Correspondent

BRITAIN is to offer the US a controversial compromise over international policies to combat greenhouse gases.

The US, the world's largest producer of carbon dioxide, the chief greenhouse gas, has refused to set targets for its reduction, although most western European and Scandinavian countries have done so. This is an increasing embarrassment in the run-up to the Earth Environmental Summit in Rio de Janeiro next year, which is planned as a forum to draw up a world climate convention to control global warming.

The proposals by Mr Michael Heseltine, the environment secretary, are disclosed in a confidential Department of Environment document prepared for his visit to Washington this week where he will attempt to bridge the gap between the US and Europe in an effort to gain a common approach at Rio.

Mr Heseltine will propose a "phased, comprehensive" programme which would allow countries to make "national commitments" to reductions in a range of greenhouse gases. This would include gases such as methane and CFCs (chloro-fluorocarbons) where cuts are more easily achievable than in carbon dioxide.

It would enable countries such as the US to claim across-the-board reductions in total greenhouse gases even if they made little progress in cutting carbon dioxide.

Britain would also be able to claim a total reduction of 20 per cent in this range of gases by 2005 - far more impressive than its present agreement merely to stabilise carbon dioxide output by that year, according to environmentalists.

But the compromise plan has angered environmentalists who believe the government plan will concede too much to the US.

They believe Mr Heseltine's position signals a change in British policy because it is a retreat from attempts to agree international targets for cuts in carbon dioxide emissions, which are mainly caused by fossil fuels such as coal, oil and gas.

Mr Heseltine will be seeing Mr John Sununu, President George Bush's chief of staff, who is the leading US opponent of targets for carbon dioxide and a sceptic on global warming. Mr Heseltine will also hold talks with Mr Bill Reilly, head of the US Environment Protection Agency.

The Department of Environment document says: "The best set of response measures will be different for each nation. Flexibility in setting national commitments will encourage all nations to adopt the maximum spread of policy responses."

Mr Steve Ellsworth, Greenpeace atmosphere campaigner, said the British plan "is a sell out to the Americans and carefully calculated to impress domestic opinion in Britain".

The Department of the Environment denied the charge. It said: "Some countries want to go faster than others in making reductions. A compromise agreement is better than no agreement at all."

Withdrawal/Redaction Sheet

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- P-5 Release would disclose confidential advice between the President and his advisors, or between such advisors [(a)(5) of the PRA]



U.S. Department of Justice

Environment and Natural Resources Division

Office of the Assistant Attorney General

Washington, D.C. 20530

January 14, 1990

MEMORANDUM

TO: Members of the DPC Global Change Strategy Group

FROM: Dick Stewart *RBS/RS*
Assistant Attorney General

SUBJECT: Article on Climate Approaches

Attached for your information is a copy of the article we recently published describing the "comprehensive" and "incentives" approaches to potential climate change. This is the article that Dr. Bromley circulated on September 20 for clearance by the DPC Global Change Strategy Group. Thank you very much for all of your helpful comments, which greatly improved the article.

A COMPREHENSIVE APPROACH TO **CLIMATE CHANGE**

**USING THE MARKET TO
PROTECT THE ENVIRONMENT**

ENVIRONMENTAL OFFICIALS from around the world are poised to negotiate an agreement that will set the framework for future efforts to address potential climate change. When the talks begin in February 1991, the need for clear thinking on climate policy will be acute.

The likelihood and potential impact of climate change must be considered. The recent First Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) found that increases in the so-called "greenhouse gases," which trap solar energy when it rebounds off the earth's surface, are likely to yield increases in atmospheric temperature, but that major uncertainties frustrate our

Richard B. Stewart is assistant attorney general, Environment and Natural Resources Division, the U.S. Department of Justice. Jonathan B. Wiener is special assistant to the assistant attorney general. The views expressed herein are their own and do not necessarily represent the views of the Department of Justice or the United States.

ability to forecast the magnitude, timing, or regional patterns of any climate change.

At the same time, the costs and benefits of climate change and of options to limit or adapt to it also must be considered. These are even more uncertain questions on which neither the IPCC nor anyone else has made much progress.

Then, if preventive efforts are deemed warranted—a big "if," given the above uncertainties—the design of any policy steps must be considered. Unfortunately, the tenor of current climate discussions indicates that old mistakes in policy design are likely to be repeated. Proposals to address potential climate change have focused narrowly on immediate, uniform controls on emissions of one greenhouse gas: carbon dioxide emitted by the energy sector. Such piecemeal, command-and-control approaches, mandating centrally specified, inflexible responses to subsets of complex environmental problems, will almost surely deliver, as they have in the past in other contexts, environmentally counterproductive and economically unsound results.

BY RICHARD B. STEWART AND JONATHAN B. WIENER

A far better approach would be a "comprehensive" one that addresses the net environmental impacts of all greenhouse gases. Such an approach is essential to understanding climate change and to determining the costs and benefits of policy options. It is also essential to fashioning environmentally effective and less-costly policy measures that nations or the world community may choose to adopt. Any such measures should use market-based incentives, rather than command-and-control methods, in order to achieve environmentally superior results at less cost.

Influences on the Climate System

Potential climate change is an issue of enormous complexity. Any change in global average annual temperature would occur over many years through the workings of very complex natural systems and in turn would affect patterns of local temperature, precipitation, soil moisture, and sea level.

The greenhouse gases (GHGs)—carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), tropospheric ozone (O₃), halocarbons such as chlorofluorocarbons (CFCs), and others—are emitted by many sources. Each gas has a different capacity to trap heat in the atmosphere, called its "radiative-forcing" ability, and each resides in the atmosphere for a different period of time. Together, these factors determine the relative radiative-forcing potentials of the GHGs (see table). Each GHG also has environmental consequences resulting from its direct chemical effects on the atmosphere and on plant and animal life: CO₂ aids plant photosynthesis and water use efficiency, for example, while CFCs deplete the stratospheric ozone layer. One GHG or another is emitted or affected by virtually every ecological, social, and economic activity in every area of the world. The gases are removed from the atmosphere in varying degrees by natural "sinks": CO₂, for example, is removed in the photosynthesis carried on by trees, crops, grasses, and oceanic phytoplankton, and stored in plant material, soils, and the deep ocean.

Environmental policy design must match the ecological system it seeks to address. From the climate perspective, the variable of environmental concern is not emissions of CO₂, or the carbon content of fuels, or energy effi-

ciency. It is the *net emissions (sources minus sinks) of all greenhouse gases, weighted by their relative impacts on the environment.* Any policy response to climate—setting a scientific research agenda, enumerating climate-relevant measures (such as reforestation or eliminating CFCs) justified on other grounds, or adopting GHG limitation measures—must therefore be *comprehensive*, matching the climate system.

Carboncentric Thinking

But those proposing immediate GHG reductions typically focus narrowly on limiting CO₂ emissions from fossil-fuel combustion. Many such proposals are made by nations that would enjoy a competitive advantage under such policies: those that can rely on noncarbon or low-carbon energy sources (such as nuclear, hydropower, or natural gas) or those that expect to conserve energy more cheaply than their trading rivals. But such a narrow focus is not warranted by the facts about GHGs or by sound policy.

First, it is clear that the greenhouse effect cannot be attributed to CO₂ alone. It is portrayed as the chief culprit in potential global warming because, by volume, it has accounted for a large share of the total output of GHGs. But because any policies to limit GHGs must necessarily address future increments of net GHG emissions, it is the comparative impact of additional amounts of each gas that must be addressed. CO₂, molecule for molecule, is the *weakest* of the anthropogenic GHGs. As the relative radiative forcing figures in the table show, a unit of CO₂, its typically long residence in the atmosphere notwithstanding, is the least potent contributor to potential warming. Moreover, because there is already so much natural CO₂ in the atmosphere, the band of the electromagnetic spectrum that CO₂ molecules block is becoming almost fully occluded, creating a saturation effect—a kind of atmospheric law of diminishing marginal returns—which means that the relative radiative forcing of future CO₂ molecules will be even less. Further, CO₂ in the atmosphere is not increasing as rapidly as other GHGs; the atmospheric concentration of CO₂ is increasing at about 0.3 percent per year, CH₄ about 1 percent, and CFCs over 4 percent. (Although the goal of the international treaty to protect the stratospheric ozone layer—the

Gas	Instantaneous radiative forcing per kg of emissions	Atmospheric residence years (estimated)	Relative radiative forcing potential over lifetime*
CO ₂	1	120	1
CH ₄	58	10	21
N ₂ O	206	150	290
CFC-11	3970	60	3500
CFC-12	5750	130	7300

Note: *—Calculated over a 100-year time horizon.

Source: IPCC Scientific Assessment, tables 2.3 and 2.8.

RELATIVE RADIATIVE FORCING OF SELECTED GASES

Montreal Protocol—is to phase out CFCs, their more ozone-friendly substitutes are still likely to be significant GHGs.)

Meanwhile, CO₂ provides significant benefits that the other GHGs do not. CO₂ is the grist of photosynthesis. Higher concentrations of CO₂ in the atmosphere are likely to substantially improve plant productivity and increase the efficiency with which plants use water. The other GHGs confer no such benefits, and some pose serious threats unrelated to possible global warming. CFCs, for example, deplete the stratospheric ozone layer. In order to provide a better guide to policy choices, the radiative forcing index of GHGs could be expanded to incorporate other—positive and negative—environmental impacts of each GHG. CO₂ would receive a credit for enriching plant growth, CFCs a debit for ozone depletion.

In sum, unit-for-unit, CO₂ is probably the most environmentally benign of the GHGs. If the biosphere had to accept any given amount of predicted warming, then on purely environmental grounds and abstracting from the costs of control, it would probably prefer to have the warming due to CO₂ and not to other GHGs. CO₂ is thus the last gas, on environmental grounds, whose incremental additions one would want to restrict. Still, any extensive measures to limit net GHG emissions—even under a comprehensive approach—would probably mean some limits on CO₂, the most-prevalent of the anthropogenic GHGs. Moreover, a full analysis requires consideration of the costs of limitation as well as the benefits. It would be economically and environmentally irrational to focus solely on one GHG in any measures to limit climate change, because the greatest benefit may often be had for less cost by addressing other GHGs.

Focus on the energy sector is likewise inappropriate. Certainly the energy sector produces a large share of global CO₂, carbon monoxide (CO), CH₄, volatile organic compounds (VOCs), and nitrogen oxides (NO_x). But the GHGs arise from a variety of sources in every sector: agriculture, where rice paddies and livestock disgorge enormous amounts of CH₄ and fertilized fields release N₂O; forestry, where tree-cutting and soil disruption liberate about 10 to 33 percent of global anthropogenic CO₂; industry, which emits large amounts of CFCs, VOCs, CO, and NO_x; transportation, which yields CO, VOCs, and CFCs in addition

**IF LIMITS ON GHG
EMISSIONS ARE DEEMED
WARRANTED, A COMPRE-
HENSIVE APPROACH
WOULD HAVE IMPORTANT
ECONOMIC AND ENVIRON-
MENTAL ADVANTAGES. IT
WOULD ALLOW EACH
NATION THE FLEXIBILITY
TO DEVISE ITS OWN COST-
EFFECTIVE POLICY MIX.**

to CO₂; and the residential and commercial sector, which produces CO₂, VOCs and CFCs.

And in addition to GHG sources, the GHG sinks deserve serious attention. It is *net* emissions that matter for climate system functions. The net flow of GHGs into the atmosphere is the result of emissions from surface sources and removal by surface sinks, including ocean mixing, oceanic phytoplankton, trees, grasses, soil biota, crops, and tropospheric chemical reactions. Plants remove CO₂ from the atmosphere during photosynthesis; preserving and properly managing forests and other vegetation or protecting phytoplankton from anthropogenic injury can help sequester CO₂ released from surface sources.

The Comprehensive Approach

Any climate policy must be comprehensive to match the diverse character of GHGs, their sources, and sinks. Scientific studies, technology development, enumeration of current climate-relevant actions taken for other reasons, or proposals to limit GHGs should be based on net emissions of all GHGs, sources, and sinks and on weighting GHGs according to an index of their comparative environmental impacts. This comprehensive design would ensure that no important GHG or GHG-related activity is ignored, while providing a guide to addressing the most environmentally significant GHGs rather than fixing narrowly on one gas or sector.

If the strategy is technology development or enumeration of otherwise justified actions, a comprehensive approach is necessary to determine which technologies and actions are climate-relevant. If limits on GHG emissions are deemed warranted, a comprehensive approach would have important economic and environmental advantages. It would allow each nation the flexibility to devise its own cost-effective policy mix. Because the marginal costs of limiting emissions will vary across nations by gas, source, sink, and technique, a piecemeal or uniform approach would impose undue costs on those who could achieve the same environmental objective by less costly means. The flexibility afforded under a comprehensive approach would allow choice among all available response options, ensuring that costs are minimized. For example, the

least-cost policy option for limiting net emissions in one nation may be switching from coal to natural gas, while for another nation it may be changing agricultural practices to reduce CH₄ and N₂O emissions, and for another it may be reducing deforestation and ensuring sustainable forest management. Put another way, reducing emissions of CO₂ from fossil-fuel combustion (or stopping deforestation, or any other single tactic) might be the cheapest way to limit overall net GHG emissions in one nation but the most expensive in another. Rigid, uniform requirements would be economically irrational, needlessly driving up social costs.

The "net emissions" aspect of the comprehensive approach would also provide significant benefits by encouraging sink expansion through expansion of forest areas and preservation and protection of phytoplankton habitats from pollution. In addition to limiting net GHG emissions, these activities could provide other benefits in biodiversity, oceanic food webs, reduced soil erosion, and better timber management.

Anticipating "Unanticipated Consequences"

The comprehensive approach would also avoid a notorious drawback of piecemeal approaches: unwanted shifts to unregulated activities that continue to produce environmental degradation. For example, under a CO₂-only approach, utilities would probably switch from coal to natural gas (methane) because, with current combustion techniques, burning coal produces almost twice as much CO₂ per BTU as burning natural gas. But use of natural gas leads to CH₄ emissions because it leaks from natural-gas mining and transportation systems. One recent study estimates that with a 3-6 percent rate of CH₄ leakage from natural-gas transport, such leaks would fully offset all the CO₂-related radiative-forcing savings from switching from coal to natural gas. Such leakage rates are probably higher than the average in the United States, but may be typical elsewhere. And a swift expansion of natural-gas transport capacity to comply with a stiff CO₂ reduction target could well mean the use of hastily designed new facilities or older facilities in disrepair with leakage rates higher than today's. Hence, the result of

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piecemeal fuel switching could be even greater net GHG emissions than in the absence of the CO₂-reduction rule. Even if the CH₄ leakage rate only offset, say, 50 percent of the CO₂ savings, the CO₂-only policy would be severely undermined. Similarly, a transportation-only policy requiring, say, the use of electric vehicles, could shift production of emissions to the central power stations that recharge the vehicles' batteries. The comprehensive approach, on the other hand, would encompass all relevant emissions and thereby ensure that policies and incentives address the full net GHG emissions inventory.

A different kind of inadvertent shift would attend restrictions on fossil-fuel consumption applied piecemeal to one group of nations (such as OECD countries). If developing countries' net GHG emissions continue to rise at current rates, even radical OECD-only policies will be unable to arrest growth in global emissions. And the OECD nations would most likely respond by limiting imported fuels first, which would lower prices for those fuels on world markets and increase consumption in other nations. Depending on the sensitivity of consumption to prices and the efficiency of fuel combustion in the various countries, total GHG emissions might even rise. Over the slightly longer term, restrictions in only some nations could induce GHG-emitting industries to move to unregulated locations. These concerns indicate the need for comprehensive scope of coverage and international cooperation on any limitations measures.

Applying the Comprehensive Approach

Any framework convention on climate change should promote a cooperative scientific research and reporting agenda that would facilitate the comprehensive approach by examining all GHGs, sources, and sinks. It should also ensure that any future protocol follow the comprehensive approach. The convention could assure that any actions taken by a nation after a chosen baseline date will be credited to that nation's limitation obligations, if any, under a future protocol, relying on a provisional index of relative GHG impacts established at the convention. Without such advance assurances, nations would be hesitant to take even climate-relevant steps that are justified

on other grounds lest they lose credit for such steps when a climate agreement is signed. This fear would frustrate independently desirable policy steps (such as energy conservation or reforestation) while adding to pressure for hasty adoption of a climate protocol.

The major objection that has been raised to the comprehensive approach is that current science is not adequate for monitoring certain sources and sinks, such as nonpoint (diffuse or mobile) sources of CH₄ and N₂O. The objectors say that we should "do what we can now" and wait until later to design a comprehensive approach. The counterargument is that while monitoring such emissions is not easy it is not beyond our reach if we orient current research efforts to support a comprehensive approach. Moreover, our experience belies the suggestion that piecemeal initiatives can eventually be transformed into a comprehensive strategy. Piecemeal measures tend to create vested interests that fight to ensure the perpetuation of their favorite measures. For example, the overbroad Prevention of Significant Deterioration (PSD) provisions in the Clean Air Act limit industrial development in many regions of the United States, often without environmental justification. But other regions oppose relaxing these limits for fear prosperity will shift to those regions now subject to PSD controls. Similarly, any global climate agreement targeted at energy-sector CO₂ limitations would benefit some nations more than others. The favored nations would resist development of a more comprehensive approach that would treat all nations with an even hand. It is vital, therefore, to start with a comprehensive approach at the outset.

The pertinent question is not what is immediately feasible but whether the costs of proceeding with a flawed policy design are less than the costs of doing the necessary groundwork to develop and implement a comprehensive approach. The answer is that we need not wait for perfection; in the interim, proxy-based estimates of difficult-to-measure emissions can be used. A framework convention (or another agreement) can provide incentives for investments in developing or improving the requisite monitoring capabilities, such as by offering credit for national reductions in difficult-to-monitor GHGs upon demonstration of the relevant monitoring techniques to an expert panel.

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Market-Based Incentives

The virtues of market-based economic incentives for environmental protection are increasingly recognized. Fees or taxes, tradeable allowances, and deposit-refund programs have been successful in several important environmental applications, and we are learning how to apply them in others. The tradeable credits program used to phase out lead in gasoline achieved its goal at about half the cost of traditional regulation, saving hundreds of millions of dollars. Deposit-refund programs have aided in reducing litter and recycling beverage containers. Both fees and tradeable allowances are now part of the U.S. program to eliminate CFC use under the Montreal Protocol. And tradeable allowances have been proposed for the acid-rain-reduction provisions of the new Clean Air Act, with projected national savings of \$1 billion annually when compared to a command-and-control program. Meanwhile, we have learned a great deal about the drawbacks of traditional regulatory approaches—the centrally specified, uniform, and rigid edicts of "command-and-control" methods—in terms of their cost, obstacles to innovation, ecological shortsightedness, and legal and administrative burdens.

Market-based incentives respond to market failures such as excessive pollution by harnessing and redirecting market forces to engender socially and environmentally responsible behavior. At the same time, they allow flexibility among regulated firms, promote diverse and cost-minimizing solutions by allowing those who can fix a problem most cheaply to do so, and stimulate efficient resource use and innovation in technologies and practices.

Market-based techniques are especially well-suited to any limitation measures for GHGs that might be adopted nationally or worldwide. Because GHG emissions arise from so many diverse and pervasive sources, the costs of abatement are bound to vary widely among emitters. Market-based mechanisms use that variation to social advantage by imposing a restraint on total emissions—a limit on the net quantity emitted or a fee for each unit emitted—but then letting the market allocate the burden of abatement to those who can most easily shoulder it.

Two main economic instruments have

been suggested for limiting emissions of GHGs: tradeable allowances and emissions taxes. Tradeable allowances would set a total limit on net emissions, issue that sum of allowances to emitters, and let emitters trade them. Those for whom emissions reductions or sink expansions would be relatively more expensive would buy additional allowances, while those who could achieve limitations goals cheaply would sell their extra allowances. Each emitter would try to develop new means of limiting emissions at less cost than its competitors so that it could sell its allowances at a profit. Emissions control, efficient use of fuels and other inputs, and innovation of new control techniques would become profit centers for the emitter. The market would allocate limitations to those who limited emissions at least cost, reducing the overall cost to society.

Domestically, governments could issue allowances for net GHG emissions. Those who were issued allowances could meet their limitation obligations through such steps as energy conservation, fuel switching, reducing CH₄ leaks, planting trees, or contracting for limitations by other regulated firms. Allowances could be made of limited duration, or leasable, to relieve fears of hoarding or other distortions due to exercise of market power. Government clearinghouses, private brokers, and banks would act to facilitate trading among disparate parties and over time.

Any internationally agreed national obligations to limit GHGs could be advantageously reallocated among nations through bilateral or multilateral trades. One nation could satisfy its obligations by investing in response actions in another. For example, Nation A could provide new energy technology to Nation B in return for all or part of the value of B's reduction in emissions. Or Nation C could plant and manage trees in Nation D's territory in return for their CO₂ sink value while offering assistance to D to compensate for the reduction in arable land area. Nation E might earn the opportunity to record certain emissions reductions achieved in Nation F in return for debt forgiveness promised to F. Given significant international variations in marginal costs of limitation, mutually agreed trades would probably enable the world economy to realize substantial cost savings. These arrangements would demonstrate the power of applying Adam Smith's lessons of comparative advan-

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tage to global environmental resources. Such trading in GHG limitations would also serve as a market-based, decentralized vehicle for introducing needed capital and low-GHG-emitting technology into the developing world. Opportunities to obtain valuable emissions allowances by investing in lower-cost net GHG emissions limitations in developing nations (where, for example, energy production facilities do not yet exist) would attract funding from industrialized countries and stimulate innovation of low-GHG technologies useful in developing nations. This framework would obviate creation of a heavily bureaucratized, centralized regulatory authority and technology-assistance fund, with its attendant opportunities for waste and misallocation of benefits.

Emissions taxes for net GHG emissions are another important option. The tax rate could be geared to the GHG index value of the emissions activity. Like emissions trading, emissions taxes offer a cost-effective solution that promotes innovation and efficient resource use. Such a plan could work well within a nation, especially where the emphasis is on specifying the cost of the GHG-limitation program more precisely than the quantity of emissions avoided, or where revenue raising is a major goal. International application of a tax would raise more difficult questions: Would nations cede their sovereignty to an international tax authority? How would the tax be set? How would the potentially enormous revenues raised be allotted and expended?

Conclusion

Experience has shown the inadequacy of employing piecemeal, command-and-control approaches in environmental policy. Reinventing these square wheels in the climate context would surely be ecologically misguided and economically disruptive. A comprehensive approach is the foundation for sound analysis and treatment of the complex climate system and its interactions with socioeconomic activities, whatever level or type of effort nations or the world community may choose to expend on these issues. Should any policy measures be implemented, both a comprehensive design and the use of market-based incentives would be indispensable.



agencies from litigation. A DOD source suggests that federal agencies may be sued for not fulfilling NEPA, despite an Oct. 2 DOJ memo arguing that NEPA does not apply to CERCLA cleanups initiated by federal agencies. This source says the DOJ opinion is not sufficient to block citizen suits, and since fulfilling NEPA takes only a small additional effort beyond the RI/FS, questions the wisdom of "go[ing] out on a legal limb" by not completing it. Another Administration source says CEQ has maintained that an EIS addresses ecological and wildlife concerns that CERCLA does not. EPA staff acknowledge that Superfund has tended to focus first on human health risks. Administration sources also argue that NEPA requires more public input in remedy selection, which may lead to greater public acceptance of the eventual remedy, thereby preventing litigation later.

Dropping NEPA would be a vote of confidence for EPA, because EPA has primary oversight authority for CERCLA while CEQ oversees NEPA, an environmentalist argues. This source suggests that NEPA "takes crucial decisions out of the hands of the regulators" at EPA and turns them over to officers of the other involved agencies. Another environmentalist suggests the dispute over NEPA may be little more than a power play between agencies, with EPA trying to maintain control over cleanups and other agencies trying to take some authority under NEPA. But EPA, CEQ and DOD sources all say the NEPA/CERCLA debate will not engender any shift in authority, and none of their agencies are looking at the debate as a power struggle. These sources say the battle is simply a philosophical debate between agencies trying to craft the most efficient method of environmental protection.

MOST COST-EFFECTIVE GREENHOUSE PLAN MUST TARGET WORST GASES, NEW STUDY SAYS

Certain greenhouse gases are far more potent than carbon dioxide in terms of global warming potential, a new EPA-prepared analysis finds, and the U.S. must consider this in determining the most cost-effective approach for tackling the problem. Many following the global warming debate have associated carbon dioxide as the most harmful of the greenhouse gases, because it is the most pervasive. But in fact other gases possess more heating potential -- such as methane, which is 21 times stronger than CO₂ -- and must be reckoned with accordingly, the new study says.

The EPA analysis, *The cost of reducing greenhouse gas emissions in the United States*, was prepared by Alex Cristofaro, director of EPA's air & energy policy division in the Office of Policy, Planning & Evaluation, for a Dec. 4-5 conference. The conference, *Global climate change: the economic costs of mitigation and adaptation*, organized by the Center for Environmental Information, Inc., was partly funded by EPA.

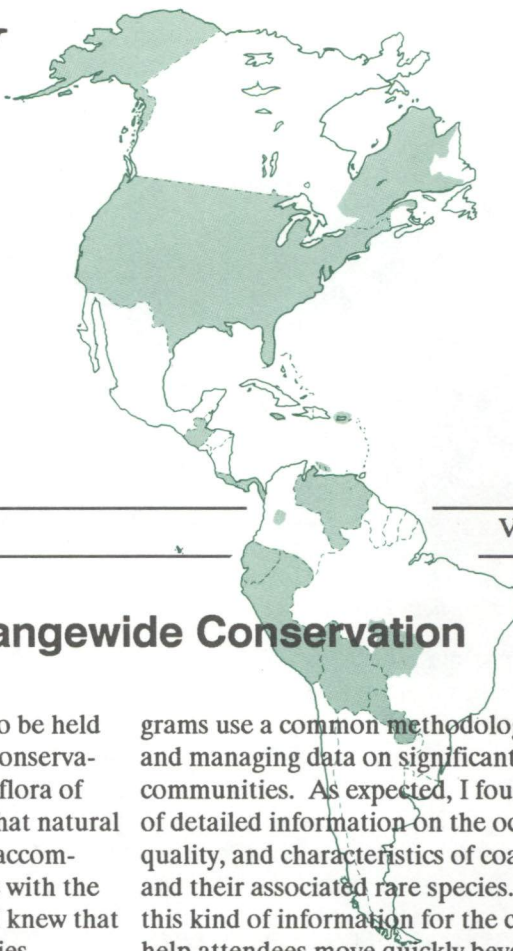
Existing federal programs may be adequate to limit greenhouse gas emissions in the U.S. to today's level on a per capita basis for the next 10-20 years, Cristofaro concludes: "This is because current government energy and environmental policies are sufficient to keep total greenhouse gas emissions (expressed as carbon equivalents) below 1987 levels in the year 2000. In 2010 total emissions are projected to be only 4% above current levels in one scenario and essentially the same as 1990 levels in another." But, he notes, CO₂ is projected to grow, so "if the goal is stabilization of the absolute level of CO₂, additional government control programs would be necessary."

The analysis says several opportunities exist for reducing U.S. greenhouse gas emissions. But the way the U.S. chooses to do this will be critical from a cost-benefits standpoint. For instance, Cristofaro points out that NO_x emissions trap 40 times more heat than CO₂, so that control costs of \$400/ton for NO_x would be as cost-effective in reducing warming as CO₂ controls that cost \$10/ton. More importantly, NO_x controls would offer other environmental benefits. "NO_x deposition has been identified as an important contributor to nitrogen loadings in water bodies and NO_x plays a role in the formation of tropospheric ozone, visibility impairment and acid deposition. These benefits should be taken into account in analyzing the economic efficiency of reducing GHGs," the analysis says.

Since methane is a significant greenhouse gas, 21 times more potent than CO₂, control opportunities should not be overlooked, the analysis says. Cristofaro notes that animal waste is a large source of methane, but points out that promising technologies currently exist for methane recovery which could both reduce emissions by almost 50% and generate electricity at a cost of five to seven cents per kilowatt hour. With regard to methane, Cristofaro emphasizes, ". . . the lack of data on methane control could be rectified in the near future. The Clean Air Act Amendments of 1990 require EPA to issue a report to Congress on methane emission inventories and control costs."

Opportunities for NO_x reductions remain as well. Cristofaro suggests low NO_x burner controls could be broadened to cover existing industrial boilers and small electric utility boilers. Carbon monoxide, which is eight times stronger than CO₂, will be limited under the new Clean Air Act, but the extent of CO controls

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Networking Heritage Data for Rangewide Conservation

*Sue Crispin
Coordinator,
Canadian
Heritage Task
Force*

Last spring, I read about a conference to be held in Nova Scotia, aimed at developing a conservation strategy for the coastal plain pond flora of North America. My first thought was that natural heritage program data was essential in accomplishing that task. From my experience with the Michigan Natural Features Inventory, I knew that amazing assemblages of rare plant species concentrate in these small coastal seepage depressions that are vulnerable to water table alterations, development, nutrient loading, and mudhole-loving off-road vehicles. Since coastal plain ponds are so threatened and are distributed in a broad geographic range along the Atlantic and Gulf coasts and disjunctly around the southern Great Lakes, this community offered a great opportunity for applying multi-state heritage data to a distinct ecological type.

I set out to gather pertinent data from heritage programs located around the Great Lakes and along the Atlantic coast. A relatively simple task, I predicted, since all heritage pro-

grams use a common methodology for collecting and managing data on significant species and communities. As expected, I found a gold mine of detailed information on the occurrence, quality, and characteristics of coastal plain ponds and their associated rare species. Summarizing this kind of information for the conference could help attendees move quickly beyond the need to document resources and begin to focus on protection strategy.

The occurrence and status information was compatibly managed and formatted, just as I knew it would be. However, each heritage program operates independently, and manages data on a state by state basis, so I found it necessary to contact programs individually in order to create a single summary usable for conservation planning. This process illuminated for me, the growing need for state and national governments to begin coordinating information across jurisdictional boundaries.

For example, heritage program ecologists in most New England and Great Lakes states rank coastal plain community types as an "S2" or "S2S3", indicating a rare to moderately imperiled status. The relatively large number of examples of coastal plain ponds per state (e.g., more than 20 in Michigan, more than 50 in New York, and more than 200 in Massachusetts) probably dilutes the priority of any given example, even though individual sites are typically small, highly vulnerable, and often at risk. Also, although coastal plain ponds usually support extraordinary numbers of rare plant species, seldom are those species rare enough rangewide to merit a high

Networking the Network

The natural heritage programs and conservation data centers form a network of permanent information-gathering institutions designed to assist in conservation planning, natural resource management, environmental impact assessment and planning for sustainable development. While these programs operate independently, they are unified by a consistent method of collecting and recording data. This issue of Biodiversity Network News looks at the variety of ways these data support regional and national conservation planning in the United States, Canada, Latin America and the Caribbean.



Dunahoe Bay, North Carolina, one of several types of Coastal Plain Pond Community in the South. Photo: Frederick Annand.

global rank. So, while this fragile community receives moderate priority for protection in most New England and Great Lakes states, the level of protection is probably not enough to balance the increasing threat and losses over the range.

I found another hurdle in attempting to synthesize rangewide coastal plain pond data when I tried to include information from the southern Atlantic and Gulf coastal states. In the highly diverse south, there is a much wider array of coastal plain pond community types and the communities may be classified differently according to vegetation. This points out another constraint in networking heritage data for rangewide conservation planning--the difficult business of ecological classification.

Traditionally, community classifications have been developed independently by individual state heritage programs. Thus, a coastal plain marsh in Michigan is called a coastal plain pond shore in Massachusetts, which is probably much the same as a small depression pond in North Carolina--or

is it? To overcome this obstacle, ecologists in The Nature Conservancy and throughout the heritage network are developing regional classifications. Besides providing translations among state classifications, standardized regional names facilitate rangewide endangerment ranking and conservation planning for natural communities and ecosystems. The regional classifications will be further integrated with national and international classifications. As a

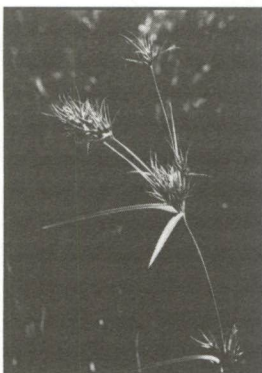
result of these efforts, the global status rank of the coastal plain pond community has been

estimated as "G3" or globally rare.

Data synthesis across jurisdictional boundaries is clearly essential to true biological (element-based) conservation planning. Without a larger picture, all efforts will suffer from the limitations imposed by the piecemeal nature of a fragmented geographic perspective--the equivalent of wearing blinders. Conversely, the potential of networked element occurrence and site data to assist rangewide conservation planning is tremendous.

Rangewide data are crucial for successfully evaluating the status and planning the protection of rare elements ranging over multiple states, provinces, or nations. Other than coastal plain ponds, prime examples include the piping plover (*Charadrius melodus*) ranging from Canada through the Bahamas and the curly grass fern (*Schizaea pusilla*) locally abundant in New Jersey and eastern Canada, and occurring disjunctly in Peru. While the U.S. Endangered Species program addresses rangewide conservation through the recovery planning process, routine access to aggregated heritage data would undoubtedly expedite that process and make such conservation planning possible for a much larger group of community types as well as species not now federally listed. Improved access would also facilitate tapping into federal protection mechanisms as well as use of national and international resources to accomplish conservation work. At the state level, access to rangewide element data would permit more finely focused state inventory/protection priorities and would also promote interstate cooperation on the conservation of shared elements. In addition to simple element conservation, any nationally or internationally integrated, large-scale plan for ecosystem protection requires the ability to see beyond political boundaries, since most ecosystems and many large sites range across those boundaries.

A convenient mechanism for synthesizing multi-state heritage data on coastal plain pond communities was absent, but I was satisfied with pulling together Natural Diversity Scorecards from individual states. The scorecard report, which summarizes all locations of priority elements in order of quality, condition, viability and defensibility, forms the basis for annual conservation planning meetings in most states. The Conservancy's Midwest Heritage Task Force has led the way in applying use of the scorecard



Rhynchospora macrostachya, a beakrush characteristic of northern coastal plain pond flora. Photo: Sue Crispin

Ecology

Dorothy Allard

The first draft of a regional classification of natural communities for the southeastern United States was completed this summer. Since 1987, this effort has been funded in part through a cooperative agreement with the U.S. Forest Service, Region 8. The classification includes terrestrial, palustrine, and estuarine communities, and covers both natural and anthropogenic types.

The regional classification relies heavily on heritage program classifications which were used to create cross-reference tables relating similar community types in different state classifications to each other. This step helped to define about 320 community types in the region.

Improved communication and continued

cooperation among heritage program ecologists and with the Conservancy's ecology unit in Charlottesville will continue to improve the regional classification in successive drafts. This interaction also provides a way for heritage program ecologists to refine their state classifications, since increased knowledge of communities that range beyond state boundaries provides a better perspective for understanding these communities within a state.

The southeastern regional classification will not only be used by The Nature Conservancy, but will also be used by the U.S. Forest Service to manage information on communities on national forests in the thirteen states of Region 8.

Animals

Larry Master

A number of neotropical migratory bird populations that breed in North America and winter in the tropics are believed to be experiencing significant declines. John Terborgh recently summarized much of the information available on this subject in "Where Have All the Birds Gone?" (Princeton University Press, 1989).

Heritage programs contribute to our collective understanding of the problem in several ways. Within their own geographic areas, state heritage programs (HPs) and conservation data centers (CDCs) maintain data on the status of all vertebrates, including neotropical migrants. The Nature Conservancy's central zoological data-

bases then track this status information for each area through regular data exchange with HPs and CDCs. By querying the central databases, any network participant can get a snapshot look at the status of any vertebrate species in all 50 states and selected countries. The Conservancy is currently seeking support to enable heritage programs, CDC's and other cooperators, to complete and regularly update global, national, and state ranking forms and characterization abstracts to provide network participants with more detailed documentation on the current status of these species everywhere they occur.

In addition to loss and fragmentation of

"Animals" continued page 7

Plants

Larry Morse

To provide the heritage network with a national and global perspective, The Nature Conservancy cooperates extensively with a number of institutions world-wide. Standards for improved inter-institutional data exchange were developed recently at the sixth meeting of the Taxonomic Databases Working Group (TDWG) held in Delphi, Greece. The standards for presenting nomenclatural, geographical, and floristic status information will be examined closely by the Conservancy for possible implementation in the Biological and Conservation Data System (BCD), particularly the element data components.

For nomenclatural data, TDWG recommendations include a full standard, appropriate to botanically exacting projects, and a simpler version, appropriate for more general use. The Conservancy is looking at ways to implement these TDWG standards in the BCD.

The Conservancy will also consider following the TDWG geographical standard, which subdivides

the Earth into contiguous areas which are under a single government. If these geographical units are included when recording data like element or element occurrence records, the information can be assembled into broad geographic areas (e.g., North America, excluding Hawaii), or into areas under the same government (U.S.A. including Hawaii).

The Plant Occurrence and Status Standard (POSS) was also approved at the Delphi meeting. POSS provides a precise notation to indicate such facts as whether a plant is native, introduced or cultivated in a specific place, such as a nation, state, or protected area. Its relation to our element data structures is being examined carefully.

By implementing TDWG standards in the BCD to the greatest extent possible, we can increase the compatibility of our data with other botanical databases worldwide.

Computers and Data Management

BCD Technical Talk - Symbolic Fields, Part II

Keith Carr

Symbolic fields are perhaps the BCD System's most powerful tool for data retrieval and formatting. In this edition of BNN we will look at some sample symbolics which you can adapt for use with your own BCD System. Symbolic formulae are written in Advanced Revelation's R/BASIC programming language. Complete information about this aspect of AREV is available in the Technical Reference, which is part of the AREV documentation set. A good way to learn how to construct your own symbolics is to take any symbolic formula that has already been set up (each BCD data file has a number of standard symbolics) and go through each line of the formula, referring to the Technical Reference as needed.

Example #1 - Joining data files (XLATE fields): Joining (or "relating") different data files is a critical operation in any relational database system. In the BCD System this is accomplished through symbolic fields which use the "translate" function. For example, if we want to report on vertebrate element occurrences for frugivorous species, we can select appropriate records and fields from the EOR (Element Occurrence Record) data file. However, the EOR does not contain feeding habit data which is general to the element; we must retrieve that information from related records in the VCA (Vertebrate Characterization Abstract) file. To do this we create a new multivalued symbolic field in the dictionary for the EOR file, which translates the contents of the multivalued field "FOODHABITS" from the VCA. This will permit us to display the contents of the FOODHABITS field for any and all vertebrate element occurrences. We can name the field VCA.FOODHABITS. The formula will be:

```
@ANS = XLATE("VCA", {ELCODE}, "FOODHABITS", X)
```

Roughly, the English equivalent of this statement is "relate to the VCA file using "ELCODE" as the joining field, and return the value found in the VCA field "FOODHABITS". If no related record is found, return a null." As with all symbolic fields, VCA.FOODHABITS behaves as if it were a real, stored data item in the EOR file. Therefore, we can use this as a searching field, and thus limit our selection to EORs for elements in which the corresponding VCA records have the desired values in the FOODHABITS field. The two following statements illustrate this:

- 1) LIST EOR SNAME LASTOBS WITH VCA.FOODHABITS = "FRUGIVORE"
- 2) SELECT EOR WITH VCA.FOODHABITS = "FRUGIVORE" OR "GRANIVORE" AND WITH COUNTYNAME OF "Washington"

Once we have created the VCA.FOODHABITS field, it remains as a permanent addition in the EOR dictionary; it can be used again without any further preparation.

Example #2: This symbolic will capitalize the scientific name correctly. It capitalizes the first letter of the genus name and puts the rest of the binomial/trinomial in lower case. Formula:

```
SNAME={SNAME}
SNAME1=SNAME[1,1]
SNAME2=SNAME[2,99]
CONVERT @LOWER.CASE TO @UPPER.CASE IN SNAME1
CONVERT @UPPER.CASE TO @LOWER.CASE IN SNAME2
@ANS=SNAME1:SNAME2
```

Example #3: This symbolic is used to replace the data in the DIRECTIONS field in the EOR with the phrase "Contact the Virginia Natural Heritage Program" in each record where DATASENS equals "Y". It could be used in reports where it is necessary to leave out locational information for sensitive elements. Of course, we can change the word "Virginia" to the name of any state.

```
DATASENS={DATASENS}
IF DATASENS='Y' THEN
  @ANS='Contact the Virginia Natural Heritage Program'
END ELSE
  @ANS={DIRECTIONS}
END
```

Example #4: This formula creates a symbolic containing several EOR fields and formats them so that when this single symbolic field is displayed it will appear as two lines of data for each EOR record in the report. This will allow us to display an R/LIST report containing two lines of data per record instead of one. We can change the fields shown to whatever fields are desired, in whatever order. However, the first line of the formula must end with "@VM". In the Dictionary window, this field must be defined as being multi-valued.

```
LINE1='SURVEYSITE: '{SURVEYSITE}:@VM
LINE2='{TENTEN}:' '{PRECISION}:' '{QC}:' '{MARGNUM}
@ANS=LINE1:LINE2
```

Example #5: This symbolic consists of blanks that can be used to widen a left margin in an R/LIST report. To create a wider margin, this field is used as the very first field in the report. The margin width can be adjusted by changing the display length of the symbolic field from within R/LIST (in EasyWriter go to the menu choice "Reformat a Display Field").

```
@ANS=""
```

Field Notes

Eastern/ Southern Heritage Conference

The Kentucky State Nature Preserves Commission staff welcomed the 1990 Eastern/Southern Natural Heritage Conference to Park City, Kentucky. Dave Mihalic, Superintendent of Mammoth Cave National Park, also welcomed the September conference. It was the first attempt to expand a heritage conference to include more than one region, and it proved highly successful and productive. 38 heritage programs registered with 190 participants.

Conservancy President John C. Sawhill gave the keynote address, emphasizing the heritage network's importance to The Nature Conservancy and to the nation. Mr. Sawhill recognized that the creation of a methodological framework for assigning conservation priorities through the element ranking system and the scorecard process have profoundly influenced the effectiveness of land protection.

The conference agenda included lectures on the risks of global warming by Dr. Orie Loucks, slide presentations on the natural history of the Mammoth Cave Region by George Gregory of Mammoth Cave National Park, and a review of the Freedom of Information Act by Hugh Archer. Continuing education seminars covered glade and barrens ecology, forest history, aquatic resources of the Green River, cave protection, management and inventory, field data collection techniques, and sessions for scientists and data managers.

During the conference, Mammoth Cave National Park was officially dedicated as a Man and the Biosphere Reserve. Mammoth Cave National Park is interested in building a partnership with The Nature Conservancy and the Kentucky Nature Preserves Commission in establishing a Natural Heritage Data Center in the Park.

Western/ Midwestern Heritage Conference

A foot of snow was dumped on Pingree Park, Colorado just in time for the October 9-12 Western/Midwestern Heritage Conference. Regional public land protection planners and 27 heritage programs were hosted by the Rocky Mountain Heritage Task Force (RMHTF).

The Colorado conference held a special attraction for community ecologists. Community ecologists reviewed listings of over 1,400 plant communities reported to occur in 10 western states, and assigned global ranks to each community. About half of the community types were covered in the limited time available, and the remaining review and ranking will be conducted by mail over the next few months. With the comprehensive western classification almost complete, community ecology efforts can soon be directed towards applying the classification in conservation planning.

A set of draft community sampling forms developed by the RMHTF regional ecologist and ecologists from the Montana, New Mexico, and Wyoming heritage programs were also distributed and briefly discussed. Use of the six forms in all heritage community surveys in the West will help achieve standardization of data sets. The

following forms were included: 1) site survey 2) community occurrence survey 3) macroplot vegetation data 4) microplot vegetation data 5) tree measurement table and 6) soil survey. Use of forms 3-6 is optional depending on survey needs. The forms are under review by western heritage ecologists and a final version will be generated in early 1991.

Presentations by western ecologists at the conference stressed the use of gradient-oriented sampling ("gradsects") to increase the efficiency of field surveys. These methods have been successfully implemented in heritage studies of the grasslands of Montana, riparian communities of Colorado, and the Gray Ranch of New Mexico. Gradient sampling will provide input data for developing models to quantify community/environmental relationships. Linkage of such models to GIS and remote sensing will enhance the value of conservation evaluations at scales ranging from small to very large preserves.

Networking With Federal Agencies

The Natural Heritage Program Network cooperates with U.S. federal agencies in a number of important ways to protect natural diversity. Through inventorying, establishing data centers, developing classification systems and providing scientific information to support stewardship, the Network works together with the National Park Service, U.S. Forest Service, U.S. Fish & Wildlife Service, Department of Defense, and Bureau of Land Management, among others. The following projects are just a sample of the many cooperative ventures undertaken in the past year.

U.S. Forest Service

Natural heritage program scientists from many states are making major contributions to the knowledge, conservation and recovery of threatened, endangered and sensitive (TES) species on National Forests by inventorying, monitoring and writing species management guides. In some cases, heritage program staff, like Steve Shelly of the Montana Natural Heritage Program or John DeLapp of the Alaska Natural Heritage Program, are assigned directly to Forest Service offices. In Florida, the Biological and Conservation Data System was installed at a National Forest. The agreement between The National Forests of Florida and The Nature Conservancy is the first such contract to establish a data center.

The Forest Service fulfills major conservation management needs through cost-share agreements to complete Element Stewardship Abstracts (ESAs) and Community Characterization Abstracts (CCAs). The Midwest Heritage Task Force, working with the Forest Service Eastern Region, is now completing or updating ESAs for 42 of the 77 TES plant species in the Region. A second cost-share agreement proposal is pending to complete ESAs for the remaining plant species in 1991. One benefit of writing ESAs for sensitive species is the identification of key management needs for critical species. ESAs can also be used as the first step in completing USFS species management guidelines.

At the national level, the Conservancy's Science division and the Forest Service are cooperatively supporting the national endangered plant program manager, Chris Topik. Chris is developing a Forest Service data module to the BCD which will track biological and administrative data for the more than 1800 plant species formally designated as 'sensitive' by the Regional Foresters.

National Park Service

The Nature Conservancy is responding to National Park Service (NPS) needs by establishing park-level heritage programs. The data center at Great Smoky Mountains National Park was the first such program. Natural heritage programs in North Carolina, Tennessee, and the Tennessee Valley Authority contributed information for building the Park databases. The Park will reciprocate by supplying with these programs a large amount of new data it has gleaned from many sources.

Heritage programs have also been established at Everglades and Biscayne National Parks and Big Cypress National Preserve in Florida. Under a recent agreement, Heritage data will be compiled for Virgin Islands National Park and Buck Island Reef National Monument. We are also assembling databases for the Southeast and Mid-Atlantic regional offices of NPS. These offices will have occurrence information for rare species and exemplary communities on NPS lands in their regions. A demonstration database will be set up in the Service's Washington, D.C., office, as well.

U.S. Fish and Wildlife Service

Since 1984, the Conservancy's Eastern Heritage Task Force (EHTF) has been cooperating with the U.S. Fish and Wildlife Service's Region 5 office to produce status surveys for northeastern candidate plants and animals. Funds received by EHTF have been used by more than 25 state Heritage programs to carry out field work. By conducting range-wide surveys, the heritage network is providing information needed by the Fish and Wildlife Service to ascertain whether a particular species warrants listing as Endangered or Threatened or, alternatively, is secure enough at present to remove from the candidate list. To date, support from the Region 5 office has enabled the global status of 47 plant taxa and 35 invertebrate taxa to be evaluated. In addition, last year the USFWS contracted with the Conservancy to review the status of all candidate insects in the eastern U.S. (Regions 3, 4, and 5).

New Conservation Data Center in Jamaica

Jamaica is the newest addition to the conservation data center network. With nearly 800 species of endemic plants, 25 endemic birds and many endemic reptiles and amphibians, it is one of the biologically most diverse islands in the world.

To address Jamaica's urgent conservation needs, a major effort is being focused on the establishment of a national park system and on the creation of the conservation infrastructure needed to successfully manage these parks. This project is being carried out with the cooperation of several Jamaican governmental and non-governmental agencies and with international technical assistance provided by The Nature Conservancy and partial funding from the US Agency for International Development.

The establishment of a conservation data center at the University of the West Indies' Mona Campus is a critical part of this effort. One of the data center's priorities will be to provide the biological and ecological information needed for the design and implementation of an island-wide

"Jamaica" continued page 8

"Animals" from page 3

habitats on their breeding and wintering grounds, neotropical migrants are also losing habitat in areas where they concentrate in large numbers during their migrations. Two such areas in the Mid-Atlantic states are the Cape May and Cape Charles peninsulas. A unique joint effort, funded in part by National Oceanic and Atmospheric Administration, National Fish & Wildlife Foundation, and U.S. Fish & Wildlife Service is underway in the states of Virginia, Maryland, Delaware, and New Jersey. The Conservancy and the four state heritage programs along with cooperating state agencies are conducting a systematic inventory of the most significant remaining migratory stopover areas for neotropical migrants in this region. Since all four state programs employ a standardized approach to collect and process information on the classification of habitats (plant communities) and their use by migratory birds, the study will yield a regional overview of priority habitats for neotropical migrant conservation.



Jamaica's Blue Mountains. Photo: Bruce Stein.

"Networking" from p. 2.

on a regional basis for select species. With assistance from the Joyce Foundation, a major project by the Midwest and Canadian Heritage Task Forces is now underway that attempts to break ground in regional networking of heritage data by establishing a Great Lakes heritage data network. More than 8,000 computerized element occurrence records from the eight Great Lakes states, plus Ontario and Quebec, are being centralized and will form the basis for selecting high priority sites along the Great Lakes coasts for protecting biodiversity and monitoring ecosystem health.

Other efforts will be required to create an ongoing ability to integrate and tap heritage data. These include overcoming compatibility problems with programs using non-standard operating systems; establishing a centralized data pool with standard procedures for input and updating; developing access protocols for users of centralized data; management of secondary datasets at the regional level and/or national (e.g., Canadian) levels; and perhaps most important, development of protection programs at the state, regional, national, and international levels that capitalize on the incredible conservation planning resource that pooled heritage data will provide. Look for other articles in this and future issues of BNN for updates on the progress in networking heritage data for biodiversity conservation.

"Jamaica" from page 7

national park system plan, and for the management of two pilot national parks: the John Crow/Blue Mountains, which includes the highest peak on the island, and Montego Bay, a marine park.

As one component of the Conservancy's technical assistance, Craig Groves, Coordinator of the Idaho Natural Heritage Program, will take a three-to-four month assignment as technical advisor to the Jamaica Conservation Data Centre beginning in January. Craig will participate in a training session for the Jamaica staff at Conservancy headquarters just before going to Jamaica to help set up data center operations. During his assignment in Jamaica, Craig will also provide orientation and training for individuals from the other participating governmental and non-governmental agencies involved with the program.

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U.S. MAB Chairman's Invited Lecture

Editor's note: Each year the Chairman of the U.S. National Committee MAB invites a distinguished scholar to present a public lecture which is held in conjunction with the summer meeting of the National Committee. In 1990, Dr. Daniel Botkin, Professor of Biology and Environmental Studies at the University of California, Santa Barbara, was invited and presented a lecture entitled "Discordant Harmonies: A New Ecology for the 21st Century." The following is a synopsis of that lecture.

The Difference Between Nature Preserves and Strawberry Preserves

When we talk about establishing a new nature preserve and putting land aside for biological conservation, the words that we use are reminiscent of the way my in-laws in New Hampshire used to speak about putting up some jam and jelly for the winter. We talk as if nature were something that we could bottle, put on the shelf, and take down occasionally to savor or admire. This is the way that many nature preserves have been managed in the 20th century.

Hartwick Pines State Park contains the last uncut original white pine stand in the lower peninsula of Michigan — 50 acres; that is all that remains of the original 19 million acres of white pine forests that were logged between 1840 and 1920. The park is maintained as a recreation area as well as a preserve, and visitors walk through the old-age forest on pleasant trails. The ground around the big trees is trampled by many feet, and there is almost no regeneration

continued on page 5

U.S. Department of State Extends Appointment of Dr. Lovejoy as National Chairman

Mr. E.U. Curtis Bohlen, Assistant Secretary of State for Oceans and International Environmental and Scientific Affairs, has extended the appointment of Dr. Thomas E. Lovejoy as the Chairman of the U.S. National Committee for MAB through December 1992.

Mr. Bohlen, in making this extension of Dr. Lovejoy's appointment, noted that the Department of State was "...particularly pleased with the direction and guidance that you have provided to the U.S. MAB Program, especially in promoting the concentrated program areas of directorate activity while maintaining a receptivity to proposals from the wider scientific community. Your leadership and insistence upon the application of rigorous scientific review principles has significantly increased the program's credibility over the past three years."

Mr. Bohlen stated that the Department of State, along with the other supporting agencies of the U.S. MAB Program "...anticipate that this momentum toward excellence will only increase under your continued leadership in the years ahead."

In This Issue

An Arctic Issue

- ITEX—International Tundra Experiment
- Northern Sciences Network Meeting
- Positions Available in Arctic Science

Notes From the Executive Director

U.S. MAB Vice Chair, Dr. Michael A. Little of SUNY-Binghamton, attended as the U.S. Observer Delegate UNESCO MAB's semiannual Intergovernmental Coordinating Council (ICC) meeting recently held in Paris.

On the bureaucratic/ administrative, as well as image side of the ledger, substantial progress was achieved. In recent years the word "man" in the title of our program has been viewed by some as an anachronism. Well, the delegates didn't change the name of the MAB program; but, they did elect Dr. Tania Maria Tonelli Munhoz to Chair the ICC for the next 2 years. She is currently the president of IBAMA, the Brazilian Institute of Environment and



U.S. MAB BULLETIN

The U.S. MAB Bulletin is published quarterly by the U.S. MAB Secretariat, OES/BGC/MAB, Department of State, Washington, DC 20522-0508. Tel. (202) 632-2816, 2786.

"The mission of the United States Man and the Biosphere Program (U.S. MAB) is to foster harmonious relationships between humans and the biosphere through an international program of policy-relevant research which integrates the social, physical, and biological sciences to address actual problems. These activities—broadly interpreted—include catalytic conferences and meetings, education and training, and the establishment and use of biosphere reserves as research and monitoring sites." Adopted by the U.S. National Committee for the Man and the Biosphere Program, January 6, 1989.

U.S. MAB is supported by the United States Department of State, the United States Department of Agriculture-Forest Service, the United States Department of the Interior-National Park Service, the Agency for International Development, the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, the National Aeronautics and Space Administration, the Peace Corps, the Smithsonian Institution and the National Science Foundation.

The program is organized into five directorates: High Latitude Ecosystems; Human Dominated Systems; Marine and Coastal Ecosystems; Temperate Ecosystems; Tropical Ecosystems; and a U.S. MAB Coordinating Committee for Biosphere Reserves.

Renewable Natural Resources. Dr. Tonelli Munhoz will be well assisted in establishing international MAB policy and program direction by the election of an exceptionally strong team of science administrators as MAB vice chairs. All of the elected vice chairs also chair their respective country's MAB Programs: MinR. Wilfried Goerke, Germany; Academician Vladimir Sokolov, USSR; Mr. Yasuo Aruga, Japan; and, Mr. Sadig Bin Abdel-Hassine Al Mascatti of Oman. Mr. W.K. Nduku of Zimbabwe was elected rapporteur. The chairperson, vice chairs and rapporteur make up the UNESCO MAB Bureau which directs the international program between ICC sessions.

The ICC also directed the international MAB Program to make one of its primary areas of concentration the world scientific and environmental policy concerning global climate change. U.S. Observer Delegate Little addressed the ICC and spoke with numerous delegates concerning U.S. support for the recommendations made by a January 1990 UNESCO/MAB workshop on biosphere reserves. The workshop recommended the creation of a network, on a pilot basis, of biosphere reserves to share basic information concerning biological indicators of global change. In our view, the strength of the MAB program's potential contribution to international global change science and monitoring efforts stems from: first, the wide representation of the world's major terrestrial biomes within biosphere reserve sites — an admitted weakness in that coverage is the lack of marine/ocean representation; secondly, all biosphere reserves are required to have had some scientific infrastructure and research history — so a new system would not have to be built from the ground up; and thirdly, most biosphere reserves are governmentally operated — which augers well for the long term commitment required for a global monitoring program system. Dr. Little received strong support and expressions of interest from a number of delegates for such an initiative and cooperative effort.

Dr. Otto Solbrig, past chairman of the International Union of Biological Sciences (IUBS), and formerly a member of the U.S. National Committee for MAB, also addressed the ICC. He spoke about how to measure biological diversity and its role in ecosystem functioning. He was commissioned by the ICC to provide a report on the scientific rationale and underpinnings for initiating a global system of monitoring biological diversity. Dr. Solbrig will submit his report to the international MAB Bureau in 1991.

All in all, these could be very significant steps towards developing the often referred to "potential" for a network of biosphere reserves. U.S. MAB looks forward to working with all of the MAB programs toward achieving this goal.

Roger E. Soles

UNESCO MAB Northern Sciences Network Meeting

The UNESCO-MAB Northern Sciences Network met in Rovaniemi, Finland, September 25–27, 1990, at the Arctic Center of Lapland University. All NSN member states except Iceland were present at this meeting. U.S. MAB was represented by Drs. Patrick Webber, Dale Taylor of the National Park Service and Charles Slaughter of the USDA Forest Service.

The NSN meeting focused on four primary themes: High Latitude Biosphere Reserves, Research and Monitoring in Biosphere Reserves and Protected Areas; Sustainable Conservation and Development; and Subarctic Birch Forests. Dale Taylor discussed U.S. Northern Biosphere Reserves, giving special attention to current US-USSR collaboration in Beringia and Noatak Nature Preserve/Biosphere Reserve in northwest Alaska. Dr. Slaughter was elected to serve on a new International Advisory Group for the Northern Sciences Network which will be chaired by Dr. Fred Roots of Canada. Dr. Webber noted that U.S. MAB has allocated funds for the support of a fellowship at Rovaniemi to facilitate circumpolar communication and information exchange through the NSN Secretariat (see following position announcement).

ITEX—International Tundra Experiment

Nearly 40 scientists from nine countries, including the Soviet Union, gathered at Michigan State University's Kellogg Biological Station December 3–6 for a workshop in which they developed an Arctic experiment. They met to develop ITEX—the International Tundra Experiment to determine the impact of global warming on specific plants.

The meeting was organized by Dr. Patrick J. Webber, director of the Kellogg Biological Station and the chairman of the U.S. MAB Directorate on High Latitude Ecosystems. The National Science Foundation provided the funds for the conference while MAB contributed funds to assist in the conference's planning stages.

Webber stated that most scientists agree that as the Earth's atmosphere warms, the impact would have a compound effect on the polar regions. This is because we expect the polar regions to experience greater warming than other regions of the Earth and because arctic organisms are specifically adapted to life in the cold. "Northern natives hear rumors of the Arctic warming up. They also hear

scientists making predictions of one sort or another, but they haven't yet heard how the plants and animals in their lives will be affected," explained Webber. "What happens to the reindeer or whitefish or blueberry plant? No one has species-specific information to offer.

The agreements reached at this meeting build upon international cooperation mechanisms, and Webber said he hopes ITEX will be a model for studies of other arctic organisms. Among the agreements the scientists reached were that:

- the first ITEX experiments should focus on responses of vascular plant species;
- a set of abiotic observations and destructive and nondestructive measurements be carefully specified to determine phenological events, reproductive and vegetative effort, physiological responses, and genetic response to the manipulation and predominant environmental variables during the growing season over a period of 3 years;
- explicit protocols be developed for simple and relatively inexpensive manipulations of air temperature and snow cover at participating sites;
- sets of selected individuals in field transplant gardens be subject to a common garden (environmental) experiment and assessed in terms of genetic variation within each species population and its phenotypic response in order to evaluate probable adaptations to climate change;
- funding for research is the responsibility of each participating country and may utilize activities already underway, and including Biosphere Reserves, protected areas, and long-term ecological research areas; and,
- future experiments focusing on other taxa and ecological parameters, including animals are desirable, and contacts for ITEX established through the MAB Northern Sciences Network are encouraged.

BUN—Biomass Users Network

Is an international not-for-profit membership organization created by and for developing countries to identify opportunities for improving rural economies while protecting natural resources. BUN facilitates information dissemination, scientific and technical cooperation, and funding for demonstration projects in biomass production and utilization.

For further information, contact P.O. Box 33308, Washington, D.C. 20033. Telephone (202) 293-4800.

Available Positions in Arctic Science

Fellowship in Northern Sciences Network

Applications are requested for an individual who would spend up to six months based at the MAB Northern Sciences Network headquarters in the Arctic Center, University of Lapland, Rovaniemi, Finland.

The fellowship would provide up to \$3,000 per month for salary, cost-of-living allowance and travel funds.

The Northern Sciences Network (NSN) is a program of the UNESCO Man and the Biosphere (MAB) Program which distributes information about ongoing Arctic and northern research through a newsletter and also acts as a clearing house for information on special problems such as sustainable development, human/environment interactions and global environmental monitoring as they relate to northern lands.

The Fellow would be expected to help with newsletter development, international communication and the development of international programs in northern science such as the International Tundra Experiment (ITEX) or the Norwegian northern pastoralist project. There will also be opportunities for personal research.

Candidates should have a Ph.D. degree or its equivalent and research experience in social and/or environmental sciences. The position has no citizenship or residency limitation.

The fellowship will be administered by Michigan State University. Applications are to include curriculum vitae and names of three references. They should be sent to Professor P.J. Webber, Chair, U.S. MAB High Latitude Directorate, W.K. Kellogg Biological Station, Hickory Corners, MI 49060-9516. Applications will close by March 1, 1990.

Michigan State University is an Equal Opportunity Employer.

Director of Arctic Environmental Information and Data Center - University of Alaska, Anchorage

The Director is responsible for the overall direction and management of the Arctic Environmental Information and Data Center. The Center's mission focuses on developing innovative methods of applying science and technical knowledge to examine natural resource and environmental problems, to assess environmental risks and consequences and to project ecological interactions and trade-offs of resource use.

This is a full time administrative appointment with an academic appointment in the School of Public Affairs. Salary will be a minimum of \$70,000. Potential applicants must contact the Personnel Office, University of Alaska Anchorage, 3211 Providence Drive, Anchorage, Ak 99508 Telephone (907) 786-4608 for a job summary, qualifications and application procedures before January 15, 1991.

The University of Alaska is an Equal Opportunity Employer.

Natural History Internships at the Smithsonian

Ten-week training opportunity specifically designed for undergraduate college students.

All applicants should be undergraduate students in botany, zoology or related biological disciplines. Affirmative actions principles will be used in the selection procedure. Applications are due February 1, 1991. For more information contact Mary Sangrey, 166 NHB, Smithsonian Institution, Washington, DC 20560

continued from page 1

of white pine in the old-growth stand. Trampling decreases regeneration, but also white pine is a species intolerant of the shade, requiring fairly open conditions for seed germination and sapling survival. New Englanders who remember the great hurricane of 1938 can attest that pastures abandoned after the storm grew back to white pine.

I have made projections about the future of the old growth pines at Hartwick State Park using a computer model of forest growth, called JABOWA, that I developed with colleagues in 1970 and has been used widely around the world since then, and that we know is realistic and accurate. Our projections suggest that the pines are reaching their maximum longevity and most of them are likely to die sometime in the next century. Without regeneration the old growth stand will cease to exist. If we want old-age white pine stands to be present for our descendants to see, then we had better begin to plan now for the next old-age stand, and actively manage areas in the park to promote white pine regeneration, by producing the right kinds of clearings on the right kinds of soils.

Hartwick Pines illustrates what we all know but so often forget: nature is dynamic, and natural ecological conditions that we seek to conserve through the Man and the Biosphere Program must be managed with an understanding of these dynamic properties. Many pieces of evidence collected during the past 20 years through ecological research make this point clear. One of the most important kinds of evidence is the history of vegetation of North America revealed by studies of pollen deposits in lakes. These show that tree species have migrated across the land in response to major climatic changes of the last ice age. Some species, such as chestnut, that we think of as part of the original, permanent forest of the Atlantic Coastal States of the United States, arrived in that region within the last 2,000 years, a short time in the history of forests.

Sometimes, what we think of as wilderness — nature undisturbed by human influence — has been altered for a very long time by people. When Peter Kalm, a Swedish botanist, visited the eastern United States in 1749–50, he wrote that the woodlands near New Brunswick, New Jersey were composed of mature oaks, hickories, and chestnuts and were so open that one could drive a horse and carriage through the forests with ease. Today, the last remaining uncut remnant of that woodland, in Huteson Memorial Forest 15 kilometers from New Brunswick, is a dense thicket of many small stems, interspersed with old oaks and hickories, but almost no regeneration of these species. Saplings are mostly of sugar and Norway maples. Fire scars visible in cut stumps of dead trees reveal that fires

burned about once a decade until 1700 — until European settlement — after which there were no more fires. The high frequency of fires prior to European settlement is generally attributed to direct actions by the American Indians. Light fires favor oaks over maples. What we have thought of as “natural” was a product of human actions.

The process of preserving Huteson Forest by fixing its condition has led to a fundamental change in its character. Once the forest was set aside and preserved, the management policy was hands off, no action, don't change the forest. Ironically, as a result the present Huteson Forest is deviating from the kind of nature the preserve was established to maintain.

Introductions of exotic species as a result of human actions are, of course, another cause of change in nature preserves. Even if you continue to believe that prior to human influence nature was unchanging, nature in the late 20th century has been so altered by our actions that it will change greatly in the future. And if global warming takes place as projected by the computer models of climate, all of our forests in North America, in fact, probably all of our nature preserves, will be subjected to drastic changes, with some of those changes beginning in the next decade or two.

As a result, those of us who desire to conserve examples of original nature find ourselves in an ironic, contradictory situation. The harder we try to achieve our goal directly — the more we try to jell nature and hold it as we think it was — the more we seem likely to fail. Something fundamental is wrong with our approach.

What is wrong with our approach was the subject of the Chairman's lecture at the annual MAB meeting in Washington, September 9, 1990. In that lecture I summarized the ideas that I discuss in my recent book *Discordant Harmonies: A New Ecology for the 21st Century* (Oxford University Press). We have been approaching the conservation of nature through a myth of constancy, a myth that nature, undisturbed by our influences, will achieve a constant condition that is its most desirable state. The reality, as revealed by many studies in ecology in the last 20 years, is that natural ecological systems are always changing, always subject to change, adapted to change, and require change. If we hope to preserve examples of nature, our management must be active and take natural dynamic qualities into account.

Another consequence of our modern understanding of ecological systems for the conservation of nature is that there is not just one kind of nature to be preserved, but at

continued on page 6

continued from page 5

least three. The standard notion of wilderness in America is the idea of land untrammelled by people — a place where there is no appearance of human actions. But as Hutcheson Memorial Forest suggests, if we really remove all human actions we create a forest nobody has ever seen. Even if exotic species had not been imported into North America, Hutcheson Forest, without disturbances wrought by fire, would not look like the forest inhabited by the Native Americans prior to European colonization, nor seen by the first European explorers. As Hartwick Pines State Park warns us, forests put up on the shelf with no provisions for regeneration will not preserve the species they were set up to save.

These lessons suggest to us that we need three kinds of nature preserves: (1) areas set aside for conservation of a specific rare or endangered species or ecological community; (2) areas with the look of land as seen by the first explorers (in North America, a nature of the 17th or 18th century); and (3) areas truly isolated from direct human actions, whose purpose is not so much to conserve a mythical climax ecosystem, but to serve as a scientific experiment, a kind of ecological experimental control, a baseline against which we can view our actions in the rest of the areas that we attempt to manage for the other purposes I have described.

As we plan for the 21st century, the primary lesson for biological conservation is that nature preserves are not like strawberry preserves; they cannot be bottled, put on the shelf, and preserved indefinitely. They must be managed dynamically for specific goals. Once we have established a natural area as part of the Man and the Biosphere Program, we must seek to conserve it as a dynamic, changing entity. That is the message of the Chairman's lecture of 1990, and one of the major messages of *Discordant Harmonies*.

Newest Release from the UNESCO MAB Book Series

Volume 5, Sustainable Development and Environmental Management of Small Islands

edited by William Beller (of the U.S. MAB directorate on Caribbean Islands), P. d'Ayala and Philippe L. Hein. This book is composed of three parts. The first addresses issues related to islands in general. The second provides case studies of particular islands and island groups. The final part coalesces the first two into recommendations for sustainable development and environmental management of small islands in specific geographic regions.

Also recently released:

Volume 3, Exploiting the Tropical Rainforest, An Account of Pulpwood Logging in Papua New Guinea

edited by D. Lamb of the Botany Department, University of Queensland, Australia. This book describes a large pulpwood logging operation in the lowland rainforests of Papua New Guinea. It examines the events leading up to the decision to begin pulpwood logging, and some of the consequences the project has had on the forests and people of Papua New Guinea.

These publications are available from The Parthenon Publishing Group, Inc., 120 Mill Road, Park Ridge, NJ 07656, USA.

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Bibliography on the International Network of Biosphere Reserves, U.S. MAB Coordinating Committee for Biosphere Reserves and the UNESCO MAB Secretariat, July 1990.

Still available from U.S. MAB:

CONNECT UNESCO-UNEP Environmental Education Newsletter Vol. XV, No. 1, March 1990. Environmentally Educated Teachers, The Priority of Priorities? and Vol. XV, No. 2, June 1990. Basic Concepts of Environmental Education.

PARK SCIENCE, National Park Service, Summer 1990 and Fall 1990 issues. A report on recent and ongoing research in parks with emphasis on its implications for planning and management. Development of new guidelines for planning and implementing resource management activities and training.

Puerto Rico Workshop on LAND-BASED SOURCES OF MARINE POLLUTION IN THE WIDER CARIBBEAN REGION, August 7-9, 1989, San Juan, Puerto Rico.

Proceedings of the U.S. Man and the Biosphere-sponsored workshop on Non-Commodity Forest Resources held at the national headquarters of the Society of American Foresters on August 24, 1989. The workshop was designed to encourage better communication between the environmental community and the USDA Forest Service regarding the need for Forest Inventory and Analysis data sets for the evaluation of noncommodity forest resources. The document contains some valuable information, and will be of assistance in the identification of additional sources of information.

Available from others:

TOWARDS SERVING VISITORS AND MANAGING OUR RESOURCES: Proceedings of a North American Workshop on Visitor Management in Parks and Protected Areas, Tourism Research and Education Center, University of Waterloo, Waterloo, Ontario, Canada N2L 3G1. Cost: \$24.95 plus \$8.60 for postage and handling.

BIOSPHERE RESERVE Brochure/Map. Listing and location of all (international and U.S.) biosphere reserves as of July 1989. Containing a new code to the location of all biosphere reserves. Available from: GPO Bookstore, 710 North Capitol Street, Washington, DC 20401. Tel. (202)783-3238. New Stock # 044-000-02277-0 @ \$3.00 each or \$225.00 for 100.

Ecoregions Map of the Continents, A New Aid to Monitoring Global Change by Robert G. Bailey A map which shows the Earth's land areas subdivided into regions based on macroscale patterns of ecosystems. These regions delimit large areas within which local ecosystems recur throughout the region in a predictable fashion. The map can, therefore, be used to spatially extend data obtained from limited sample sites. Copies of the map are available from: Robert G. Bailey, USDA Forest Service, 3825 E. Mulberry St. Fort Collins, Colorado 80524.

World Resources 1990-91 a complete reference book produced by the World Resources Institute on global environmental trends and conditions. It contains new findings on the rate of tropical deforestation; rankings of greenhouse gas emissions, by country; an overview of Latin America's environment; and reports and analyses of the most critical environmental and natural resource problems. This publication is available at a cost of \$17.95 plus \$3.00 for handling from WRI Publications, P.O. Box 4852, Hampden Station, Baltimore, MD 21211

UNESCO Publication, MAB Digest 1 on Eutrophication Management Framework for the Policy-Maker by Marjorie Holland, Walter Rast and Sven-Olof Ryding. Eutrophication of lakes and reservoirs is one of the most pervasive water quality problems worldwide. This digest aims to provide: quantitative tools for assessing the state of eutrophication of lakes and reservoirs; a framework for developing cost-effective management strategies; specific

continued on page 8

continued from page 7

technical guidance and case studies for effective management of eutrophication. Available from: MAB-UNESCO, 7, place de Fontenoy, 75700 Paris.

UNESCO Publication, MAB Digest 3 on Contributing to Sustained Resource Use in the Humid and Sub-Humid Tropics, Some Research Approaches and Insights, by Malcolm Hadley and Kathrin Schreckenber. An overview of recent, ongoing, and planned activities within the MAB framework pertaining to the ecology of humid and sub-humid tropical ecosystems, principally forests and savannas. Available from: MAB-UNESCO, 7, place de Fontenoy, 75700 Paris.



Final Report of the International Workshop, "Long-Term Ecological Research - A Global Perspective," September 18-22, 1988 in Berchtesgaden, Federal Republic of Germany. It is available from: MinR Wilfried Goerke, Dipl.-Biologe, Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, Godesberger Allee 90, 5300 Bonn 2, Federal Republic of Germany.

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Mr. Jan W. Mares
Senior Policy Analyst
Office of Policy Development
The White House *
472 Old Executive Office Building
Washington, DC 20500

Chill on 'greenhouse' treaty

Experts see big splits among nations at global warming talks

By Deborah Blum
Bee Science Writer

Sacramento
12/8/90

SAN FRANCISCO — Drafting a treaty to save the Earth's ozone layer was easy compared to the battles expected over controlling global warming, a federal climate expert said Friday.

John Knauss, head of the National Oceanic and Atmospheric Administration, said he expects major difficulties when delegates meet next year to start drafting a treaty to reduce "the greenhouse effect."

The United States is hosting the first international session on a "Framework Convention on Climate Change" in February. At a preliminary meeting in November, the United States took a position against setting hard limits on industrial gases associated with warming, angering many other countries.

"Ozone was a trivial problem compared to what we face with the greenhouse effect," Knauss warned during a meeting of the American Geophysical Union here. "Already we are hearing critical disagreements and we haven't even started the formal meetings yet."

N. "Ram" Sundararaman, secretary of the international Intergovernmental Panel on Climate Change, agreed. He said the world's governments already have split into at least seven different positions, ranging from powerful industrial interests, expressed by the United States, to tiny countries who fear that they will be victims of the pollution from the wealthier nations.

"We have disagreements between governments. And we have disagreements within governments," Sundararaman said. "With ozone depletion, that was pretty much handled by environmental agencies. But, with the greenhouse effect, you bring issues of major finance, of trade, of energy policy. It's much more complicated."

Depletion of upper atmosphere ozone and the greenhouse-like warming of the Earth have become major issues for world governments. Both are related to human activities. Scientists discovered the planet's ozone layer, which protects life against harmful solar radiation, was being severely damaged by industrial pollutants. Researchers have documented a steady increase in certain gases that tend to trap heat in the planet's atmosphere, an effect often compared to a greenhouse.

In 1987, disturbed by the appearance of holes in the ozone layer, an international agreement was signed to end the use of chlorofluorocarbons, the compounds blamed for the damage. Chlorofluorocarbons, used as coolants and insulators, also help drive the greenhouse effect. But, even more troubling is a soaring

buildup of other gases, particularly carbon dioxide, which is generated by burning fossil fuels.

Although no one yet has clearly documented a resulting trend toward global warming, scientific studies of the planet's history show that when carbon increases in the atmosphere, the Earth heats up. Scientists worry the greenhouse effect could dramatically alter the global climate, causing severe droughts, melting glaciers and ice sheets, driving up ocean levels.

"We see a slight rise in temperature and slight rise in sea levels already," said Geoff Jenkins, of the British Meteorological Office. "But, it could be natural variation and it could be the greenhouse effect."

Jenkins led a scientific assessment of the greenhouse effect for the Intergovernmental Panel on Climate Change, which was created by international agreement in 1988 to world governments begin to deal with global warming. Its first report was released in August.

Fred Bernthal, acting director of the National Science Foundation and another member of the panel, said the report should be considered only interim. Nevertheless, the panel did conclude the greenhouse effect was scientifically valid and severe environmental impacts are likely during the next century.

The growing consensus that the greenhouse effect must be controlled led to a confrontation between the United States and other countries during a November meeting on world climate.

European countries, in particular, wanted quotas set on greenhouse gases, urging at least a 20 percent reduction in carbon dioxide by the year 2000. The United States refused to join a non-binding statement to that effect, arguing more research is needed.

"We were looking for U.S. leadership at the November meeting and we didn't see it," said Delphine Boriene, of the French Ministry of Foreign Affairs. "Europe was pushing and the U.S. was braking. And we're concerned to see this attitude from a

country that is emitting more carbon per capita than any other country in the world."

U.S. annual carbon emissions are equivalent to about 5 tons of carbon per resident. The average for other industrialized nations is 3.1 tons per resident a year.

Knauss, a U.S. delegate to the Second World Climate Conference in November, admitted the country's position was not popular.

"I'm not defending it," he said, adding the U.S. tends to take non-binding resolutions, such as that proposed last month, more seriously than other countries. Knauss said he expects the American position to

soften during the treaty negotiations on global warming.

"For one thing, if it doesn't, there won't ever be a treaty," he said.

Both he and Bernthal said the United States already is weighing regulations that would solve other environmental problems while helping out with the greenhouse effect.

"I would point out that while we haven't been signing political documents, we have just passed a very stringent Clean Air Act," Knauss said. "So, unlike some countries, we are not just talking about action."

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Claiming the Eagle Mountain project "is not feasible ... not practical ... not cost-effective," he said bitterly: "I was going to take out an ad in the Wall Street Journal: 'Come to Riverside County. Future home of the biggest garbage dump on Earth.'"

In Los Angeles County, both Rail-Cycle and Mine Reclamation Corp are already targeting sites along rail lines to build waste-loading facilities to transfer Angelenos' garbage onto trains.

Rail-Cycle officials, who hope to have their San Bernardino landfill ready for 3,000 daily tons by 1993, have pledged to remove some 40 percent of solid waste materials for recycling before taking the rest to the desert. A task force of 29 San Gabriel Valley residents is studying the plan.

Recently, 15,000 residents signed petitions fighting expansion of the garbage-glutted Puente Hills landfill in the San Gabriel Valley. With its landfills filling up and angry citizens having fought off proposals for air-polluting incinerators and having battled new or expanded dumps, Los Angeles County is unquestionably looking for relief.

"We're on the threshold of a crisis," said Don Nellor, a planner for the county sanitation district.

Waste Management last year opened a high-tech garbage dump in tiny Arlington, Ore. to truck household waste from Portland, 137 miles away. But the waste-by-rail proposal, a system utilized by some European cities, has never been tried in the United States.

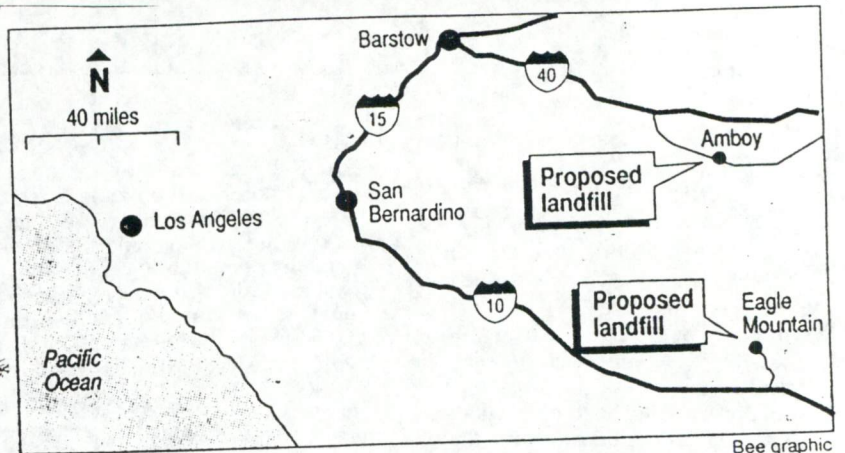
It remains a notion unacceptable for Peter Burk, vice chairman of the Sierra Club's Southern California desert committee. Burk said he wants proof the landfills won't "turn into raven breeding grounds" and leak contaminants into underground water sources.

"There are so many things in the desert that need saving," he said. "It's painful to hear this other view: 'Well, let's just dump it in the desert.'"

Phil Beautrow, Waste Management's manager of landfill development, contends that special plastic liners and state-of-the-art drainage systems would prevent any seepage into groundwater. He said protective covers and other steps easily address any fears "that all of a sudden you'll have Alfred Hitchcock's 'Birds' out there."

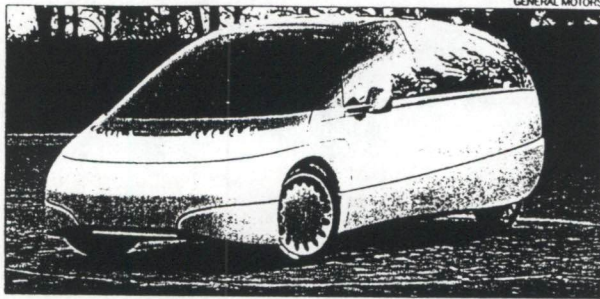
At Eagle Mountain, MRC senior vice president Gary Kovall claimed that thousands of tons of existing clay will safely line the landfill and said the project also includes a land swap to protect 3,000 acres of desert tortoise habitat.

Kent Statler, who once owned the Eagle Mountain Shopping Center, said, "I'd rather see a manufacturing plant. Everybody would like to see something nice. But let's face it, we don't have that opportunity or choice. I'd like to see the town back."



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SCIENCE & SOCIETY



Hybrid. General Motors' new van uses electricity and gas.

Motoring into the future

The war in the Persian Gulf has heightened the urgency of finding alternatives to gasoline

Operation Desert Storm has underscored in the most dramatic way possible America's continued dependence on imported oil. But one fact that remains poorly appreciated is that the only crucial energy-supply problem facing the country today is the fueling of Americans' favorite personal technology, the automobile. And that crisis, too, is likely to begin diminishing before the end of the century, as clean-air policies force the development of alternative motor fuels and motor cars that use them. In fact, America could enter the next millennium well on the way toward reducing the twin plagues of automobile pollution and energy insecurity.

Virtually all the energy used to make electricity, heat homes and drive factories comes from secure, low-cost and plentiful domestic sources, principally coal, natural gas, nuclear and hydro. But America's mobile society requires liquid fuels that pack enormous energy into small portable tanks. Nearly two thirds of the 17 million barrels of petroleum consumed by Americans every day is used by 185 million cars, trucks and buses as well as aircraft and locomotives. During the seven months before Iraq's invasion of Kuwait, over half the oil burned in the United States was imported, the highest

level ever. Worse, imports are projected to rise in the future as old U.S. oil fields run dry. If nothing were done, the bulk of the nation's future transportation fuel would have to come from politically unstable countries around the Persian Gulf, where two thirds of the world's known oil is located and war now rages.

Fortunately, steps are being taken on the environmental front that guarantee the availability of cars, vans and pickup trucks powered by electricity, natural gas and reformulated gasoline within the decade. Alcohol fuels such as methanol and ethanol may also be on the way. For one thing, the 1990 Clean Air Act mandates that gasoline be "re-engineered" to reduce harmful pollutants and requires that certain commercial fleets use "clean" fuels such as domestically produced natural gas. Perhaps more important, California, long the leader in auto pollution reductions, decreed last fall that, starting in 1998, all car builders doing business in the state must offer zero-emission electric vehicles for sale. Since Californians buy 1 of every 10 cars made in the United States, this will have the effect of forcing all manufacturers to offer electric vehicles.

Both the federal law and the California action are meant to cut back on the

filth of gasoline engines, which contributes significantly to urban smog. Alternative fuels could help reduce these harmful emissions.

Compressed natural gas. This fuel, known by the initials CNG, is the first alternative likely to make a dent in gasoline sales. With a cost comparable to about 70 cents a gallon, CNG is cheaper than gasoline, causes less tailpipe pollution and comes from relatively abundant U.S. and Canadian sources. CNG's low cost has already won over many fleet operators. About 30,000 cars and trucks in the United States and 700,000 worldwide burn CNG, including 300,000 in Italy, where it has been used since the 1930s. The Clean Air Act requires that, starting in 1998, large-city operators of centrally fueled fleets of 10 or more vehicles begin to use "clean" fuels. According to the American Gas Association, 8 to 10 million vehicles could be powered with less than 6 percent of current U.S. natural gas consumption. CNG is reportedly so clean that crankcase oil lasts 50,000 miles and spark plugs rarely need replacing.

Burning natural gas in cars is not without problems. The gas must be pressurized to 3,000 pounds per square inch and stored in bulky cylinders similar to those used by scuba divers. Even

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under high pressure the gas contains only about one fourth as much energy as the same volume of gasoline. As a result, a tank of CNG must be four times as big as a tank of unleaded to give the same driving range. The entire trunk of a small car, for example, would be required just for fuel storage.

Because of the bulky tanks and lack of public filling stations, most CNG is now used in commercial fleets that return to the same parking lot each night to be refueled. Washington Gas, which serves

homes in the District of Columbia area, operates 220 service vans that can switch between gasoline and natural gas. With two CNG tanks that together hold the equivalent of 9 gallons of gasoline, the vans almost never use gasoline while traveling an average of 60 miles a day. Refueling can take up to six hours with less-expensive "slow-fill" compression systems. At "quick-fill" facilities with big compressors, filling up takes little longer than for gasoline.

So far, most CNG vehicles have been converted from gasoline with simple add-on kits that cost between \$2,000 and \$3,000. Next month, the first factory-warranted natural-gas vehicles, GMC Sierra pickups, will go on sale in Texas and California. Three slender fiberglass-wrapped tanks over 5 feet long, tucked along the pickup's frame, hold enough CNG for 150 to 200 miles; the truck carries no gasoline. Equipped with a catalytic converter and computerized engine controls, the GM truck promises better performance and lower emissions than retrofitted gasoline models. General Motors will build 1,000 new pickups under a cost-sharing agreement with gas utility companies but, says Richard Pennell, GMC's product-line manager, "we're looking at this as the start of a new business." Initially, the cost and inconvenience of CNG-powered cars will probably deter consumers, but manufacturers believe sales will grow as fuel storage, delivery and marketing develop.

Electric. After years of promise, it is nearly certain that electric vehicles finally will be sold generally in the United States, perhaps as soon as 1995. The California Air Resources Board is trying to force the development of a market with a new rule requiring any manufacturer selling cars in the state to offer zero-emission vehicles (ZEVs). In practice, this means "electrics." Starting in 1998, 2 percent of a manufacturer's car and light-truck sales must be ZEV; by 2003, 10 percent. This translates into a market of about 200,000 a year. The edict applies to all makers, foreign and domestic, and

proponents argue that once electrics are marketed sales will go higher still.

Electric vehicles promise enormous environmental and energy-security advantages. The vehicles themselves don't pollute at all and, even when the emissions from power plants used to charge batteries are considered, an electric car adds less than 5 percent of the pollution of a typical gasoline-powered car. Furthermore, about 95 percent of power-plant fuels are domestic. Because electric cars would be recharged at night when there is a large surplus of generating capacity, tens of millions of electric cars would have to be on the road before there would be a need for new power plants to support them.

The Big Three U.S. auto manufacturers all have clear plans to meet California's requirement. Ford and Chrysler expect to offer electric versions of their popular minivans. GM will sell a small, sporty, two-passenger electric commuter similar to the Impact show car it demonstrated last year. The U.S. companies all say they will offer these vehicles in other states with acute smog problems and probably in Europe, too.

First, however, car builders must overcome psychological as well as technological hurdles. "How do you sell a vehicle that doesn't quite measure up in driving range and performance at a premium price?" asks Robert Davis, executive engineer for Chrysler's electric-van project. First-generation electric vehicles will go only about 100 miles before

they must be plugged in for several hours to be recharged, and they will cost several thousand dollars more than equivalent gasoline cars. Because of their higher price, electrics over their lifetime will cost the consumer somewhat more than gasoline cars, even though the cost of electric power for recharging will run only two to three cents a mile. Heating and cooling electrics is also a major technical problem, since using the battery power for passenger comfort cuts a car's driving range. Electrics will be heavily insulated to minimize the energy needed for air conditioning and heating.

Public concern about air quality may help spur sales. In fact, after GM showed the Impact last year at the Los Angeles Auto Show, the company was deluged with requests for information. But consumer good will won't be enough to make electrics succeed; federal and state governments will need to offer potential

buyers incentives such as tax advantages, special access to car-pool lanes and preferential parking with electric outlets for recharging, contends GM President Lloyd Reuss.

Even with government incentives, motorists will have to like the cars' performance if they are to be a success in the long run, and manufacturers are banking on the electric cars' unique qualities: Electrics make almost no noise, for example and, since they lack complex engines "they have the potential to be very reliable—in essence, no-maintenance vehicles," argues Bradford Bates, Ford's manager for electric power.

Batteries remain a crucial weakness. At present, Chrysler and Ford plan to use advanced nickel-iron or sodium-sulfur batteries costing \$5,000 to \$10,000 a set that last the life of the vehicle; maintenance will be largely limited to replacing worn tires, brakes and windshield wipers. The \$1,500 lead-acid battery pack in GM's Impact is expected to last about 20,000 miles.

Lack of range may not be the problem many fear, given the way most people actually use cars. The average Ameri-

can driver goes only 15 to 35 miles a day, well within an electric's range, says Donald Runkle, GM vice president for advanced technology. For longer trips, motorists will have to take a gasoline car—or perhaps an unusual hybrid vehicle. Around town, a hybrid like the new GM van demonstrated last month operates on batteries. On long trips, a small gasoline-driven generator kicks in automatically to recharge the batteries.

Reformulated gasoline. For the foreseeable future, analysts believe that gasoline will remain the dominant fuel. But gasoline will be changed to produce less pollution, even in older cars. Beginning in 1995, the Clean Air Act requires that reformulated gasoline be sold in the nine cities with the worst ozone pollu-

tion; reformulation means an adjustment in gasoline's chemical components to reduce harmful emissions. Compliance with the new law will account for over one fifth of U.S. gasoline sales. As much as one half of all gasoline will have to be

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re-engineered by refiners if other urban areas that do not meet ozone standards decide to join the program voluntarily. The cost to modify refineries could reach \$40 billion.

Research on how to make the changes has already begun. Fourteen oil companies and the three major U.S. auto companies have joined forces to figure out the best ways to modify both gasoline and the cars that burn it. Oil and auto companies, which in the past rarely spoke to one another, are for the first time working together on the pollution problem.

Alcohol fuels. Although alcohol fuels got a lot of early hype as sound alternatives to gasoline, experts say now that they have failed to live up to their early promise. Both methanol, made from natural gas or coal, and ethanol, derived from corn and other crops, have proved too costly to serve as clean substitutes. In addition, methanol would have to come from the Soviet Union and countries around the Persian Gulf that have large surpluses. Importing from these regions would not contribute much to energy security. Both compounds, however, may prove useful as blends in reformulating gasoline to comply with emissions requirements.

Stricter emissions rules alone will raise the future cost of motoring. But Operation Desert Storm may raise the ante higher and more quickly. Congress may decide to raise gasoline taxes to promote conservation, spur adoption of alternative fuels and pay for the war. The country is learning that assuring supplies of inexpensive petroleum can have a very high price. As energy analyst Adam Sieminski of Washington Analysis Corp. observes, "The public's appetite for cheap gasoline might be curbed by the sight of blood." ■

BY WILLIAM J. COOK

Choosing a route

All future fuel options have advantages and disadvantages

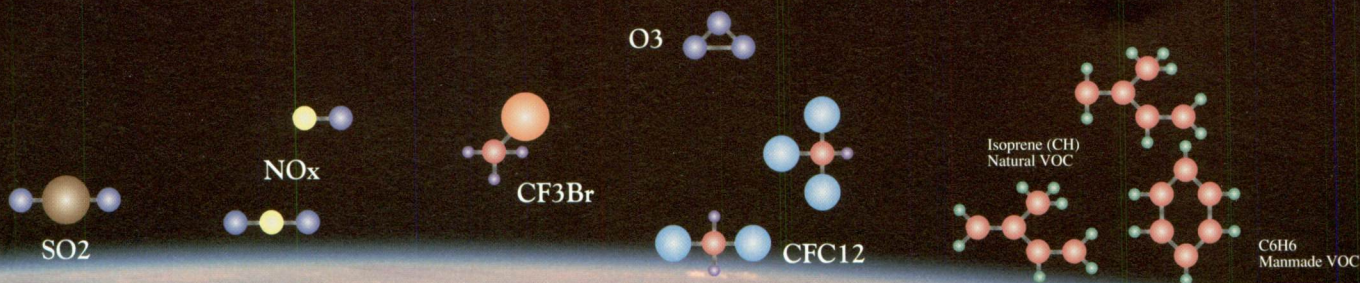
Advantages	Disadvantages
<p>■ Natural gas <i>Some domestic supplies</i> <i>Abundant gas overseas</i> <i>Low emissions</i> <i>Lower fuel cost</i> <i>Vehicle development advanced</i></p>	<p><i>Very widespread use requires imports</i> <i>One fourth the range of gasoline</i> <i>Filling stations must be built</i></p>
<p>■ Electric <i>Abundant domestic fuel</i> <i>Zero vehicle emissions</i> <i>Generating capacity now available</i> <i>Low fuel cost</i></p>	<p><i>Limited range and power</i> <i>Batteries expensive</i> <i>Slow refueling</i> <i>Some power plant emissions</i> <i>Heating, cooling difficulties</i></p>
<p>■ Reformulated gasoline <i>Existing filling stations</i> <i>Small to moderate emission reduction</i></p>	<p><i>No energy security advantage</i> <i>Possible high costs to modify refineries</i></p>
<p>■ Methanol <i>Liquid fuel</i> <i>Abundant supplies</i> <i>Less ozone pollution</i></p>	<p><i>Half the range of gasoline</i> <i>Imported from Middle East</i> <i>Formaldehyde problem</i></p>
<p>■ Ethanol <i>Liquid fuel</i> <i>Domestic production efficiency</i> <i>Less ozone pollution</i></p>	<p><i>Much higher fuel cost</i> <i>Corn supply limited</i> <i>Competition with food</i> <i>Less range than gasoline</i></p>

USN&WR - Basic data: Office of Technology Assessment, others

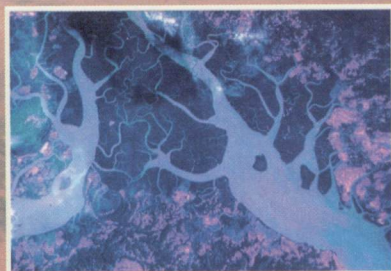
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"What is important in addressing future climate change is the total and cumulative effect of all gases—all sources and all sinks."



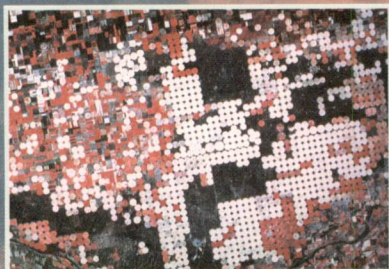
Coastal Marsh



Watershed Ecosystems



Ocean Phytoplankton Concentrations



Irrigated Land



Burning Rainforest



Tundra

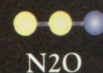
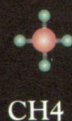
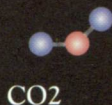
GAS	Instantaneous Radiative Forcing per KG (rel. to CO ₂)	Atmospheric Residence Years (estimated)	Relative Radiative Forcing Potential over Years		
			20	100	500
CO ₂	1	120	1	1	1
CH ₄	58	10	63	21	9
N ₂ O	206	150	270	290	190
CFC-11	3970	60	4500	3500	1500
CFC-12	5750	130	7100	7300	4500

Source: IPCC Scientific Assessment, 1990, Tables 2.3, 2.8

Photos: Cover: Caribbean as seen by IMAX camera from the Space Shuttle, © MCMXC Smithsonian Institution/Lockheed Corporation. Inside Flap Background: Straits of Gibraltar by IMAX, © Smithsonian Institution/Lockheed Corporation. Highland Rainforest, © Robert & Linda Mitchell; New Growth & Old Growth Forests, © Charles A. Mauzy; Coastal Marsh, © Tom Blagden, Jr.; Electricity Production, © Erich Hartmann; Transportation, © Japan Broadcast Corporation; Rice Paddies, © Mike Yamashita; Burning Rainforest, IMAX Image, © Smithsonian Institution/Lockheed Corporation; Tundra, © Dr. Jerry Brown, Global Change Research Background Image is the Atmosphere as seen by an IMAX Camera from the Space Shuttle.

CLIMATE CHANGE: Comprehensive Approach

Gases



Sinks



Rainforest



New Growth Forest



Old Growth Forest

Sources



Electrical & Industrial Production

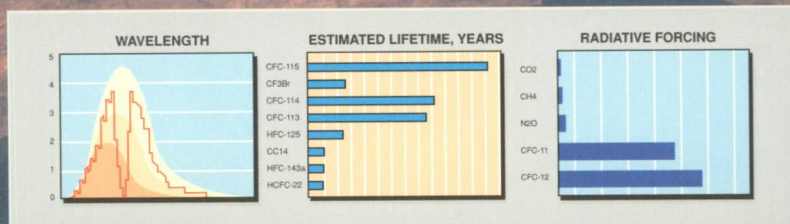


Transportation



Rice Paddies

Global Warming Potential Index





An Actio

THE COMPREHENSIVE APPROACH TO CLIMATE CHANGE

The science and economics of human interactions with the global climate involve multiple trace gases affected by activities in every sector of human society. Each of these greenhouse gases is emitted from a variety of sources and is trapped or affected by “sinks” in different ways. Each gas has a different residence time in the atmosphere, a different ability to trap heat, and different potential impacts on the environment. What is important in addressing future climate change is the total and cumulative effect of all gases—all sources and all sinks.

In November 1990, the government ministers at the Second World Climate Conference (SWCC) declared: “We recommend that in the elaboration of response strategies, over time, all greenhouse gases, sources, and sinks be considered in the most comprehensive manner possible ...”

The “Comprehensive Approach”* has several advantages:

- It provides flexibility for each nation to develop a diverse, innovative, cost-effective mix of measures to meet its global responsibilities in a manner tailored to its own domestic circumstances;
- It is designed to employ the results of integrated scientific and economics research on a comprehensive basis, leaving no important variable omitted;
- It maximizes the benefits to the environment and to humanity from each investment; and
- It accounts for all greenhouse gases, insuring that choices do not reduce one gas but inadvertently increase another.

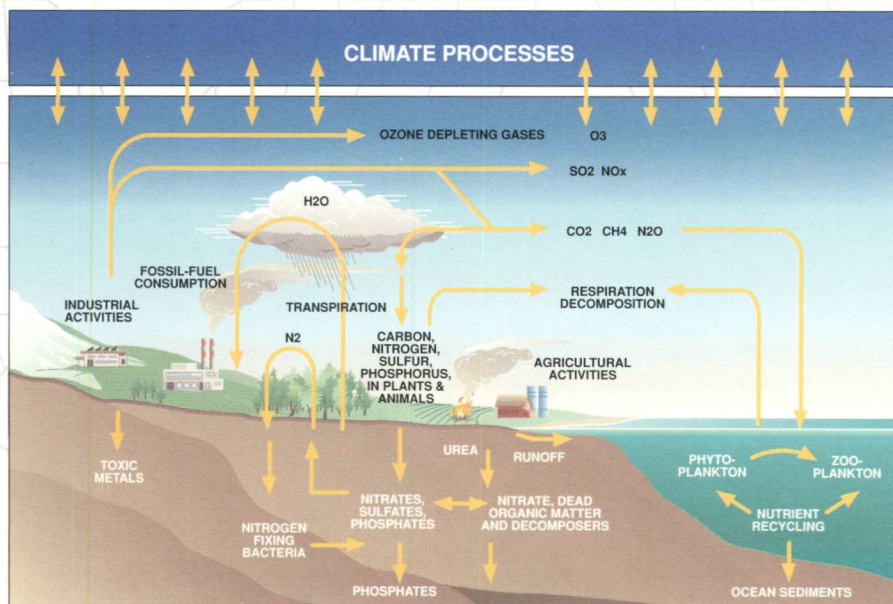
The relative benefit from a unit reduction in the net emissions of each greenhouse gas can be approximated by a measure of “global warming poten-

tial” (GWP) based on the radiative behavior of the gas in the atmosphere. The Intergovernmental Panel on Climate Change (IPCC) has calculated such a relative measure, giving carbon dioxide a value of one (1) and expressing all other gases in terms of carbon dioxide equivalents. This “index” enables a comparison of the contributions of different gases, incorporating both sources and sinks.

The comprehensive approach should inform the development of scientific and economics research, monitoring, technology development, and each country's action plan for dealing with global change. The costs of achieving a given reduction in the added greenhouse effect will vary from gas to gas and will vary depending on which sources or which sinks of any given gas are affected. Using the Comprehensive Approach, for example, maximum reduction in net climate impact—and therefore maximum benefit to the environment—can be achieved for any given level of investment.

If response strategies were designed to apply piecemeal to one greenhouse gas or economic sector, economic actors could simply adjust to such narrowly focused regulation by shifting to unregulated activities that could continue to contribute to potential climate change.

A comprehensive approach, on the other hand, matches the scientific, economic, and environmental nature of the whole climate system.



* A larger report on "A Comprehensive Approach to Addressing Potential Climate Change", prepared by a U.S. Interagency Task Force is available on request.

THE BOTTOM LINE

Implementation of the President's Comprehensive Climate Change Strategy will result in United States greenhouse gas emissions in the year 2000 being equal to or below 1987 levels.

The specific actions which will contribute to this result include:

- Phasing out CFCs and many other ozone-depleting compounds which are also greenhouse gases;
- Putting a permanent ceiling on sulphur dioxide emissions at sharply reduced levels and allowing freedom of choice in meeting the ceilings, thereby encouraging energy efficiency and reducing greenhouse gas emissions. Under the recently enacted Clean Air Act Amendments, utilities were given the flexibility to make reductions by any means—a powerful incentive for energy saving measures;
- Reducing, under the Clean Air Act, air pollutants which are either greenhouse gases themselves or greenhouse gas precursors (volatile organic compounds, carbon monoxide and nitrogen oxides);
- Initiating a program to plant a billion trees a year and to make other forest improvements, thereby enhancing sinks;
- Implementing a number of programs aimed directly at speeding the adoption of energy efficient technologies and practices in homes and businesses; and,

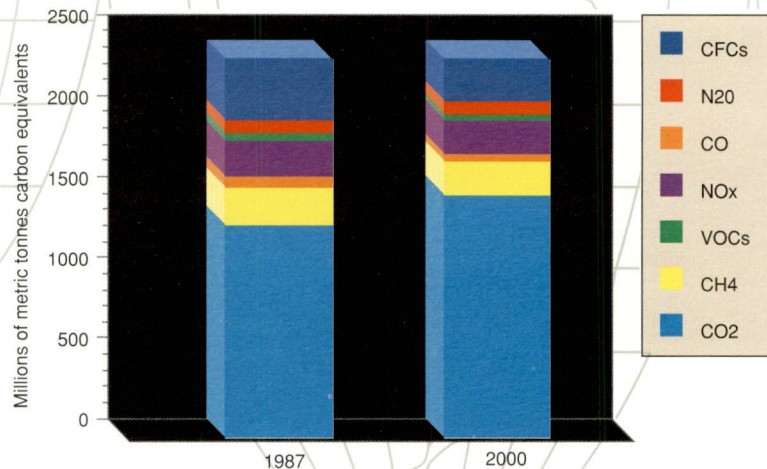
- Promoting the use of, and accelerating research into, non-fossil fuel energy sources such as solar, nuclear, and alternative fuels.

The results of these currently planned U.S. actions are illustrated by Chart 1, which shows projected U.S. greenhouse gas emissions for the year 2000. The estimate is based on calculations made by the U.S. Environmental Protection Agency.

Chart 2 shows an alternative estimate based upon a different economic model prepared by researchers at Harvard University.

Projected U.S. Greenhouse Gas Emissions

(With Current Policy Commitments)
Based on IPCC CO₂ Baseline Estimate



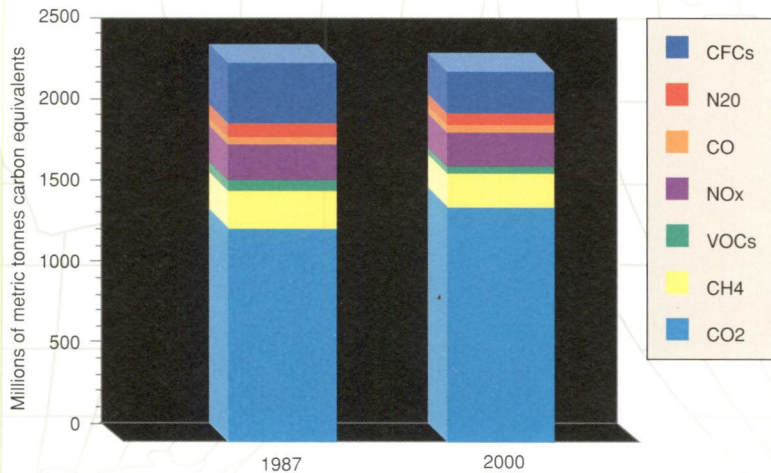
From EPA, "The Cost of Reducing Greenhouse Gas Emissions in the United States", Presentation by Alex Cristofaro, Director, Air and Energy Policy Division, December 4, 1990

CHART 1

The actions which are currently included in the U.S. Climate Change Strategy will result in U.S. greenhouse gas emissions in the year 2000 being equal to or below the 1987 levels.

Alternative Model For Projected U.S. Greenhouse Gas Emissions

(With Current Policy Commitments)
Based on Jorgenson/Wilcoxon (1990) Model



From EPA, "The Cost of Reducing Greenhouse Gas Emissions in the United States", Presentation by Alex Cristofaro, Director, Air and Energy Policy Division, December 4, 1990

CHART 2

PHASING OUT CFC's

The United States has long taken a leadership role in addressing the problem of stratospheric ozone depletion. In 1978, the U. S. banned the use of CFCs as propellants in spray can products. Such use was considered a low value use which could be forgone given the potential damage which it was believed CFCs might be causing. Most other countries continued to use CFCs as propellants.

At the London Meeting of Parties to the Montreal Protocol, the U. S. supported a complete world-wide phase-out of CFCs, halons, and certain other ozone-depleting substances such as carbon tetrachloride and methyl chloroform. The Protocol was amended to achieve that objective.

BEYOND THE MONTREAL PROTOCOL

The U. S. has enacted legislative provisions in the recent Clean Air Act amendments which will phase out U. S. production and consumption of these ozone-depleting compounds more quickly than the amended Montreal Protocol provisions. (See charts opposite)

For each and every one of these compound groups and gases, the Clean Air Act reduces the allowed U. S. production and consumption between now and the final phase-out date substantially below what the Protocol permits. (For example, see Chart 3 regarding CFC production)

Between now and the phase-out deadlines, the U. S., under the mandates of the Clean Air Act, must reduce U.S. production below what is permitted by the Montreal Protocol by at least the following amounts:

"Cumulative Near-term Reductions in Clean Air Act Below the Montreal Protocol"

Major CFCs	19%
Halons	32%
Other CFCs	22%
Carbon Tetrachloride	13%
Methyl Chloroform	20%

THE U.S. IS AHEAD OF SCHEDULE

In addition to the more restrictive phase-out schedules required by the Clean Air Act, the 1989 Budget Reconciliation Act enacted a tax on ozone-depleting chemicals during the period of phase-out. The tax rates for each compound are its ozone-depleting potential (ODP) multiplied by \$1.37 per pound in 1990 and 1991, \$1.67 in 1992, \$2.65 in 1993 and 1994, and an increase of an additional \$0.45 in each year after 1994.

This tax has already helped to reduce U. S. CFC production in the 12-month period ending June 30, 1990 to 23% below the levels permitted by the Montreal Protocol and other U.S. law.

While these actions by the United States are justified by their benefits relating to stratospheric ozone depletion, they are also very highly significant for climate change. CFCs, halons, and carbon tetrachloride are extremely powerful greenhouse gases, thousands of times more powerful than carbon dioxide.

Phase-Out of Major CFCs

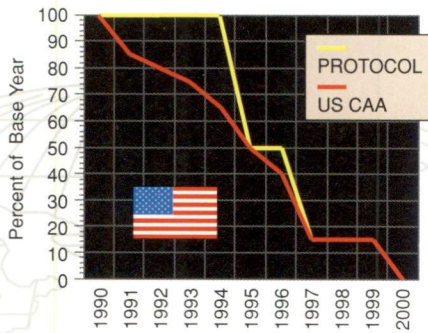


CHART 3

From Article 2A - 2E, Montreal Protocol text and Title 6 of the Clean Air Act Amendments of 1990 CAA did not apply in 1990

Phase-Out of Halons

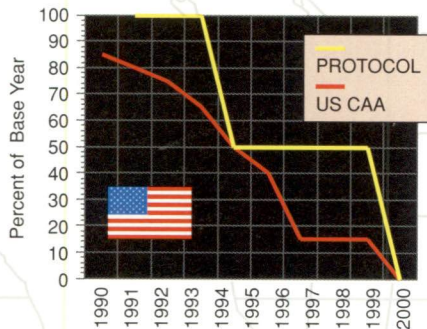


CHART 4

From Article 2A - 2E, Montreal Protocol text and Title 6 of the Clean Air Act Amendments of 1990

Phase-Out of Carbon Tetrachloride

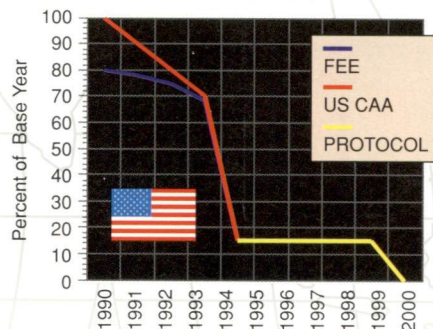


CHART 5

From Article 2A - 2E, Montreal Protocol text and Title 6 of the Clean Air Act Amendments of 1990 Production estimates under the User Fee are based on Treasury Department estimates

Phase-Out of Methyl Chloroform

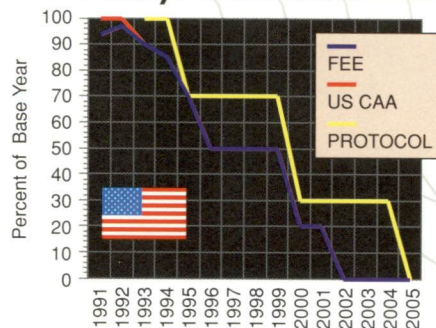
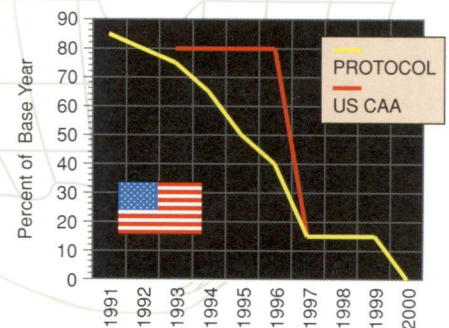


CHART 6

From Article 2A - 2E, Montreal Protocol text and Title 6 of the Clean Air Act Amendments of 1990 Production estimates under the User Fee are based on Treasury Department estimates

Phase-Out of Other CFCs



From Article 2A - 2E, Montreal Protocol text and Title 6 of the Clean Air Act Amendments of 1990

THE 1990 CLEAN AIR ACT AMENDMENTS

The 1990 Clean Air Act Amendments, signed by the President in November 1990, will achieve substantial reductions of greenhouse gases and their chemical precursors. The Act will reduce U.S. emissions of volatile organic compounds, carbon monoxide, and nitrogen oxides, which will curb tropospheric ozone levels, in addition to reducing emissions of the more familiar pollutants such as sulfur dioxide. When converted into equivalent units of carbon emissions, taken together, these reductions will amount to a 16% decrease in greenhouse gases from these affected sources between the years 1987 and 2000. Moreover, the Act will result in direct carbon dioxide reductions due to more efficient electricity generation.

Electric Utilities

The most dramatic reductions will come from electric utilities. Under the Act, utilities, which must reduce sulfur dioxide (SO₂) emissions by 10 million tons below 1980 levels, are given the flexibility to choose how to achieve these reductions. Utilities are thus free to choose cost-effective conservation measures to achieve compliance. This powerful conservation stimulus should sharply reduce carbon dioxide (CO₂) emissions from this sector.

Further, the Act requires utilities to reduce their nitrogen oxide emissions by two million tons from projected levels under the acid rain provisions. These provisions also contain strong incentives for both electric utilities and industrial sources

to adopt advanced, energy efficient technologies that will lower overall emissions, including carbon dioxide.

The Act is also expected to induce oil-burning utilities to switch to natural gas, which produces less greenhouse gas emissions than does oil.

Smog Reductions

Substantial reductions in either greenhouse gases or their chemical precursors also will result from new controls on stationary and mobile sources mandated by the new Act in order to bring cities into attainment of national air quality standards. A wide variety of stationary sources of volatile organic compounds will be required to reduce emissions by adding controls or by changing production processes. Newly tightened automobile emission standards will further reduce emissions of hydrocarbons, carbon monoxide, and nitrogen oxides, and new controls on gasoline evaporation will greatly cut volatile organic emissions. In addition, gasoline itself will be reformulated to reduce its volatility, thus reducing volatile organic emissions at the source. In total, these various requirements of the Act will result in a sharp and steady drop in U.S. tropospheric ozone, which is a key greenhouse gas.

Cleaner Fuels & Cleaner Cars

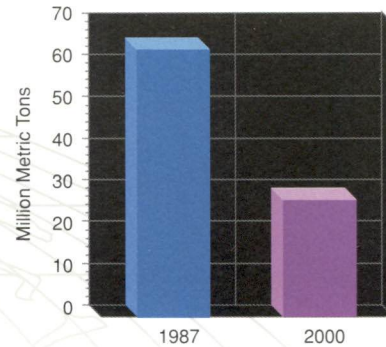
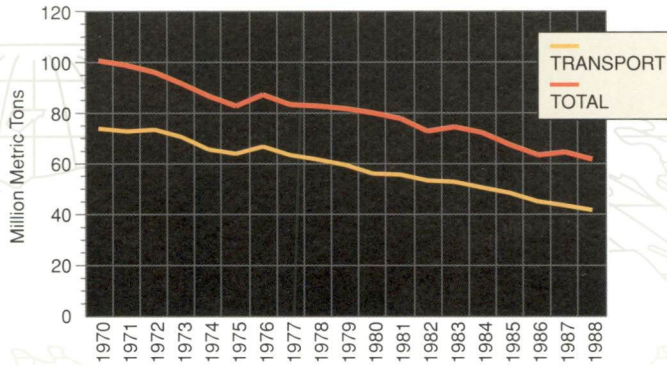
The Act will dramatically expand the introduction of clean-burning alternative fuels into the U.S. transportation sector. Several large states and the fleets of America's major

cities are expected to introduce fuels and vehicle technology which will emit fewer greenhouse gases.

Beginning in model year 1994, new tailpipe emissions standards for hydrocarbons, carbon monoxide, and nitrogen oxides will be phased-in. Auto manufacturers will also have to reduce refueling emissions. Gasoline volatility will be reduced and cleaner fuels will be required in the nine cities with the worst ozone problems and in 41 areas during the winter months when carbon monoxide standards are exceeded. A clean fuel car pilot program in California will use combinations of vehicle technology and cleaner fuels to meet tight standards. Twenty-six areas will have to limit emissions from centrally-fueled fleets of 10 or more vehicles.

Regulations also are being proposed under the new source performance standards of the Clean Air Act to require capture of pollutant gases which are given off by landfills. The purpose of the regulations is to capture air toxics and volatile organic compounds which are the chemical precursors of the greenhouse gas ozone. Methane also will be captured and, if it is not economic to be processed, it will be flared. Greenhouse gas emissions in the year 2000 will be reduced by approximately 40 million tons of carbon equivalent.

Trends in Emissions of Carbon monoxide, 1970-1987,



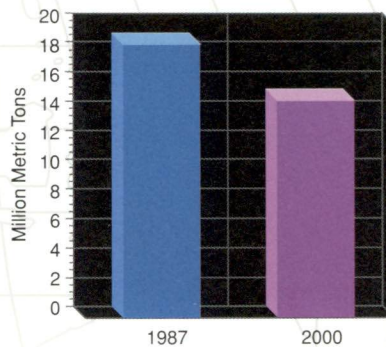
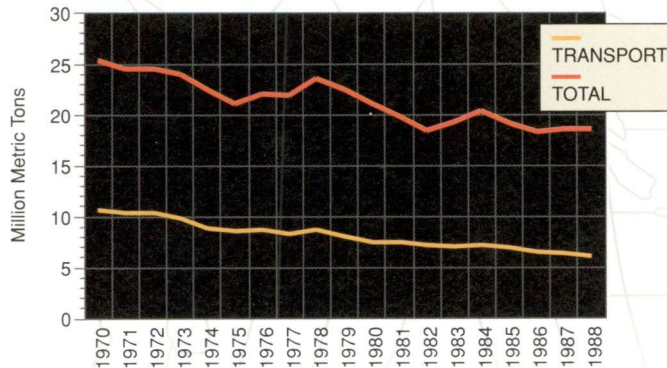
Source: U.S. EPA

CHART 9

From EPA, "National Air Pollution and Emission Estimates, 1940-1982" Feb. 1984
 EPA, "National Air Quality and Emissions Trend Report, 1988" March 1990.
 EPA, "National Air Quality and Emissions Trend Report, 1987" March 1989.

CHART 8

Trends in Emissions of Reactive Volatile Organic Compounds 1970-1987



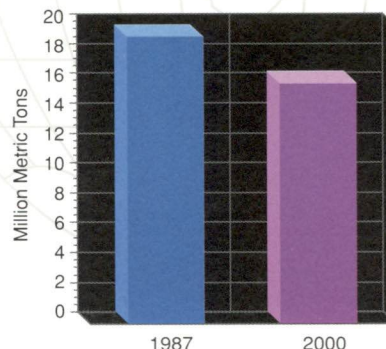
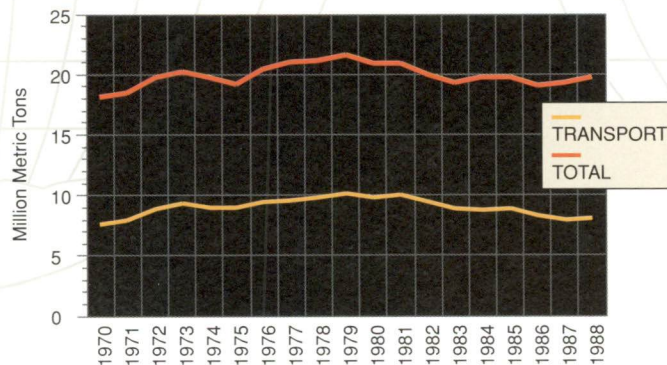
Source: U.S. EPA

CHART 11

From same sources as Chart 8

CHART 10

Trends in Emissions of NOx



Source: U.S. EPA

CHART 13

From same sources as Chart 8

CHART 12

ENHANCING NATURAL SINKS

The term "sinks" of greenhouse gases is meant to include human and natural activities, processes, and phenomena that remove greenhouse gases from the atmosphere or reduce their atmospheric lifetimes. Examples include forests, soils and oceans. The IPCC recognized the importance of sinks in a report of its Response Strategies Work Group (RSWG): "The RSWG reviewed potential measures for mitigating climate change... These measures include those which limit emissions from greenhouse gas sources (such as energy production and use), those which increase the use of natural sinks (such as immature forests and other biomass) for sequestering greenhouse gases, as well as those measures aimed at protecting reservoirs such as existing forests."

Reforestation

The President has included in both his FY 1991 and FY 1992 Budgets a major, multiyear reforestation proposal to plant one billion trees per year on 1.5 million acres and to improve forest management practices. This initiative will encompass cities and towns across America, as well as rural, private, non-industrial forest lands. It comes in addition to reforestation which Federal agencies and private companies normally perform on lands under their jurisdiction.

One purpose of this initiative is to improve the condition of private, non-industrial forest lands which now are often in poor condition due to low levels of management and investment. Improving these lands will increase benefits from soil protection, wildlife, wood products, and recreation.

This initiative also will have climate change benefits through the carbon which growing trees (sinks) remove from the air and store both as plant tissue and in the soil. The estimates of carbon removed from the atmosphere by the trees to be planted under the initiative are 9 million metric tons of carbon annually by the year 2000, growing to 50 million tons per year by 2010. (See Chart 15)

Global Forest Convention

The President proposed at the Summit of Industrialized Nations in July 1990 at Houston to begin negotiations as expeditiously as possible on a global convention on forests, aiming for completion and signing by 1992.

The world's forests absorb carbon dioxide as well as provide many benefits in the form of timber and fiber, soil and water protection, biodiversity, wildlife habitat, recreation and other valuable outputs. They provide the habitat for some 80% of the planet's remaining unknown and unspecified gene pool—a completely irreplaceable

and potentially enormously valuable heritage for all humankind. Temperate zone forests are being damaged by air pollution stresses and tropical forests are being rapidly lost.

The U.S. believes that the forest convention should emphasize market-based mechanisms and flexibility to achieve sound, sustainable forest use, to improve the health and vigor of forests, to encourage reforestation, and to increase the value of forests as sources of income and jobs. In addition, increasing the productivity of activities using the land base can minimize deforestation.

Areas suggested for international cooperation and joint action include: reforestation and rehabilitation; research and monitoring; education, training, and technical assistance; reform of the Tropical Forestry Action Plan; reduction of air pollution; bilateral and multilateral assistance; debt-for-nature swaps; and removal of harmful subsidies.

Reductions in Carbon Dioxide Emissions

From Tree Planting Initiative

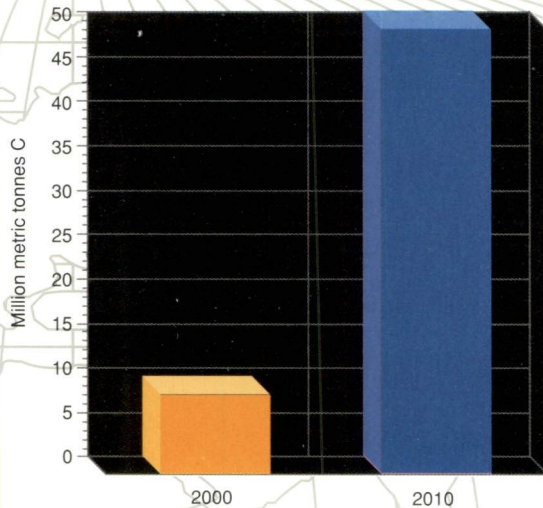


CHART 15

From EPA, "The Cost of Reducing Greenhouse Gas Emissions in the United States", Presentation by Alex Cristofaro, Director, Air and Energy Policy Division, December 4, 1990

Tree Planting Initiative

Example Carbon Sequestration by Age of Stand (Cutover)

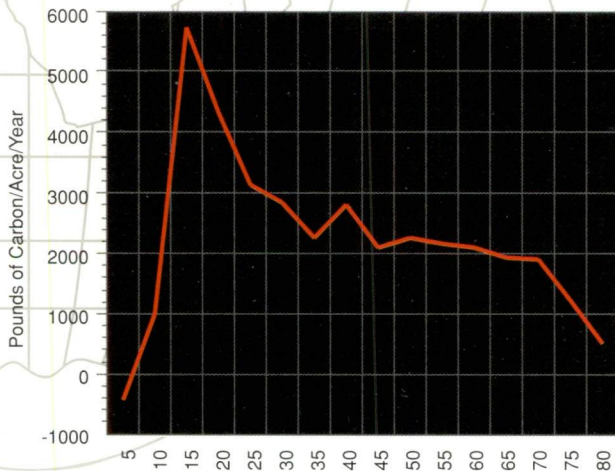


CHART 16

Source: U. S. Forest Service

To put the power of trees as "sinks" into perspective, consider the example of an acre of improved stock of southern pine planted on a high quality site in the southeastern U. S. In the 15th year after planting these trees would take up between 5700 and 6200 pounds of carbon per acre. While the amount taken up declines thereafter as the trees mature, additional carbon continues to be taken up. (See Chart 16)

ENERGY INITIATIVES: *Efficiency*

The Administration is currently developing and will announce shortly a National Energy Strategy that will further contribute to the greenhouse gas emissions reductions cited here. Certain National Energy Strategy initiatives have been included in some of the calculations in this document.

The U.S. strategy for action includes a number of other energy efficiency measures beyond those in the Clean Air Act.

More efficient new appliance standards.

Large appliances account for over two thirds of home energy usage, excluding space heating. In the past three years the U.S. has imposed energy efficiency standards on many of the most energy-intensive appliances, including refrigerator/freezers, clothes washers, dryers, and dishwashers. These standards should achieve annual energy savings of 7-8% relative to projected use by the year 2000, and 14-15% relative to projected use by the year 2010.

The imposition of appliance standards has already resulted in a reduction of greenhouse gas emissions. As older appliances are replaced with new, environmentally friendly models, the greenhouse gas reductions will increase dramatically. By the year 2000, the U.S. anticipates an annual reduction of 4.4 million tons of carbon equivalent from projected greenhouse gas emission due to these standards; the annual reduction will increase to 4.9 million tons of carbon equivalent in 2010.

Level Playing Field Between Electricity Supply and Demand Reduction.

In some cases utilities can meet demands for energy services without any additional greenhouse gas emissions by investing in energy efficiency rather than by increasing electricity supply. Utilities in only 15 states are now fully able to recover costs from such investments. Absent such efficiency measures, new capacity requirements by the year 2000 are projected at more than 100,000 MW.

The U.S. will work with the States to identify regulatory barriers that discourage utility investment in cost effective energy efficiency. Utility planning techniques will be developed to consider all alternatives and their costs. The U.S. will provide training, information dissemination, and other types of technology transfer activities. These actions will reduce greenhouse gas emissions in the year 2000 by 9 million metric tons carbon equivalent.

Encourage use of energy efficient building standards.

Both the U.S. and the private sector have developed standards that would achieve 20-25% energy savings in buildings. They could save \$5 billion over 20 years from the new buildings built in a single year.

The U.S. will promote voluntary use of these standards through training programs, design manuals and computer-aided design systems. It will encourage State and local governments to use the standards in their building codes. These actions to encourage adoption of the most energy efficient modern technology in residential and commercial building will reduce greenhouse gas emissions in 2000 by 8.2 million metric tons of carbon equivalent.

Use of the modern standard in public housing assistance programs will reduce greenhouse gas emissions by 800,000 metric tons carbon equivalent in 2000.

Expand national energy audit capabilities and use.

Industry, with some 350,000 separate establishments, uses 24.7 quads of energy annually. Many options exist for low-cost quick payoff energy saving investments, but smaller firms often lack the information, expertise, and specialized resources to do energy audits of their plants.

The U.S. will increase its program to train engineers in energy audit and diagnostic methods from the current 13 engineering schools to 40 nationwide in the year 2000. This will reduce greenhouse gas emissions in the year 2000 by 6 million metric tons carbon equivalent.

More efficient lighting in federal facilities.

Twenty-five percent of federal agency energy use is for lighting of facilities. However, lack of adequate flexibility for facility managers and restrictive procurement practices have slowed adoption of efficient new technologies.

The U.S. will identify energy savings options in Federal facilities. Project plans, procurement methods, and financing options will be developed to overcome the barriers to improve lighting efficiency. This will reduce greenhouse gases in the year 2000 by 1.4 million metric tons carbon equivalent.

U.S. Savings in Emissions From Initiatives in Energy Efficiency and Renewables.

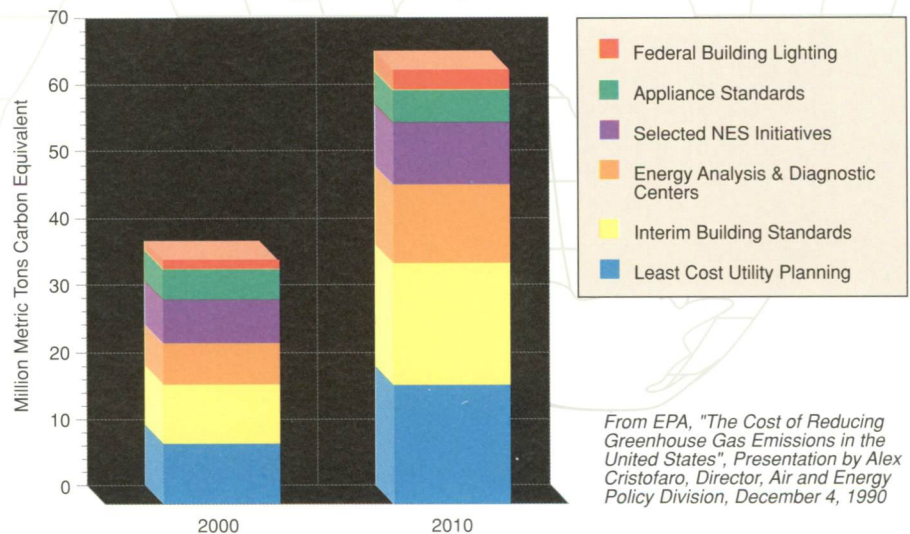


CHART 17

From EPA, "The Cost of Reducing Greenhouse Gas Emissions in the United States", Presentation by Alex Cristofaro, Director, Air and Energy Policy Division, December 4, 1990

ENERGY INITIATIVES: *Renewables and Non-fossil Fuels*

Accelerate the transfer of photovoltaic technology to U.S. commercial production:

Recent laboratory research has achieved photovoltaic efficiencies of over 30%. With such efficiencies and improved manufacturing, today's \$4-5 prices per peak watt could be cut in half.

The U.S. will start an intensive effort with industry to understand potential improvements in photovoltaic processes. Industry joint ventures to provide practical solutions and maximize transfer of results will be encouraged. The U.S. will also provide cost-shared technical assistance to adapt manufacturing improvement techniques to specific processes. By the year 2000, greenhouse gas emission reductions will begin to phase in at 500,000 metric tons of carbon equivalent.

Expand nuclear energy capacity:

As the Nation enters the 1990s, nuclear power is the second largest source of U.S. electricity, providing almost 20 percent of America's electricity needs, and nuclear power causes no greenhouse gases.

Because of the availability of nuclear power the nation is able to avoid the use of large amounts of fossil fuels. In terms of the displacement of fossil fuels, nuclear power can be thought of as reducing utility emissions of carbon dioxide—a major greenhouse gas—by 20 percent, or approximately 128 million tons, annually in the U.S. In effect, then,

nuclear energy plants reduce overall U.S. emissions of carbon dioxide by nine percent. Worldwide, nuclear energy reduces these emissions by more than seven percent.

A comprehensive strategy for nuclear energy is being developed as a part of the National Energy Strategy and is supported in the President's Fiscal Year 1992 budget. This strategy includes:

- Developing advanced light water reactors that will incorporate passive safety features in a standardized (modular) design. This will reduce the time needed to license new plants, while assuring that safety issues are adequately addressed. The U.S. is currently supporting first-of-a-kind engineering work that will assist companies in their efforts to have the Nuclear Regulatory Commission certify the safety of standardized designs;
- Conducting research and development on advanced reactor concepts with safety features that go beyond even the standardized designs ("to be intrinsically safe") currently before the Nuclear Regulatory Commission. High temperature gas cooled reactors use specially coated fuel elements that will not fail even under the high temperatures that could occur in an accident. Liquid metal reactors use liquid sodium as the heat exchange medium. Researchers have demonstrated that these new reactor types can shut themselves down safely under

conditions that would be extremely serious for present-day reactors;

- Reforming the nuclear licensing process through consolidation of the redundant aspects of the construction and operating licensing processes, without compromising nuclear safety concerns; and,
- Developing a long-term solution to the nuclear waste problem by developing a permanent repository, and possibly an interim retrievable storage facility.

DOE is funding programs that are supporting growth in nuclear energy capacity and the life extension of many currently operating plants. According to analysis done for the National Energy Strategy, support from DOE is expected to result in adding new nuclear capacity by 2000, which would result in further reductions in greenhouse gas emissions.

Increase transportation use of alternative fuels.

Use of oxygenated fuels, such as ethanol, can reduce urban smog levels and emissions of CO₂ and carbon monoxide.

U.S. research has demonstrated the technical feasibility of the processes to produce ethanol from non-food domestic resources such as wood or herbaceous crops.

The U.S. will expand current research programs in alternative fuels to include cost-shared joint ventures aimed at reducing the cost of ethanol from non-food resources. This effort will be coordinated with industry vehicle and engine development programs.

Conservation and Renewable R&D

The U.S. is funding a large research and development program for conservation and renewable energy. In Fiscal Year 1992, this effort is increased by 18 percent to a level of \$495 million, which represents an increase of over 50% since 1989.

In the long run, an adequate response to climate change will involve the use of new technologies that conserve energy or that provide energy without causing greenhouse gas emissions. These technologies will be needed in all of the economy's sectors.

The Administration is proposing to initiate, in the fiscal year 1992 budget, a new joint auto industry-government consortium to develop a battery for electric vehicles. Improved batteries could extend vehicle range to 120 to 200 miles. Fuel-cell-powered electric vehicles offer the potential to achieve up to 50 percent efficiencies.

R&D for energy efficiency in transportation includes work on high temperature internal combustion engines, gas turbine engines, fuel cells and a new initiative for electric vehicles. Air transportation energy efficiency work includes research in hybrid laminar flow, composite

materials, improved terminal operations, and improved air traffic control.

An initiative to address the problem of combustion emissions in waste-to-energy plants is being started. Further, alternative-fuel vehicle demonstration and a scale-up of a wood-to-ethanol process are being initiated.

Industrial energy efficiency R&D includes funding for more efficient steel, aluminum, and paper processes. A scale-up and test of the use of concentrated solar energy to detoxify liquid wastes is also planned.

Building energy efficiency research focuses on the interactions of energy systems, and the efficient use of advanced window technologies and building materials to control light and heat entering a building.

Total FY 1992 funding for research in new energy technologies is over \$900 million.

TRENDS: CO₂ Emissions

United States emissions in 1988 were only 2.7% above the 1973 level, despite the fact that real U. S. Gross Domestic Product (GDP), in 1985 dollars, grew by 48 percent over that period.

A key unanswered question about responding to the climate change issue is how to achieve economic growth in developing countries and economic reform in formerly centrally-planned countries without massive increases in greenhouse gas emissions.

It is important to remember that anthropogenic emissions of CO₂ contribute about 4% of the total global CO₂ flux.

Charts 21 and 22 compare the recent U. S. emissions trend with countries which contain most of the world's population. Those in Chart 21 have trends of rapidly growing CO₂ emissions, and are likely to have substantial emissions growth in the coming decades.

Growth in CO₂ Emissions and U.S. GDP

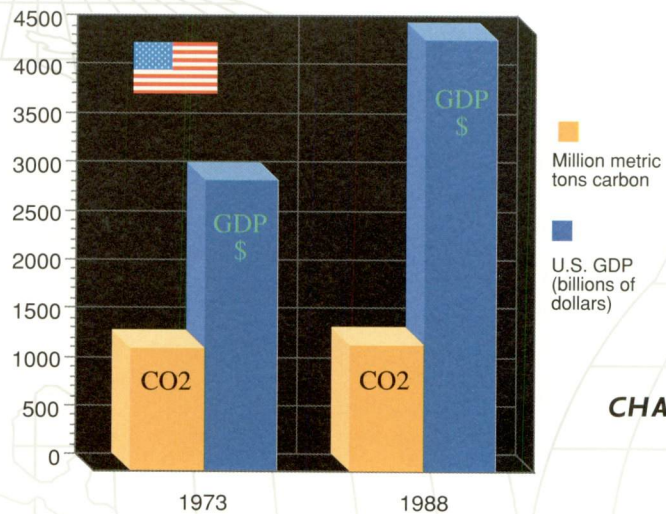


CHART 19

Source DOE Trends '90; OECD National Accounts, 1960-1988, (Paris 1990)
GDP deflators 1982=100 Source 1990 Economic Report

Emissions of CO₂ Per Unit of GDP, 1988

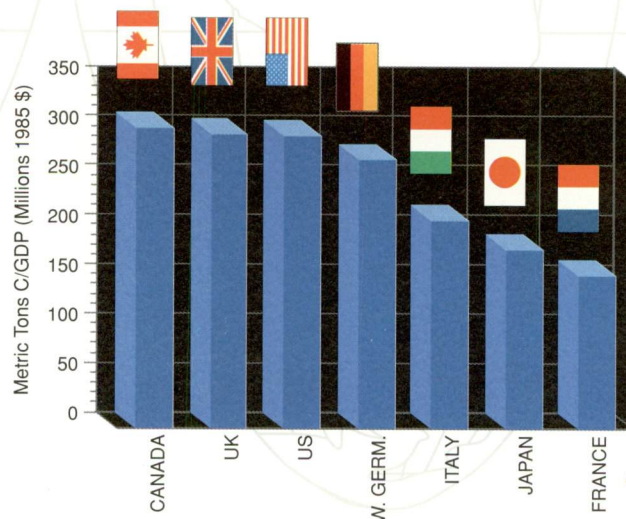
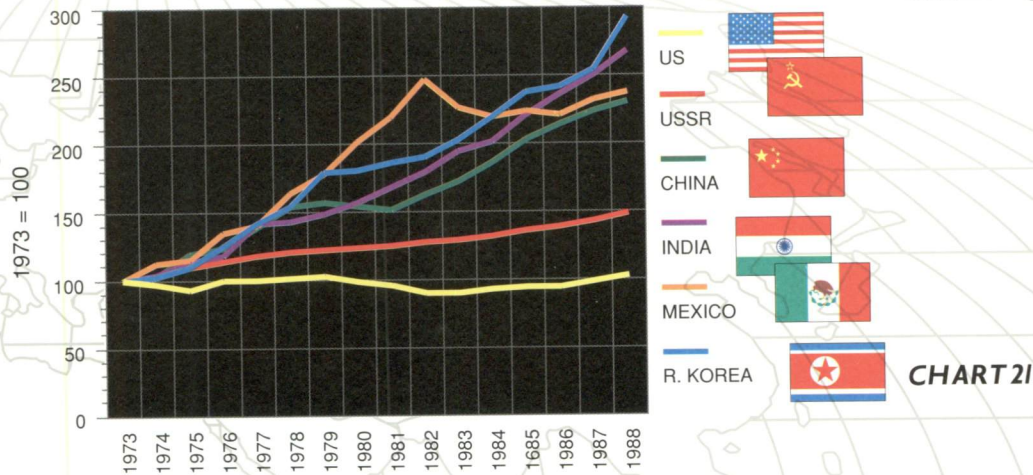


CHART 20

Emissions from DOE, "Trends '90, A Compendium of Data on Global Change", August 1990.
GDP from OECD, "National Accounts 1960-1988", (Paris 1990)

Trends in Carbon Dioxide Emissions

U. S. and High Emissions Growth Countries

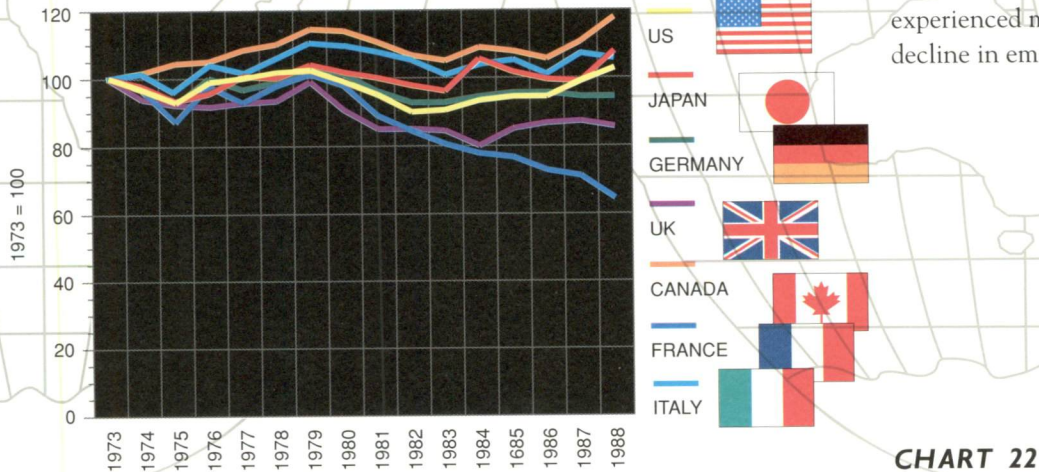


Calculated from data in DOE, "Trends '90, A Compendium of Data on Global Change", August 1990

CHART 21

Trends in Carbon Dioxide Emissions

U. S. and G-7 Countries



Calculated from data in DOE, "Trends '90, A Compendium of Data on Global Change", August 1990

CHART 22

Chart 21 compares the U. S. trend to countries which have experienced substantial growth in emissions.

Chart 22 compares the U. S. trend to industrial countries which have experienced moderate growth or decline in emissions.

TRENDS: Energy Intensity

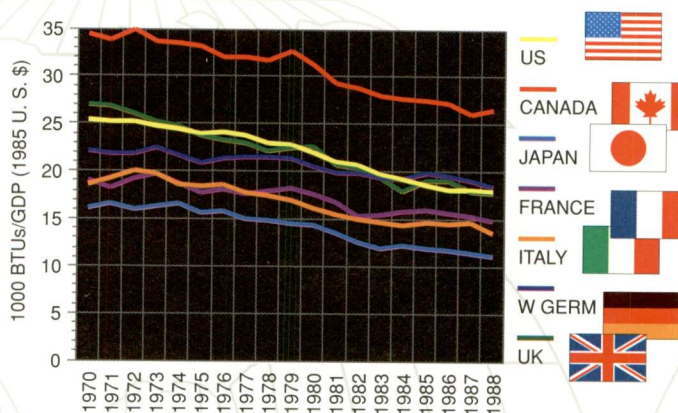
Chart 23 compares United States energy consumption per unit of gross domestic product (GDP) with Canada, Japan, France, Italy, West Germany and the United Kingdom—the other G-7 countries.

As shown in Chart 23, the United States has improved its energy use/GDP ratio since 1970, averaging an annual improvement of 2 percent per year. In 1988 the U. S. used only 70.9 % as much energy per unit of GDP as it used in 1970.

The United States' rate of improvement in the industrial energy use/gross product originating (GPO) ratio has been greater than most other G-7 countries, averaging close to 3 percent per year since 1977 (Chart 24).

Since the early 1970s, the United States has improved its heating efficiency on an energy used per square foot per degree day basis. The U.S. used in 1987 only 68.4% of the energy used per square foot in 1972. Today, U.S. energy use in dwellings per square foot per degree day is much lower than most other G-7 countries.

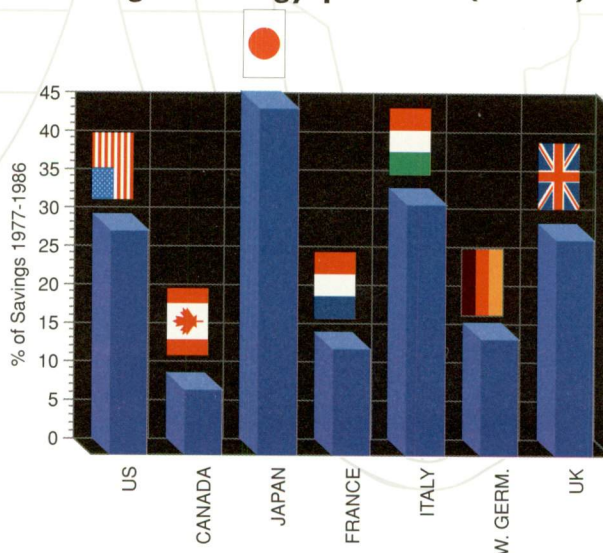
Energy Consumption per Unit of GDP



Total Consumption in Quads from International and Contingency Information Division, Statistics Branch, Energy Information Administration
GDP in 1985 \$ from "National Accounts 1960-1988", OECD (Paris 1990)

CHART 23

Savings in Energy per GPO ('77-'86)



From same source as Chart 23

CHART 24

Energy consumption per unit GDP in the U.S. is comparable to other G-7 countries.

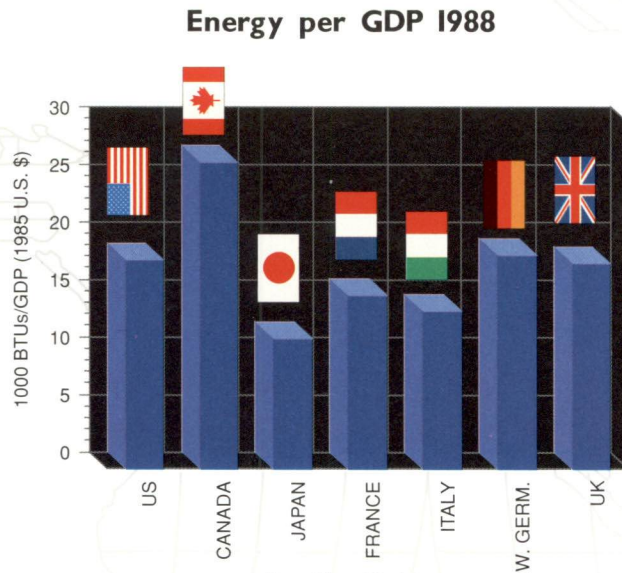


CHART 25

From Chart 23 data

TRENDS: *Transportation*

Population density in the United States is 5 to 10 times less than in many of the other G-7 countries (Chart 26). With such a low density, the U. S. spatial spread between work and home naturally increases transportation use per capita. Distribution of economic activities across a wide continent requires substantial energy consumption for moving people and freight long distances. Transportation energy consumption per capita is highest in the United States and Canada and substantially lower in the G-7 countries with high population densities.

New car fuel efficiencies in the United States are now roughly even with those of most of the other G-7 countries (Chart 27), despite much more demanding U. S. emissions and auto safety standards. The U. S. 1987 miles per gallon ratio was 28.3, within a relatively narrow range from Japan at 27.7 to the United Kingdom at 31.8. The U. S. from 1973 to 1987 increased its new car fuel economy by almost 100 percent (Chart 29).

Population Density per Square Mile, 1988

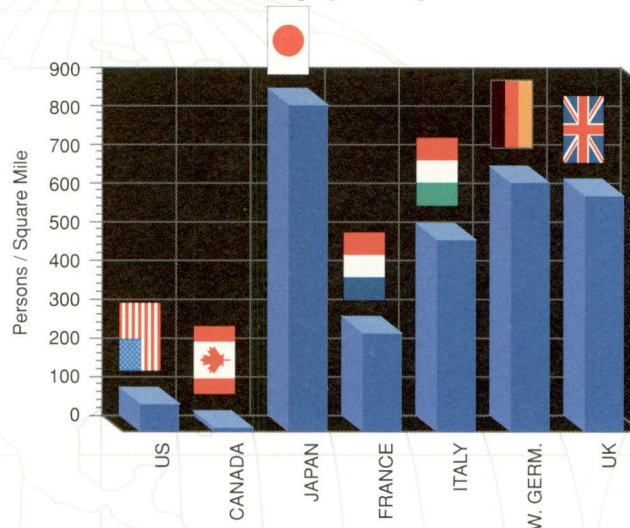


CHART 26

Population from OECD, "National Accounts 1960-1988" Vol 1 (Paris, 1990)
Area from Pharos Books "The World Almanac and Book of Facts 1990", (New York, 1989)

New Car Fuel Efficiency

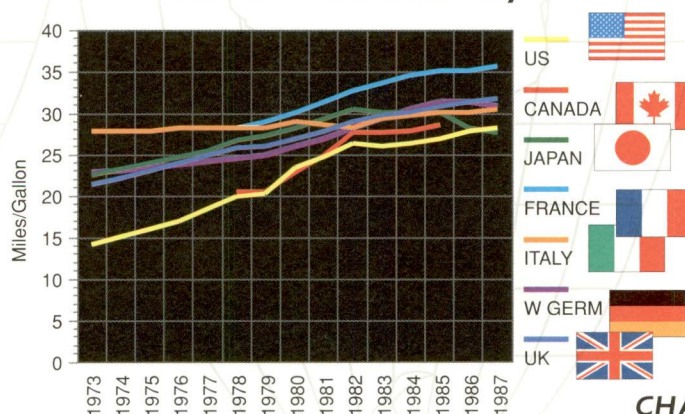
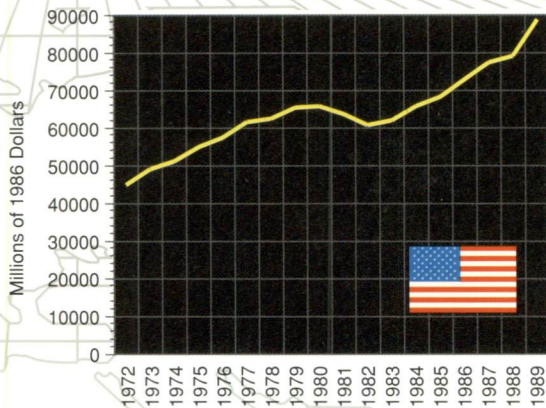


CHART 27

From OECD, "Energy Conservation in IEA Countries" (Paris 1987); IEA country submissions; and Lawrence Berkeley Laboratory (French amounts)
Conversion factors: 3.785 liters per gallon, 1.609 kilometers per mile.

U. S. Pollution Control Expenditures

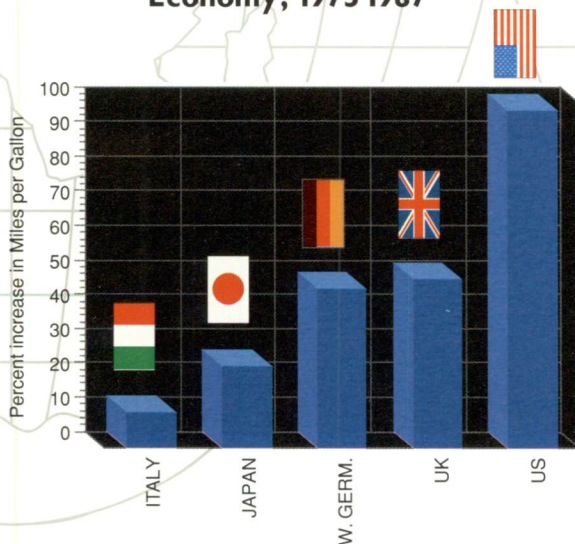


From EPA, "Environmental Investments: the Cost of a Clean Environment", July 6, 1990 draft.

CHART 28

United States' declines in emissions of volatile organic compounds, carbon monoxide, CFCs, and, to some degree, the stabilization of carbon dioxide emissions over the period from the early 1970's to the present can be attributed, in part, to U. S. investment to protect and to clean up the environment. U. S. spending for all pollution control purposes over the period is shown in Chart 29. It has grown by 100 percent from 1972 to 1989. It is expected to continue growing. Enactment of the Clean Air Act Amendments of 1990 alone is estimated to increase U.S. pollution control expenditures by an additional \$25 billion a year when fully implemented.

Improvement in New Car Fuel Economy, 1973-1987



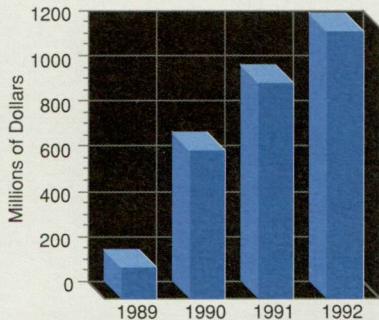
Source: same as chart 27.

CHART 29

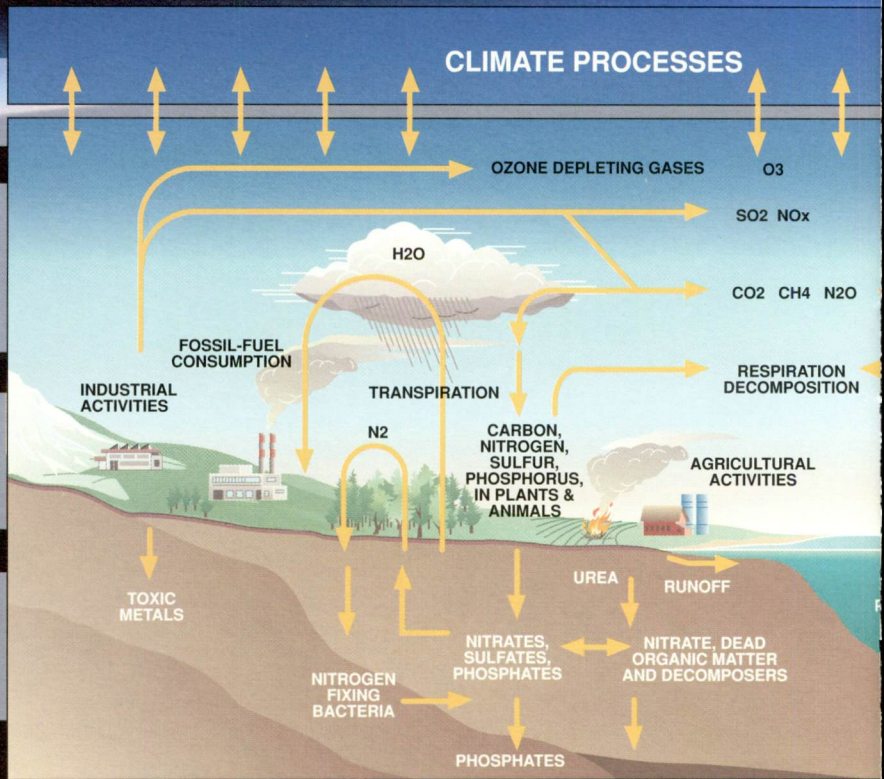
U. S. pollution control spending has historically been larger compared to the country's Gross Domestic Product than spending by other countries for which data is available.

invest almost \$1.2 billion in this Program, which virtually doubles the U.S. commitment to the research program of the US/GCRP since it was initiated in FY 1990 (see chart below).

Funding for Global Change Research Focused Programs



Source: U.S. Office of Management & Budget



GOAL: To establish the scientific basis for National and International policy making relating to natural and human—induced changes in the global Earth system.

particularly the climate aspects. This is to be complemented by a program of economics research to better understand the economic factors and consequences of global change and various mitigation and adaptation strategies. It is the intent of the US/GCRP to provide leaders of government with the best possible scientific and economic information as inputs to environmental policy decisions.

The highest priorities for the US/GCRP in FY 1992 are to:

1. Enhance scientific research efforts that seek to *reduce the scientific uncertainties* identified during the IPCC scientific and impact assessments.

Specifically, the USGCRP research will focus on understanding the processes affecting:

- *changing concentrations of greenhouse gases* which are implicated in future global warming predictions;
- *clouds and radiative balance* which strongly influence the magnitude of climate change at global and regional scales;
- *oceans* which influence the timing and patterns of climate change;
- *land-surface hydrology* which affects regional climate change and water availability;
- *polar ice sheets* which affect predictions of global sea level changes; and

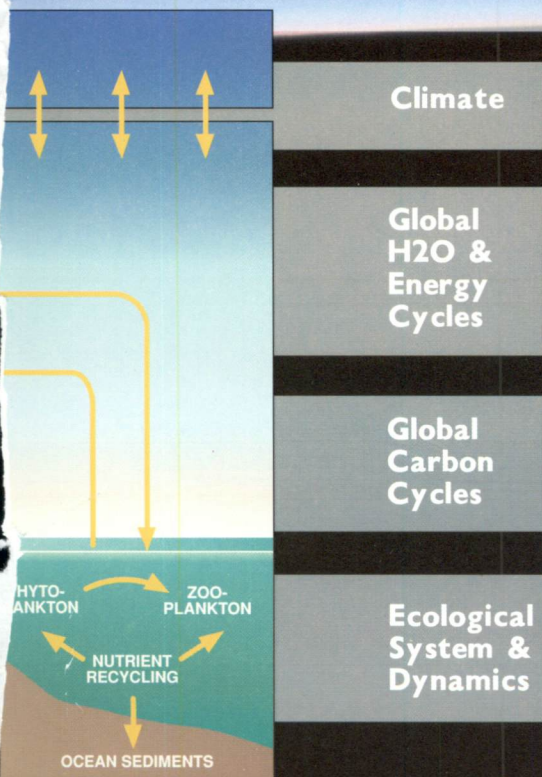
• *ecological dynamics* which are impacted by and respond to climate change.

2. Enhance scientific and economic research to support the development and implementation of a *comprehensive approach* to greenhouse gas emissions reductions, specifically a focus on:

- *sources and sinks of greenhouse gases;*
- *development of a quantitative index of radiative forcing; and*
- *development and use of economic models to generate predictions of future scenarios that cover multiple greenhouse gases and multiple economic sectors.*

The ultimate goals of the US/GCRP are to (1) Obtain a predictive understanding of the interactive physical, chemical, biological, geological, and social processes that regulate natural and human-induced changes in the total Earth system and, (2) Provide a strong scientific and economic basis for national and international policy-making related to changes in the global environment and their regional impacts.

INTEGRATING THEMES FOR RESEARCH



OBJECTIVES

- Establish an integrated, comprehensive long-term program of documenting the Earth system on a global scale.
- Conduct a program of focused studies to improve our understanding of the physical, geological, chemical, biological, and social processes that influence Earth system processes and trends on global and regional scales.
- Develop integrated conceptual and predictive Earth system models.

LEADERSHIP AND ACTION

President Bush has established the comprehensive strategy for action and leadership outlined on the following pages. This strategy flows from his commitment to responsible stewardship of our planet, which includes the promotion of economic growth and sound environmental policies. It is built upon a series of actions which will have broad ranging benefits—from curbing air pollution, to conserving energy, to restoring forest lands—and which will help curb net greenhouse gas emissions.

The U.S. believes that any successful global climate change strategy must be:

- **comprehensive**, incorporating all relevant greenhouse gases, their sources and sinks;
- **long term**, taking into account the full range of social, economic, and environmental consequences of proposed actions for this and future generations;
- **flexible**, built on many diverse actions (including market incentives) and readily adjustable as knowledge is improved through a robust research and development program; and,
- **integrated**, designed to involve all nations and dynamically reflect and incorporate each nation's unique circumstances into the development of a truly global response strategy.

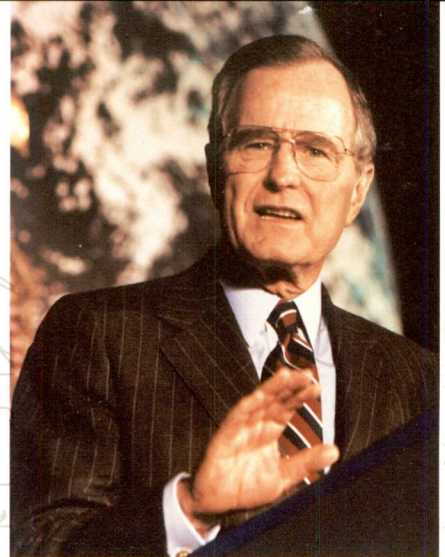
The actions which are currently included in the U.S. Climate Change Strategy will result in U.S. greenhouse gas emissions in the year 2000 being equal to or below the 1987 level. In addition, the U. S. has essentially stabilized its emissions of carbon dioxide (CO₂) over the last 15 years despite a growth in economic output of about 50 percent. During this same period, global carbon dioxide emissions have increased substantially.

This U.S. Strategy for Climate Change includes many specific actions:

- eliminating stratospheric ozone-depleting compounds which are also strong greenhouse gases;
- directly controlling various greenhouse gases and their precursors which are also air pollutants;
- reducing utility and other industrial emissions in a way that strongly encourages energy efficiency;
- increasing forest greenhouse gas sinks;
- encouraging energy efficiency in such areas as buildings, appliances, and lighting; and
- increasing the use of renewable and non-fossil sources of energy.

Integral to the U.S. Climate Change Strategy is the world's largest program of research and development:

- to increase our scientific and economic understanding of climate change and to provide a sound knowledge base for making major policy decisions; and,



- to develop and to accelerate the adoption of economically sound, environmentally beneficial, and energy efficient technologies.

In total, the U.S. proposes to invest over 2 billion dollars in these R&D efforts next year alone.

In August 1990, the Intergovernmental Panel on Climate Change (IPCC) declared in its Overview: "A comprehensive strategy addressing all aspects of the problem and reflecting environmental, economic, and social costs and benefits is necessary."

The President of the United States has established such a comprehensive strategy. The United States, today, is working to curb emissions, promote economic growth, and exercise leadership in meeting our shared responsibilities as stewards of the planet.

The United States is taking action.

The Washington Post

Challenges Await Global Warming

Researchers Divided on Call for Strong Action While Many Meeting

By William Booth
Washington Post Staff Writer **A8**

Questions Remain Unanswered

Scientists and government officials from 130 countries will gather here this week to forge a world response to a threat that some regard as a potential nightmare and others consider a mere inconvenience.

Despite attempts at consensus, researchers are still deeply divided over global warming and its potential impact and say it could be a decade before they have the answers to such critical questions as whether rising temperatures will cause the seas to rise.

Yet this week's conference reflects the fact that many experts feel some action must be taken before anything definitive is known.

"I believe the greenhouse is coming and I believe it is going to be a serious problem," said Richard Alley of Pennsylvania State University, a world authority on reading past climates in ancient ice. "Yet by the time we can with confidence say that the greenhouse is here, it will be too late."

Delegates will be pressed to follow the lead of European nations that have already pledged to reduce emissions of carbon dioxide, a gas produced by burning fossil fuels and the one most responsible for computer-generated scenarios predicting a worldwide warming of 6 degrees by the end of the next century.

The Bush administration has resisted such calls in the past and insisted that more research is needed before the United States undertakes the kind of disruptive changes that cutting carbon dioxide emissions would involve.

While scientists generally support attempts to increase energy efficiency and to move away from fossil fuels and toward renewable energy, many of them also shy away from recommendations that would cost large sums or disrupt the economy.

"There are tremendous uncertainties that led me to say that tremendous costs are unwarranted at present," said Patrick Michaels, a climatologist at the University of

Virginia and a skeptic of scenarios that predict significant warming.

The reluctance of most researchers to call for stringent controls of carbon dioxide stems from the fact that the greenhouse debate is still very much alive. Policy-makers and the public are left to sort through the bewildering cross talk that occurs when scientific cultures and personalities collide.

"There is a selective use of facts. Nobody tells an untruth. But nobody tells the whole truth, either," said S. Fred Singer, an atmospheric and space physicist at the Washington Institute here. "It all depends on the ideological outlook."

Singer said the greenhouse effect has been used by all sorts of interest groups to further their agendas. "My nuclear friends are happy to promote the greenhouse effect. My natural gas friends are happy to promote the greenhouse effect," Singer said. "A lot of scientists promote the greenhouse effect because of increased funding."

"The public is rightly confused," said Stephen Schneider, a climatologist at the National Center for Atmospheric Research in Colorado. "The good thing about science is that scientists argue. But the public doesn't understand that. They think that because scientists argue, they don't know what they're talking about."

Schneider maintains that scientists generally agree on the basics of global warming. Indeed, in almost two dozen interviews with scientists who study all aspects of climate change, there was general agreement that the accumulation of carbon dioxide and other greenhouse gases in the atmosphere will probably warm the planet.

"Most of my colleagues feel that there will be some warming," said Michael Bender, a climatologist at the University of Rhode Island.

But Bender said there is still wide disagreement over the magnitude of the warming. It is this uncertainty, in part, that keeps the Bush administration from committing to reductions in carbon dioxide. As one administration official who has negotiated over climate change put it: "If the temperature goes up 1 degree, who cares? If it goes up 6 degrees, everybody cares."

A U.N.-sponsored group of 300 scientists concluded last year that temperatures will probably rise 2 degrees by 2025 and 6 degrees by the end of the century. However, these predictions are based on computer simulations, which many scientists say are too crude to warrant great confidence.

Scientists are even less confident that they understand what a temperature increase will do to crops and the natural world. Many investigators believe that plants will be more vigorous in a carbon-dioxide rich world, but there is the fear that with rising temperatures, soil moisture will decrease.

"Humanity is hurtling toward a precipice," according to Michael Oppenheimer, a senior scientist at the Environmental Defense Fund. If we fail to reduce emissions, Oppenheimer and a colleague believe we "are likely to alter the Earth's climate so rapidly and so thoroughly as to destroy much of the natural world and turn the world that we call civilization upside down."

Yet many others are not quite so hyperbolic.

"I just don't feel in my gut like it's a catastrophic issue," said James Angell, a climatologist with the National Oceanic and Atmospheric Ad-

CONTINUED

ministration who has been tracking worldwide temperatures with weather balloons. "My personal feeling is that we'll be able to deal with it."

"Yes, I think some warming will occur," said Peter Brewer of the Monterey Bay Aquarium Research Institute, a leader of an international project to study the response of marine algae to climate change. "But it's not a catastrophe. It's a trend we have to deal with. It's irreversible. But it will probably be subtle and spread out over decades."

The Earth's climate is so dynamic—and the product of such a complex interplay of currents and clouds, polar ice and marine plants—that to simulate it on a computer and predict what the future will bring is a daunting task.

Moreover, there is still tremendous uncertainty about "wild cards" in the climate, which could dampen or accelerate warming.

There is some agreement that

increased temperatures will cause a slight rise in sea levels because of the way oceans expand when heated. But researchers are unsure whether even the predicted temperature increase will cause the polar icecaps to melt.

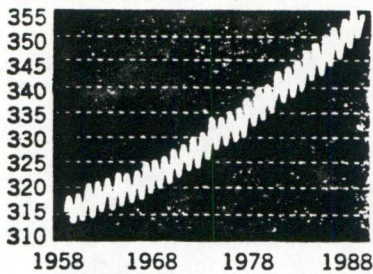
"I am supposed to be an expert on what the greenhouse effect will do to ice sheets and sea level," said Alley. "But I am only confident in one thing. I am confident that we cannot make a reliable prediction at this time about sea-level rise."

Scientists also are trying to understand if rising temperatures will lead to increased cloudiness, which could shield the planet from incoming sunlight and perhaps act to mitigate warming. Some researchers, however, have speculated that certain types of clouds may increase warming by trapping more heat.

In a perverse twist, researchers also suspect that the main ingredient in acid rain—sulfur dioxide—might act to seed clouds in the atmosphere and so cool the planet.

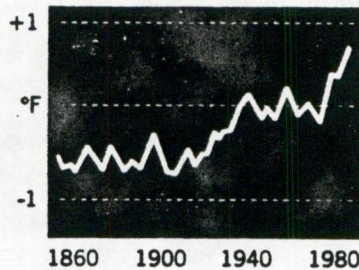
THE GREAT GREENHOUSE DEBATE

CO₂ Concentration (PPM)

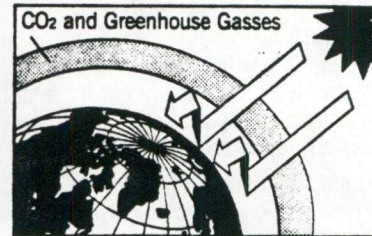


■ Carbon dioxide, the most potent greenhouse gas, is rapidly accumulating in the atmosphere due to human activities, such as burning fossil fuels and forests.

WHAT'S KNOWN



■ Global temperatures appear to have increased on average 1 degree Fahrenheit in the last 130 years. It is uncertain whether the modest warming is due to human activities or natural phenomena.



■ A natural greenhouse effect keeps the Earth warmer than it otherwise would be. Computer simulations predict that the accumulating carbon dioxide will increase global temperature 2 degrees by 2025 and 6 degrees by 2100.

WHAT'S TO LEARN

■ Will the ice sheets of Greenland or Antarctica melt, causing a large rise in sea level? Predictions are that sea level will rise about 8 inches by 2030.

■ What will be the ecological effects? Plants grow more vigorously in a carbon dioxide rich atmosphere, but rising temperatures might also cause a decrease soil moisture and change in rainfall patterns.

■ Will cloud cover increase? Increased cloudiness could mitigate the greenhouse effect.

■ The Earth's climate is a complex interplay of ocean currents, soil microbes, marine algae, clouds and gases, which both cool and warm the planet. Unknown feedbacks could worsen or dampen the predicted warming.

Jessica Mathews

A Cure for Nuclear Neurosis

Let us be optimistic for a moment and assume that the president follows through on his State of the Union pledge to propose a comprehensive national energy strategy. In the much-needed debate that will follow, the hottest and most perplexing charges and counter-charges will be aimed at nuclear power.

One side will say that efficiency and conservation can only go so far and that the only sure answer to pollution, greenhouse warming and oil import dependence is nuclear energy. The other side will assert that nuclear is the highest cost option among many and that safety, proliferation, waste disposal and other considerations make nuclear power a last resort at best. One thing is certain, the vehemence of the arguments will bear no relation to the judgment the marketplace has rendered.

The last time a nuclear reactor was ordered that was not later canceled, Spiro Agnew was vice president, the Vietnam War was still being fought and Three Mile Island was six years in the future. It was 1973. Yet no subject so reliably brings discussions of energy policy to a screeching halt.

As hard-core proponents see it, the nuclear industry has been the victim of a conspiracy they variously attribute to the president, to Congress, to a biased elite that has misled an otherwise pro-nuclear public or to a strain of "irrationality" that infects public opinion. The other side sees a uniquely favored technology that was allowed to sidestep political checks and balances through secrecy and a special regulatory arrangement and grew into a sloppy industry incapable of ever managing a demanding technology.

A few battle-scarred souls believe there is a middle ground. In their view, nuclear power may be an important element of the nation's long-term energy mix if it can regain public trust and lower its costs. Changes in federal policy, such as streamlining the licensing process and requiring a standardized reactor design, are worthwhile but will contribute less than the industry hopes to either goal. Regaining trust will be achingly slow.

Attempts to force the pace, for example by excluding public intervenors or rushing to choose a new reactor design, are guaranteed to backfire. There must also be a solution to waste disposal. Most sensibly, that would entail dropping the ludicrously inflated official goal of assuring the wastes' safety for 10,000 years in favor of an achievable target, but doing so may be politically impossible.

The key to a saner future life with nuclear energy is understanding what went wrong. From the beginning, neither government nor industry took this technology seriously enough. Some in the industry still don't. They put too much effort into buying poll after phony poll showing overwhelming public support for nuclear energy and too little into the demanding task of technical and managerial reform. Despite efforts to tighten up after Three Mile Island, the industry is still plagued by utilities that simply shouldn't be in the nuclear business. Not long ago regulators discovered that a plant in Pennsylvania

was being run by operators who slept and played video games while on duty, apparently with management's knowledge. Until such incidents are only dim memories, the industry need look no further for the source of its woes. As Peter Bradford, chairman of New York's Public Service Commission, bluntly puts it, "The lesson that Wall Street learned from Three Mile Island was that a group of federally licensed operators—not appreciably better or worse than any other crew—could convert a \$2 billion asset into a \$1 billion cleanup job in about 90 minutes."

Government bears a heavy responsibility for the industry's poor record. Victor Gilinsky, a former federal regulator, points out that the first medium-sized commercial reactor was licensed in 1964. Before it had operated even a single day, 38 larger

reactors had been licensed. Most of today's 115 reactors were licensed and built at the same time, leaving no opportunity to learn from others' mistakes. Worse, the great majority of nuclear utilities operate just one or two plants, which means they also have had no opportunity to learn from their own experience. It is no coincidence, says Gilinsky, that the most notorious problem plants—Diablo Canyon, Shoreham, Seabrook, Zimmer and others—were each their respective utility's first commercial nuclear project.

The solution is to consolidate the more than 50 nuclear utilities, leaving fewer and better management teams each in charge of a sizable number of plants. That process could also ease safety concerns by removing some of the chronically poor performers, which would in turn lighten the regulatory burden for all.

Even after all this has been achieved—a perfect operating record, improved management, growing public confidence, more efficient regulation, a functioning waste disposal system and an improved reactor design—a question mark will remain. Will nuclear power be more or less costly than other means of supplying electricity, including efficiency improvements? No one knows. Today it is one of the most expensive options. Reforms should lower costs, and pollution surcharges for fossil-fired plants will help nuclear compete, but the ultimate outcome is impossible to predict. It will be about a decade before reactor construction resumes, if it does. There is time to turn down the heat. If the industry can end its fruitless hunt for villains and its long habit of promising more than it can deliver, and if nuclear opponents can relax long enough to allow regulatory changes that will improve performance, a way might yet be found to come to terms with this promising, troubled technology.

The writer, vice president of World Resources Institute, writes this column independently for The Post.

JANE BRYANT QUINN

As War Economy Unfolds, Rates and Oil Remain Key

H 3

Two pieces of good economic news emerged from the Persian Gulf War's opening days: The world most likely will continue to have an adequate supply of oil, and interest rates are lower now than they were a couple of weeks ago.

This means lower inflation, easier credit and some debt relief. The recession is quite likely closer to its end than its beginning—passing, perhaps, as early as spring and no later than summer. "Worst-case scenarios don't make sense any more," says economist David Rolley of the economic forecasting firm DRI/McGraw-Hill Inc. in Lexington, Mass.

This good cheer, however, assumes that the hot war subsides within a very few weeks. If Saddam Hussein has an ace up his sleeve, or the ground troops get bogged down—in sand or in a chemical storm—the pain on the home front may be protracted, too.

In a long war, oil prices might move up again. Deficit spending on war production would telegraph more inflation ahead. The critical decline in interest rates would come to an end. Consumer confidence might take another dive.

Some war damage is already apparent in the economy, as worried travelers stay home, airlines and hotels lose customers and businesses put international deals on hold.

Nevertheless, it's hard to think of an industry that can't be helped by the current drop in interest rates and oil prices. Economist Roger Bird, a vice president of the forecasting firm the WEF Group, is especially optimistic about the manufacturing firms that produce for export (heavily concentrated in the Midwest). Europe has been a steady buyer of American-made machine tools, business electronics and other capital goods. Cheaper oil supplies will cushion Europe's downturn and increase its appetite for shopping in the United States, he says.

Oil prices may still jump around, but John Lichtblau, chairman of the Petroleum Industry Research Foundation, thinks they won't rise by much. The entire world stocked up on crude for fear that the Saudi fields would close. When they didn't, the oversupply spilled into the market, driving prices—in just one day—down to \$21 from \$32 a barrel, a historic drop.

At that price, gasoline at the pump eventually should fall by 20 cents a gallon, says Ben Brockwell, editor of the Oil Price Information Service. Heating oil could drop by 10 cents a gallon almost immediately and 45 cents by next September.

Slower inflation and easier money should lower interest rates even further,

It's hard to think of an industry that can't be helped by the current drop in interest rates and oil prices.

in the opinion of Jerry Jordan, chief economist at First Interstate Bancorp in Los Angeles. He puts the prime business lending rate at 8.5 percent by spring, down from 9 percent now.

If he's right, that means lower costs for businesses whose loan interest rates are pegged to the prime. Such a broad drop in rates should also bring out strong demand for home-mortgage money.

Jordan's interest-rate forecast falls on the optimistic side. Even so, most economists now believe that—barring a long and expensive war financed with vast amounts of deficit spending—the prospect of much higher rates is remote.

If you're living on income from your savings, consider switching some of your money out of floating-rate, money-market mutual funds or bank accounts. The yield on short-term investments is likely to shrink. An intermediate-term Treasury or certificate of deposit, with a maturity of five years or so, is a better bet for protecting your income.

As for U.S. stocks, it's impossible to know whether a new bull market has begun. Stocks have been strong since the day that the shooting started, reflecting the general expectation that lower oil prices and interest rates will soon show up in higher corporate profits. Doubtters, however, point to the lingering recession as reason to think that stocks are likely to slide again.

Long-term investors should disregard this chaff. Stick to a regular investment program of buying and holding stock-owning mutual funds. Ten years from now, you'll be glad you did.

The New York Times

Technology Is Found to Exist To Cut Global Warming Gases Air

WASHINGTON, Feb. 7 (AP) — Current technologies can sharply reduce gases that scientists say would contribute to global warming, but not without significant expense and dramatic changes in how Americans use energy, a Congressional study reported today.

The report estimated that substantially cutting emissions of one of the gases, carbon dioxide, could eventually cost the economy as much as \$150 billion a year, about what Americans now pay for compliance with all existing environmental laws.

The study by the Congressional Office of Technology Assessment comes as delegates from 130 nations are meeting near here to work toward a worldwide treaty on global warming. It also follows pressure from some members of Congress to commit the United States to specific goals to reduce gases that contribute to global warming, something the Bush Administration says should await more study.

There is division among scientists over the extent, and indeed the existence, of global warming. But many scientists believe that global temperatures will rise because increasing levels of carbon dioxide and other man-made gases will trap and retain heat from the sun in a process similar to what happens in a greenhouse. Such a warming trend could cause sea levels to rise, cause severe droughts and storms and severely disrupt the earth's biological systems.

Number of Gases Involved

The phenomenon has been attributed to a number of gases, including chlorofluorocarbons and methane. But carbon dioxide, primarily from the burning of fossil fuels, accounts for more than half of the gases identified as creating the greenhouse effect. And scientists believe significant cuts in carbon dioxide emissions will require sharp reductions in the burning of fossil fuels, oil, coal and wood.

The new study concluded that carbon dioxide reductions of 35 percent are feasible over the next 25 years in the United States with the adoption of stringent energy-saving policies.

“Such emission reductions will be difficult to achieve and could be costly,” said the study, which had been requested by several Congressional committees, but it added that the reductions would require no major technological breakthroughs.

The report said the cost was difficult to estimate. Energy savings would increase because of conservation and fuel efficiencies, but the cost of appliances, automobiles and houses, would most likely increase.

The report said predictions on how much it would cost to deal with global warming vary widely, from saving the economy money to costing as much as \$150 billion a year to cut carbon dioxide emissions alone by the year 2015.

Environmentalists have argued that at the very least, industrial nations must reduce carbon dioxide emissions by 20 percent to have any hopes of reversing the trend toward unusual warming of the earth.

The report said a substantial cut in carbon dioxide emissions would require energy conservation measures to be taken by virtually all sectors of the economy, including construction, manufacturing, transportation and energy industries.

Energy Taxes Could Be Needed

The energy savings most likely would have to be brought about through a mixture of energy taxes, financial incentives and government regulation, the study concluded.

The Congressional study did not endorse any specific approach or suggest what kinds of energy taxes or incentives might be preferred. But it suggested that tougher energy efficiency standards would have to be developed for commercial buildings as well as for homes, appliances, heating and cooling systems, windows and other elements of construction.

It cited the need for more energy-efficient transportation systems, including steep increases in automobile fuel economy standards, more incentives toward development of mass transit and perhaps reinstating the 55-mile-an-hour speed limit nationwide.

Regulators have plan to monitor smokestack filth via computer

By Diana Schobel
CAPITAL NEWS SERVICE

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ANNAPOLIS — Environmental regulators may one day be able to monitor air pollution at nearly two dozen Maryland plants without ever leaving their office, an idea industry groups say is premature and costly.

A proposal now under consideration in the Department of the Environment would require 22 plants to install continuous emission monitors in smokestacks.

The selected plants either are major sources of pollution or have failed to meet government standards in the past.

A special monitor, a device about the size of a small television set, would be installed in a control room at the base of the smokestack. A line from the monitor would extend into the smokestack, collecting emission samples.

The monitors would use the samples to measure either the sulfur dioxide level or the thickness of the emission. An average reading, calculated every six minutes for thickness and every three hours for sulfur dioxide, would be sent to a computer at the plant.

The data would be compiled and issued in quarterly reports, said Carl York, division chief of regulation development for the Air Management Administration.

A second, controversial part of the proposal would be the installation of a computer "telemetry" system. This would allow state environmental regulators in Baltimore to access a company's computer at any time and obtain an immediate reading on whether clean air standards are being met.

"Say you wanted to know what the reading was at Pepco's Chalk Point plant at 8 a.m. I could call it up," said Mr. York.

"It's almost like me being at your plant ... recording what you're doing all the time," he said. "You as the owner of the plant know I'm watching you all the time through the [monitor] and will be more careful."

Utility companies have opposed

BUSINESSES BRACING FOR POLLUTION PROPOSAL

Companies that would need to add or replace sulfur dioxide monitors under Maryland Department of the Environment proposal:

- Baltimore Gas & Electric Co. Brandon Shores and Wagner plants (Anne Arundel County); Crane plant (Baltimore County); and Gould Street plant (Baltimore)
- Potomac Electric Power Co. Dickerson plant (Montgomery County); Morgantown plant (Charles County); and Chalk Point plant (Prince George's County)
- Potomac Edison Power Co. Williamsport plant (Washington County)
- Wesvaco paper mill (Allegany County)
- Pulaski incinerator (Baltimore)
- Medical Waste Associates (Baltimore)
- Waste Energy Partners Limited Partnership (Harford County)
- Baltimore City Resource Recovery Facility

Companies that have no sulfur dioxide monitors and would have to install them:

- Lehigh Portland Cement Co. (Carroll County)
- Delmarva Power and Light Co. Vienna plant (Dorchester County)
- Bethlehem Steel Co. (Baltimore)
- Independent Cement Corp. (Washington County)
- Coplay Cement Co. (Frederick County)
- National Institutes of Health (Bethesda)
- Indian Head Naval Ordnance site (Charles County)
- Baltimore Gas & Electric Co. plants in Westport (Baltimore) and Riverside (Baltimore County)

Source: Maryland Department of the Environment

The Washington Times

the telemetry system.

"Enforcement of environmental regulations cannot be enhanced by having someone call up for the readings," said Ted Ringger, supervisor of air and water quality in environmental programs at Baltimore Gas and Electric. "They still have to come to the plant and verify that the monitor did its job before they can give notice of violation."

The utilities and the Maryland Chamber of Commerce have urged state officials to withhold their decision on this proposal until this summer, when the U.S. Environmental Protection Agency presents new regulations for the federal Clean Air Act.

"The new Clean Air Act takes nitrogen oxides very seriously, and it would cost a lot more money to have these [monitors] adjusted to measure this rather than have Maryland wait awhile," Mr. Ringger said. "We don't want to have to do this twice."

EPA guidelines direct state reg-

ulators to monitor emissions, so a portion of the proposal will be implemented, Mr. York said. The computer telemetry system that provides the instant data is not required, however.

The Department of the Environment estimated that it would cost the 22 affected sites a total of \$2.5 million for equipment and installation and another \$830,000 for operation and maintenance. Industry officials said that estimate is far below costs.

"The cost is significantly more than what the department has estimated," Mr. Ringger said. "It's going to cost Baltimore Electric \$2.6 million, equal to what the state said it would cost all the affected sources. Pepco said it would cost them \$8 million to do what they had to do. The department is not counting a lot of things in their estimate that should be counted."

• Staff writer Cheryl Wetzstein contributed to this article.

Not Using Fossil Fuels Could Add to Warming

By WILLIAM K. STEVENS

Efforts to head off a predicted global warming by reducing the burning of fossil fuels, as is widely being urged, could actually worsen the warming in the short run, scientists say.

Fossil fuels like coal and oil emit carbon dioxide when they are burned, and the carbon dioxide traps heat in the Earth's atmosphere much like a greenhouse does. Climatologists predict that if the emission of carbon dioxide and other greenhouse gases like methane and chlorofluorocarbons continues at current rates, the average surface temperature of the Earth will rise 2 to 5 degrees Fahrenheit in the next century, causing widespread ecological, agricultural and social damage.

But in a less-noticed phenomenon, the burning of fossil fuels also emits sulfur dioxide particles, which scientists refer to as aerosols. These reflect sunlight, cooling the Earth and partly offsetting whatever warming may be taking place. A reduction in the burning of fossil fuels would reduce this cooling effect.

The resulting rise in temperature could more than compensate for the cooling that would be achieved by the accompanying reduction in carbon dioxide in the next 10 to 30 years, according to a study reported in today's issue of the British journal *Nature* by Dr. T. M. L. Wigley, a climatologist at the University of East Anglia in England.

Warming Could Be More Intense

This means that global warming could be more intense than expected for up to three decades, Dr. Wigley found, after which the reduction in burning fossil fuels would begin to bring about a global cooling.

The reason for the lag is that the effect of carbon dioxide reductions would be felt only over decades, since that is how long it takes them to work their

way through the ocean-atmosphere climate system. By contrast, the effect of atmospheric sulfur dioxide particles is felt almost immediately and dies away rapidly once emissions stop.

"If you instantly stopped burning fossil fuels, then the aerosols would fall out in a couple of days," said Dr. James

A worsening of global warming would be only a short-term effect.

E. Hansen, a climatologist at the Goddard Institute for Space Studies in New York. "The greenhouse gases stay there for 100 years, so you'd actually increase the heating" in the short term. "But in the long run," he said, "you'd decrease the temperature and the heating."

Calculations Look 'Reasonable'

The calculations "look very reasonable," said Dr. Robert J. Charlson, an atmospheric chemist at the University of Washington who is an expert on aerosols and climate. Dr. Charlson said that both he and Dr. Wigley are persuaded that the question of the aerosols' effect on global warming is "a sleeping giant of a sort." It is "something that has been missed, and the consequences are not trivial," he said. "It is going to complicate matters in terms of setting policy."

Delegates from 130 countries are now meeting at Chantilly, Va., outside Washington, in the first negotiating sessions toward a treaty limiting emissions of greenhouse gases.

Both Dr. Wigley and Dr. Charlson warned against using the aerosol effect as a justification for taking no action to reduce the burning of fossil fuels. For one thing, Dr. Charlson said, the cooling effect of the sulfur dioxide aerosols must be viewed as a temporary phenomenon "that has masked what's really going on in the temperature record."

The average surface temperature of the Earth has been rising over the last decade and is now at a record level, although few scientists are yet ready to conclude that the warming has been caused by the greenhouse effect rather than other climatic factors.

In the long run, Dr. Charlson said, failure to rein in the greenhouse gases would risk a dangerous warming despite the aerosol effect.

Moreover, both he and Dr. Wigley pointed out, the cooling effect of the aerosols takes place mostly in the Northern Hemisphere, where most sources of sulfur dioxide aerosols are located, while the carbon dioxide and its warming effect are diffused around the globe.

Big questions remain as to how the aerosols would affect weather patterns, Dr. Charlson said. That is crucial, since weather is what distributes heat around the planet. And Dr. Wigley wrote in his report that the very imbalance in aerosol effects between the Northern and Southern hemispheres is "potentially even more disruptive to the climate system than a uniformly distributed 'pure' greenhouse effect."

For this reason, Dr. Wigley concluded, the effect of sulfur dioxide aerosols should not be seen as a benefit, but "as further reason for implementing controls on fossil fuel use."

Scientists have known for some time that the aerosols directly reflect sunlight back into space and that they also serve as nuclei for cloud droplets.

THE WASHINGTON POST A22 THURSDAY, FEBRUARY 7, 1991

Vast Kuwaiti Oil Slick Begins Threatening Saudi Coastal Facilities

The following is a journalists' pool report filed by Edith M. Lederer of the Associated Press and Tarek Hamada of the Detroit News.

TANAJIB, Saudi Arabia—The world's largest oil spill has begun washing ashore near oil processing facilities at Safaniya on Saudi Arabia's northeast Persian Gulf coast, posing a threat to production from the world's fourth largest oil field.

Thick patches of oil from the leading edge of the giant spill started blackening beaches near an oil treatment complex and desalination plant at Safaniya two days ago, according to a Saudi oil official who is directing the fight to contain the spill at Safaniya and at another oil complex here at Tanajib, 12 miles farther south along the Saudi coast.

An official with the Saudi-government owned oil company, Saudi-Aramco, said that Safaniya—about 100 miles south of the Kuwaiti pumping station where Iraqi forces let loose the flood of crude oil more than two weeks ago—was “all full of oil,” and he told reporters that Tanajib would look the same way “in three days.”

Segundo Fernandez, superintendent of the desalination plant at Tanajib, said Aramco would not be able to process oil from wells sited offshore above the Safaniya field if the spill clogged the water intake system at the shoreline oil distillation facilities. At the moment, however, Aramco spokesman Joseph Kenny said the Safaniya field “is in full operation.”

Safaniya is the largest offshore oil field in the world and the fourth largest of any kind. A 1978 Rand Corp. report says it has the potential of producing between 1.5 and 2 million barrels a day.

An international media pool organized by the Saudi government had been scheduled to visit the Safaniya facility this week and had already been briefed on Aramco's efforts to prevent oil from seeping into the

plants, but the visit was abruptly canceled after the reporters toured Tanajib.

Although the spill has not yet reached here, reporters who visited the beachside facility saw young

birds whose wings were so coated with oil that they could not fly and were staggering aimlessly on blackened sand. Another bird, its feathers thick with oil, lay dead in the sand near a large rusting pipe.

“Look at the poor bird. Look at the poor thing,” said Suleiman Abdul Aziz Fasad, the maintenance director at Tanajib, as he pointed to one of the small creatures struggling in vain to spread its wings.

There are now specialized spill-surrounding booms, oil-skimming boats, tight-mesh filters and even fishnets protecting the channel leading from the open gulf to the desalination plant.

At Tanajib, multicolored snake-like booms stretched across the turquoise water. Red ones looking like cotton-stuffed bolognas absorb oil on the surface at the shallowest part of the coastline. Yellow and black booms made of plastic and fabric were visible in calm water a little farther from the coast to block the oil from drifting shoreward. Farthest out were several dark-colored, heavy rubber booms with skirts descending nearly two feet into the choppy water.

“All the area is enveloped in booms,” said one Aramco official, who added that crews at Safaniya were still working furiously to extend the floating barriers even farther.

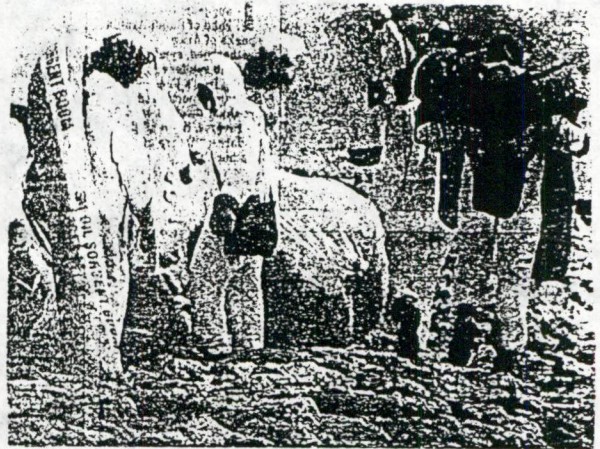
“There is still a chance of more oil because of weather. . . . We have no control over it. We will get oil around us, but we try to minimize the impact on the shoreline, on the water intakes,” he said.

Two Aramco employees said the slick would have a devastating effect

on this section of the gulf. “The water is full of plants and animals,” said Othman Taoud. “We used to eat the fish.”

But now, said Taoud and co-worker Jaafar Abdul Karim Munasif, people here have stopped eating gulf fish, which include a popular kind of cod known as hammour.

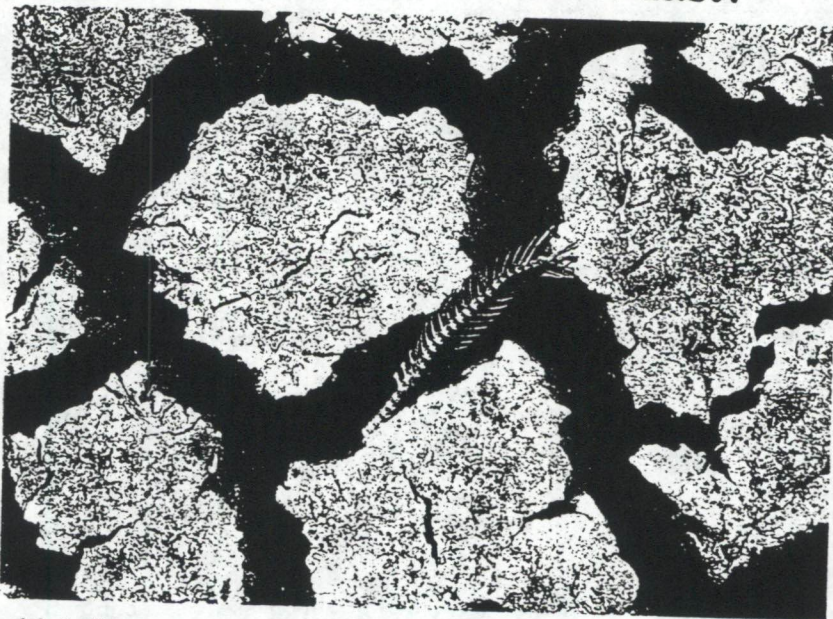
“[Iraqi leader] Saddam Hussein has gone out of bounds,” Munsaif said. “The things he has done aren't the actions of a true Muslim.”



Saudi oil-spill workers clad in protective gear hoist floating booms into position around intake valves of a desalination plant at Tanajib on the Persian Gulf coast.

HEATING THE GLOBAL WARMING DEBATE

In 1988 scientist Jim Hansen testified that the world was getting hotter. But how hot? And how fast?



LAST MONTH SCIENTISTS reported that 1990 was the warmest year on the meteorological record: the average global temperature, measured over land and sea, exceeded that of any year in the past century or so. Citing this, a group of 16 senators, including Albert Gore Jr., Democrat of Tennessee, wrote a letter to President Bush calling for immediate policy action to counter global warming. The 1990 information, said the senators, "illustrates clearly that global climate change is real."

Does it?

In the five years since the terms "global warming" and "greenhouse effect" became shibboleths of environmental awareness, the weather as a topic of conversation has gone from casual to confounding. The briefest of heat waves is enough to kindle despair over the future of the planet, while a transient cold spell can send greenhouse consciousness into hibernation. Environmentalists conjure images of disaster; industrialists appeal to scientific uncertainty; the media

seize on any hint of controversy with intemperate zeal. And climate experts offer scant relief, insisting as they do that the day-to-day fluctuations ordinary people notice aren't nearly as significant as the long-term trends about which they themselves don't seem to agree.

Anyone who's had traffic with the global-warming issue eventually longs for an oracle or a scapegoat, a figure to trust implicitly or to blame entirely. Both man-

gles have come to rest on the shoulders of one unlikely individual: a mild-mannered scientist in the National Aeronautics and Space Administration named James E. Hansen. Hansen, the director of NASA's Goddard Institute for Space Studies, located in Manhattan, is the plain-spoken climatologist who testified before the Senate Committee on Energy and Natural Resources in the summer of 1988 that the world was warming, probably because of an increase in the atmospheric levels of carbon dioxide and other so-called greenhouse gases, which trap heat the way the glass plates of a greenhouse do.

For those seemingly modest statements, Hansen has been alternately praised, denounced, lionized and lampooned by peers and public alike. Meanwhile, his views on the greenhouse effect

Karen Wright is a contributing correspondent for Science magazine and a former staff writer for Scientific American.

BY KAREN WRIGHT

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The Cincinnati Post 1-18-91 *OH.*

Clean Air Act changes will press Ohio businesses

By Jennifer Kent
Post staff reporter

Greater Cincinnati businesses are in for a lot of paperwork and a lot of expense to come into compliance with the new Clean Air Act amendments, environmental experts said Thursday.

"It's going to affect the hospital you were born in, the mortuary they take you when you die and everything in between," said Robert Brubaker, attorney with Porter, Wright Morris & Arthur, paraphrasing U.S. Rep. John Dingell, D-Mich., chairman of the House Energy and Commerce Committee.

No one knows yet how many additional businesses will be affected by 525 pages of sweeping changes to the Clean Air Act — the first major overhaul in 13 years. It was signed by President Bush Nov. 15.

"My guess is that it's going to affect tens of thousands of businesses in Ohio alone," Brubaker said.

Brubaker was one of several speakers to address representatives of government and small and large businesses throughout Greater Cincinnati at the Chamber of Commerce-sponsored Clean Air Act Seminar.

Area businesses have failed to meet attainment — or federal standards — only in ozone and sulfur dioxide emis-

sions, said David Kee, director of the regional U.S. Environmental Protection Agency office in Chicago.

While Cincinnati is classified as having achieved attainment in sulfur dioxide emissions, the U.S. Environmental Protection Agency is sending Gov. Voinovich a letter "within days" to declare Hamilton and Butler as non-attainment counties, he said.

The governor will have 120 days to acknowledge the new classification and until 1993 to submit a plan for reaching attainment by 1996.

In ozone emissions, Cincinnati rates a "moderate" on the five-level non-attainment scale, the second-lowest rat-

ing but within 5 percent of a "serious" ranking, Kee said.

Among effects of the Clean Air Act:

■ The Ohio Legislature will be charged this year with drafting a bill

that toughens tailpipe emissions tests and enacting it by November. It will likely involve motorists having their tailpipes electronically tested at a state-run facility as opposed to having it manually inspected at a gas station, Kee said.

■ Industries such as printers and dry cleaners who release certain solvents into the air also face considerable cutbacks in their emissions.

Cincinnati, which must cut emissions by 15 percent, has until 1993 to develop a plan for doing so and until 1996 to do it.

■ Cincinnati Gas & Electric will probably raise its rates 12 to 16 percent to offset costs of scrubbers and fuel-switching to come into compliance with the new legislation, said Greg Ficke, manager of environmental affairs. Of the 111 plants affected around the country, Ohio has the most with 15. CG&E's Miami Fort and Beckjord plants are among them.

■ New federal regulations, not expected to be implemented until 1996, will require affected firms to pay \$25 a ton for each regulated pollutant up to 4,000 tons. There are now 189 regulated pollutants, compared to the former 19. Manufacturers now pay a nominal amount for an operating permit from the state of Ohio.

■ In two years, businesses in 41 industries emitting more than 10 tons of a regulated pollutant or 25 tons of a combination of two or more pollutants will face regulation. Prior to November, the Clean Air Act was largely inapplicable to sources under 100 tons per year.

Companies exceeding limits would trigger regulation in the form of Maximum Achievable Control Technology, which requires them to switch to alternative materials or buy whatever machinery is needed to control emissions.

"It's likely we'll lose some businesses and it's going to make smaller businesses less competitive," said Kim Burke, an attorney with Taft, Stettinius & Hollister.

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 have come to form the nexus of the scientific debate on when, where and whether global warming will occur in the next century. Some of his conclusions have already become dogma.

In fact, it's not his science that gets Jim Hansen in trouble — it's his style. Hansen has all the moves of a hustler but none of the guile. Backed by a body of exhaustive and universally respected research, he routinely flouts his profession's tacit restrictions on categorical and unauthorized statements while maintaining the pacific innocence of a curious child. It's a combination that baffles his friends, who can't give him their unqualified support, as well as his critics, who can't even manage to dislike him.

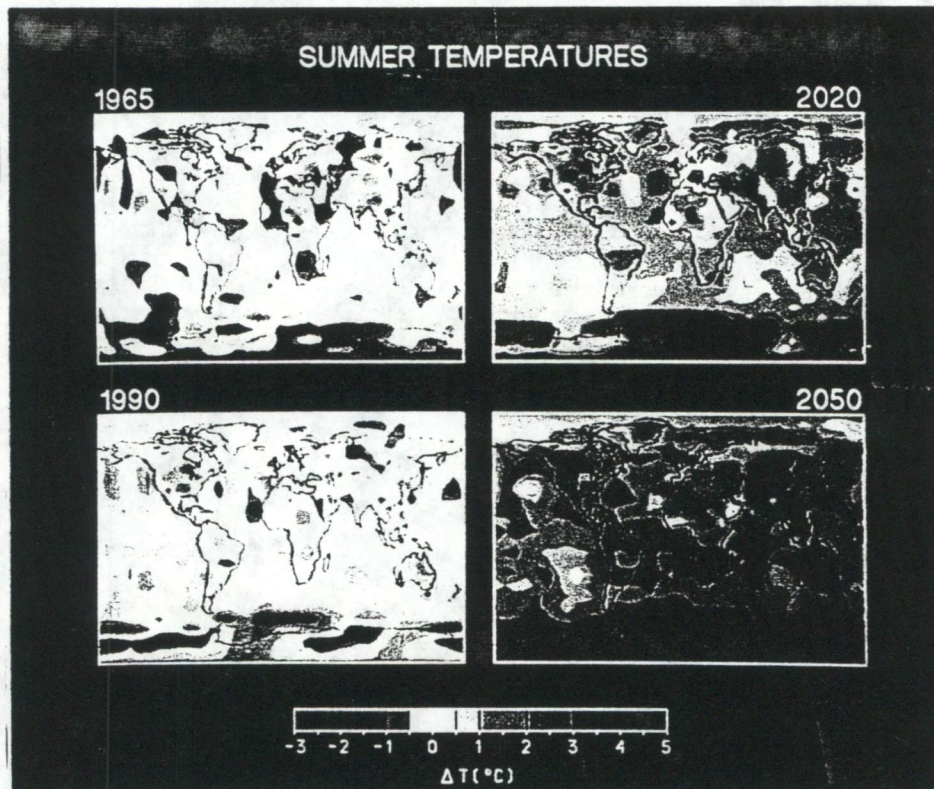
This week, representatives from dozens of countries will meet in Washington to begin negotiating an international agreement on global climate change. The conferees will discuss, among other items, the need to control emissions of greenhouse gases. Although Hansen won't be attending, the event itself is part of his legacy; the first Washington-based meeting, last April, was believed by many to have been a conciliatory effort by the White House to quell criticism surrounding its alteration of Congressional testimony given by Hansen in 1989. Both his supporters and his detractors admit that Hansen has done them a service by putting global warming on the political agenda. But Hansen can also be accused of polarizing opinion on an issue that should not really be all that divisive. "You almost have to start your discussions by saying, 'Do you agree or don't you agree with Jim Hansen?'" says James Van Allen, Hansen's former teacher, a professor emeritus in physics and astronomy at the University of Iowa and a seasoned observer of the debate. The answer, it seems, is more a profession of faith than a rational judgment.

KAREN, JIM HANSEN wrote in pencil on lined notebook paper last September. *I'm skeptical about whether a Times magazine article is a good idea. For one thing, I'm not at all an appropriate personality for a profile — I'm a very quiet and shy scientist. I am very inarticulate.*

Also, scribbled Hansen, *an article focusing on me will just annoy other researchers — of course, they're already pretty mad.*

For such a shy, quiet guy, Jim Hansen has indeed caused a bit of a fuss. A frequent guest during the past decade at Congressional committee hearings on climate change, the "inarticulate" scientist has regularly managed to say something to raise the eyebrows, if not the ire, of his colleagues. His 1988 Congressional testimony drew a barrage of criticism from other climate experts. In 1989 he earned more demerits from his publicity-wary peers when he revealed that his statement of that year had been altered by the Office of Management and Budget. And in 1990 he managed to raise the hackles of a whole new cadre of scientists by proposing a climate-satellite project that other NASA investigators see as a direct challenge to a system they have been planning for years.

"I think you just have to do what you think is right — that's what I



GODDARD INSTITUTE FOR SPACE STUDIES

Hansen's computer-generated models, above, illustrate changes in global temperature relative to the average 1950 to 1980 temperature. If the rate of change remains the same, the world's weather will be dramatically altered by the middle of the next century. Hansen believes, however, that there is a good possibility of reducing the growth rate of greenhouse gases, which would lead to smaller changes than those illustrated.

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learned in 1988. Now I'm really not concerned about the repercussions," says Hansen. Certainly his is not the posture of an anxious man. The 49-year-old Midwesterner is slumped in one of several beat-up leatherback chairs occupying his office at the Goddard Institute. His feet are propped on the only bare spot his desk has to offer. Every surface in the room, including most of the floor, is covered with piles of articles and computer printouts, like the blasted foundation of a paperwork temple.

In his standard office attire — khaki pants, a plaid cotton shirt and a crew-neck sweater — Hansen looks like somebody's dad at a P.T.A. meeting. He speaks with the placid deliberation of an Iowa farmer describing last fall's harvest.

"I think that, after not too long, the better science does rise to the top." Pause. "The scientific process will tell who was right."

Hansen made three claims before Congress in the fateful summer of 1988: First, that he was 99 percent sure the earth was warming. Second, that he could say with a high degree of confidence that the warming was due to an increase in greenhouse gases. And third, that because of global warming, events like droughts would increase noticeably in the 1990's. He hasn't changed his mind about any of those points, except to add floods, storms and fires to the list of events.

Those who disagree with what Hansen says — one climatologist calls them "greenhouse agnostics" — fall into three sects corresponding, more or less, to Hansen's three statements:

- Those who don't believe the temperature record (begun by national meteorological agencies only 140 years ago) is reliable enough to demonstrate a warming trend.

- Those who agree that there has been a warming but aren't sure blame can be assigned solely to increases in the emissions of greenhouse gases. World climate is, after all, the sum total of largely mysterious interactions among clouds, oceans, trees, volcanoes, ice, snow, dust particles, water vapor, aerosols and the sun, as well as greenhouse gases.

- Those who don't think anyone understands climate well enough to predict the meteorological effects of global warming.

Against this legion of critics, Hansen has a corps of admirers as well, climate experts who praise his courage and laud his science. "I don't have any fundamental disagreements with Jim," says Stephen H.

Schneider of the National Center for Atmospheric Research (N.C.A.R.). "He is probably right."

But Schneider, like many others, tiptoes away from endorsing Hansen's statements. Though he is one of the most outspoken advocates of a government policy to address the greenhouse effect, Schneider won't go as far out on the limb as Hansen has in his scientific appraisals.

"It's just that he believes more in the scientific certainty than I do," says Schneider. "I think intuitively he has a higher confidence in the tools."

THE TOOLS TO WHICH Schneider refers are climate models: computer programs descended from the algorithms used to predict the weather, but much more complicated and much less reliable than those used for

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weather forecasting on a day-to-day basis. One of the three most advanced models in the United States is at the Goddard Institute; the other two are at N.C.A.R. in Boulder, Colo., and at the National Oceanic and Atmospheric Administration's

Geophysical Fluid Dynamics Laboratory in Princeton, N.J.

All the models are based on two verities of atmospheric science: that gases like carbon dioxide, methane, ozone, nitrous oxide and chlorofluorocarbons (known as CFC's) trap heat in the earth's atmosphere through what is commonly known as the greenhouse effect, and that the atmospheric levels of these gases have risen since the beginning of the Industrial Revolution.

That the greenhouse effect keeps the planet about 30 degrees centigrade, or 54 degrees Fahrenheit, hotter than it would be otherwise is not in dispute. Nor is the amount of the increase in greenhouse gases at issue. There is general agreement that carbon dioxide has increased by about 25 percent in the past century, and methane has doubled; long-term measurements don't exist for the other gases.

Essentially, the increases mean that the earth's atmosphere holds on to 1 percent more of the sun's energy than it did in 1800. It would be fairly easy to calculate the change in average global surface temperature from that figure if the buildup of greenhouse gases were the only factor in climate variability. But there are many, many more.

The ocean, for example, absorbs heat from the atmosphere and seems to act as a buffer against climate change. How fast the heat exchange occurs, however, and how long

the buffer effect will last are anyone's guess. Clouds have a net cooling effect on the earth, but it is not clear whether cloud cover will increase or decrease if the global temperature rises. And even the warming contribution of carbon dioxide is complicated by the fact that the burning of fossil fuels — the main source of carbon dioxide — also releases gases into the atmosphere that form aerosols, which serve to cool the earth.

In science, the traditional approach to such complex phenomena is the empirical method: make a simplifying assumption, generate a prediction and then see if the prediction comes true. If it doesn't, revise the assumption and try again. That's how models for weather forecasting are developed.

"If you find that your forecasting is right eight out of 10 times, you say, 'Look, my simplifying assumption is correct, as demonstrated by the fact that I've succeeded in predicting the weather,'" explains Syukuro Manabe, a veteran climate modeler at the Fluid Dynamics Laboratory. Climate models make predictions on time scales of decades and centuries, however, rendering empiricism impotent.

In the absence of verification, some experts think the models aren't worth the chips they're programmed on.

"I think there's reason to believe that the models are not only bad — that you can't rely on them as forecasting tools — but that when they're used to forecast greenhouse warming, they tend to be systematically too hot," says Andrew R. Solow of the Woods Hole Oceanographic Institution in Massachusetts. Solow says current models underestimate the ocean's capacity to absorb

heat and fail to reproduce either the geographic or temporal patterns of temperature changes in the past century.

"We know the greenhouse effect is real," Solow says. "And we know that the levels of the gases are increasing. And so, other things being equal, you would expect there to be some warming. But other things needn't be equal: other climate processes could act either to suppress or reinforce the warming. And the real question is, how much warming do we expect to get from this, and at what rate? That, I think, is uncertain, highly uncertain."

Hansen doesn't deny the uncertainty. In fact, some days he, too, rues the state of climate modeling. But then he may turn around and bet 75 colleagues at a NASA conference that at least one year from 1990 to 1992 will be warmer than any year in the previous century. Hansen did just that last spring. Only one scientist took him up on his bet, and he lost \$100 when 1990 set the record.

A CASUAL SPECTATOR MIGHT GET THE impression that the implications of the greenhouse effect are disputed as often as the hazards of cholesterol. But disagreement about what has happened to the world's climate over the past century is greater than disagreement over what will happen. Since 1979, when the first comprehensive report on global climate change was compiled for the National Academy of Sciences, consensus statements from the scientific community have predicted a warming of between about 1.5 and 4.5 degrees centigrade (between about 3 and 8 degrees Fahrenheit) in the next 100 years. Climate models haven't challenged that estimate.

The consequences of such warming would range from the uncomfortable to the downright catastrophic. Temperature averages during the last Ice Age, which ended roughly 12,000 years ago, were probably 5 degrees centigrade colder than

global averages today and brought dramatic changes in sea level, mass extinction of species and a widespread redistribution of flora and fauna.

Greenhouse scientists place themselves at different points along the warming range. Hansen puts himself at the hot end, predicting a warming of 3 or 4 degrees centigrade. Schneider falls somewhere in the middle. Solow says he could "live with" a forecast of 1.5 to 2.5 degrees. Richard Lindzen, a Massachusetts Institute of Technology meteorologist who has been one of the most dogged critics of Hansen's results, bitterly protests the exercise of predicting climate change, then reluctantly offers an estimate of 1.2 degrees. Truth is, it's hard to find a climatologist these days who *doesn't* believe in global warming.

Last year a comprehensive survey of scientific opinion published through the World Meteorological Organization and the United Nations Environment Program drew the broadest consensus yet on the issue. Hundreds of scientists from around the world participated in the survey. (Hansen limited his participation, deciding that involvement would deprive him of time he would rather spend on research.)

The familiar conclusion of the survey was that average global temperatures would increase by about 3 degrees centigrade by the end of the next

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century if controls on greenhouse-gas emissions were not instituted. If stringent controls were instituted, the report said, the increase could be cut to 1 degree centigrade. At the same time, the report admitted, "The unequivocal detection of the enhanced greenhouse effect from observations is not likely for a decade or more."

The consensus report offers cold comfort for those who choose not to believe in global warming. But they can find their own sacred texts. A report published in 1989 by a Washington-based think tank called the George C. Marshall Institute, for example, suggested that factors such as variations in solar activity could influence the calculus of global warming. Some greenhouse agnostics have used the report's conclusions to argue that solar activity could mitigate the effects of greenhouse-gas accumulation; most scientists have disregarded it.

OCTOBER 1990: JIM HANSEN, RELUCTANT profile subject, sends me several pounds of background material, including scientific articles, newspaper clippings, letters, Congressional statements and transcripts of speaking engagements, in three separate mailings. His secretary prepares a five-hour videotape of his television appearances.

November 1990: Hansen sends two four-page letters clarifying his thoughts about questions I'd raised in interviews. Several more packages of background material arrive. One contains an older sister's memoirs (unpublished) of their childhood. *I'm not a good interview on personal things*, he writes, and actually seems to believe that's true.

Hansen is the son of a waitress and a tenant farmer from Denison, Iowa (pop. 5,000). He earned money for college with a paper route, played pool in beer halls after school and walked miles of railroad tracks with his dog Skeeter. He claims he almost never cracked a book he didn't have to until he got to the University of Iowa, where he met James Van Allen, then chairman of the physics and astronomy department. Van Allen discovered and gave his name to the belts of radiation that circle the earth; he is something of a legend and, according to Hansen, he ran the kind of program that can change the course of a student's life. Van Allen suggested the topic for Hansen's dissertation and then helped him get a postdoctoral fellowship in 1967 at the Goddard Institute, an offshoot of the Goddard Space Flight Center in Greenbelt, Md.

"I was so excited by the opportunity to study at a NASA laboratory that I drove all the way to New

York without stopping to sleep," Hansen says. Two years later the institute offered him a staff position, and he got involved in the weather-prediction research that was a major part of Goddard's charter in the 1970's. In 1981, Hansen succeeded Robert Jastrow as the institute's director.

Hansen is lord of a modest manor. Goddard is housed in a gloomy gray edifice on the northeast corner of 112th Street and Broadway near Columbia University. The institute sits atop Tom's Restaurant, a greasy spoon of local renown whose fumes often waft up to the floors above. Inside, the

hallway is lit like a catacomb. The carpet on the seventh floor is the color of boiled spinach; there's a plant dying in almost every window.

This neglected corner of the NASA empire suits Jim Hansen just fine. "We're close to being a non-civil-service organization, because only 20 people here have hard money for their salaries," he says, including his own \$79,200 annual paycheck. By soliciting additional financing from the Environmental Protection Agency and NASA, Hansen has managed to build the institute's staff to 140.

"We're handicapped, but there are some advantages: The key benefit is independence. We've sometimes expressed strong or unpopular opinions and just ignored the fact that we're civil servants. I recognize the forces that come back and push on us because of those statements. We haven't had a new hire here in four years, and in my gut I know very well that the reason we haven't is that they don't like things I've said." After a moment, he adds, "Though there's no way to prove that," and smiles.

Hansen's initial encounter with the "forces" was in 1981, when he published the first solid evidence that the earth was warming. The Department of Energy reneged on a promise of financial help after Hansen's study made front-page headlines, and he had to lay off five people. "For a while there, I became a 40-hour-a-week scientist."

It didn't last. A year later Hansen managed to wrest some money from the Environmental Protection Agency, and he plunged back into 80-hour workweeks. In testimony before Congress in 1982, 1986 and 1987, he grew ever more confident in his appraisals of the seriousness of greenhouse warming. But few people outside Congress and the scientific community took notice — with the exception of the Office of Management and Budget, which, mindful of the Reagan Administration's penury regarding climate research, tried to tone down the statement he planned to make in 1987. (Hansen was permitted to offer his testimony as a private citizen.)

Then the summer of 1988 struck. Drought stranded barges in the Mississippi and blistering heat tried Congressional tempers in the Capitol. Jim Hansen found himself in front of a Senate committee once again. But this time he had more ammunition: he'd just had a paper accepted by the *Journal of Geophysical Research* that would document the statements he wanted to make.

Within a few weeks of that memorable testimony, a House subcommittee invited Hansen to repeat his performance. "I was told about calls from the White House to NASA expressing great displeasure about my testimony. There were rumors about what might happen to me, with possible implications for the Goddard Institute." Hansen testified anyway, and kept his job in the bargain.

A year later, when O.M.B. tried to alter his testimony a second time — inserting qualifiers about the uncertainty of model predictions and about man's contribution to the greenhouse-gas accumulation — he took his grievances straight to Senator Gore, who played the situation for all it was worth in the media.

"He may have turned it into a circus," Stephen Schneider says of Gore, "but the circus worked. A day later the White House was on the defensive

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because Hansen was the opening story on the evening news on every network." Before the week was out, the White House announced it would hold a workshop on global warming to prepare for negotiations on an international treaty, a meeting eventually held in April of last year.

LAST OCTOBER HANSEN WAS HOST OF A barbecue in his backyard in Ridgewood, N.J., about 15 miles west of New York City. The festivities began at 11 A.M. with a game of softball. Hansen's team — a spirited if somewhat bedraggled group of Ph.D.'s with thin necks and thick glasses — took on Goddard's computer-support staff, tanned and brawny youths in dazzling blue and white uniforms. Hansen pitched, and in the space of half an hour gave up four home runs, the ball soaring over maple trees and across Pleasant Avenue.

With each homer Hansen, calculating the flight trajectory with a baleful expression, merely tugged at his baseball cap. No cuss words or histrionics here — this is the man who once asked a writer paraphrasing his thoughts to change "damn" to "darned."

Hansen has described himself as "overcompetitive." "Can you believe we actually beat these guys last year?" he asked as he walked off the field.

I couldn't, so I changed the subject. "Nice day for a picnic."

"Yeah," he agreed, pulling off his hat and wiping the sweat from his forehead. "Could be about 10 degrees cooler, though."

Hansen wasn't thinking about carbon dioxide. But I asked the loaded question anyway: could this unseasonably warm fall be a sign of the greenhouse effect in action? Can the man in the street judge for himself whether global warming has arrived?

"You can't stick your head out the window to look for the greenhouse effect unless you're clever enough to compare the climate to what it was a few decades ago," he said. "The problem that people have is not recognizing the magnitude of natural variability, which is large in comparison to the warming." Actual warming, Hansen believes, has been about half a degree centigrade since 1850, a quarter of a degree between 1850 and 1950 and another quarter of a degree since then.

But Hansen says the next 10 years "will tell us quite a lot." He predicts that by the end of the 1990's the world will have warmed up a few tenths of a degree. "The things that we'll see in the 1990's are not necessarily going to seem very threatening. They'll be noticeable, but probably not dramatic." But, he added significantly, "the same models that project dramatic impacts in 30 or 40 years are predicting noticeable but small effects in the 1990's. I think the public can recognize that statistical change."

Hansen seemed at a loss for an analogy. Then, suitable to the occasion, he came up with the Yankees.

"For example, the public can recognize a significant difference in the chances of Don Mattingly getting a hit as compared to Alvaro Espinoza, even though the percentages represented by their bat-

ting averages may not seem so different."

Partly because Hansen is convinced the 1990's will be a pivotal period for climate prediction, he proposed last summer that two small, relatively inexpensive satellites could gather much of the missing data pertaining to global warming by the end of the decade.

Some of Hansen's peers have been less than enthusiastic about his idea — much less. NASA has plans to include some of the same tracking instruments on its mammoth multibillion-dollar Earth Observing System (E.O.S.) project, which is scheduled to be launched in 1998, and some NASA scientists fear that Congress will try to supplant their grand orbiting platform with Hansen's puny satellites. They are also annoyed at the way he went about presenting his ideas. Hansen waited until his proposal was virtually in print (in the National Academy of Sciences magazine) before showing it to his boss at the Goddard Space Flight Center's earth sciences directorate. He says he just forgot, then admits there may have been a method to his amnesia. "If I'd talked

to them beforehand, then I'd have gotten some input, which was the last thing I wanted."

His boss was "sorely distressed," Hansen says. "He felt that I was not supporting the institution's objectives" — meaning E.O.S. "But anyway, it doesn't really matter. Eventually these people come around."

GIVEN THE BUSH ADMINISTRATION'S recent history regarding the issue, Washington seems an unlikely place to convoke this month's global warming conference.

Last fall, climate experts meeting in Geneva issued the most sweeping policy recommendations from the scientific community to date, urging all countries to take immediate steps to reduce greenhouse gases. The report said many industrialized nations could cut carbon dioxide emissions at least 20 percent by the year 2005 with existing technologies and without significantly burdening their economies. Even before the report, many industrialized nations had instituted plans for stabilizing greenhouse gas levels. All 12 nations of the European Community have set targets for slowing carbon-dioxide emissions generated by cars, homes and factories. Representatives from Western Europe, Japan, Australia and New Zealand stated at the conference that they could impose such restrictions at no extra cost to their economies.

But the United States, which is responsible for more than 20 percent of the world's carbon-dioxide output, has maintained that more needs to be known about global warming before major policy decisions can be made. The Soviet Union

Cont'd —

Cont'd

and oil producers like Venezuela and Saudi Arabia have sided with it. But the weight of international opinion is bearing down on Washington. Although United States negotiators succeeded in excluding explicit targets for emissions cutbacks from the conference declaration last fall, at this week's conference, some observers say, the Administration might have to capitulate.

Hansen plans to observe the convention proceedings from the peaceful refuge of his office on the seventh floor at Goddard. "The argument they all make is that if you really care about this, you've gotta help publicize it," he says. "But I think that the best contribution I can make is to the science.

"We're not environmentalists; we're not trying to defend some position that we've taken in the past. We're trying to advance our understanding. We're changing the atmosphere. What's that going to do?"

"Now when the time comes," Hansen continues, "if we have a result that's important, we're not going to be bashful about presenting it."

And Hansen does indulge in a little public relations from time to time. He holds out a letter from a high-school sophomore in Connecticut who had asked him for information on global warming for a term paper. (Did he send her five pounds of background material, too, I wonder?)

"Now she wants advice on college. So I have to think about what to say to her." Hansen lapses into silence again, mulling over recommendations to a 15-year-old girl. In a few days he'll write back to Katie Mottes, stressing the importance of "being what you want to be." *If you do that, you will be more likely to do well and be happy. I have just relearned that myself.* ■

end

U.S. Gets Mixed Reviews On Global Warming Plan

'Action Agenda' Lacks Carbon Dioxide Target

By Michael Weisskopf
Washington Post Staff Writer

The Bush administration yesterday announced what it called an "action agenda" to combat global warming, predicting that it will cut emissions of some climate-warming gases to 1987 levels by the turn of the century.

But the plan, unveiled at the first day of a U.N.-sponsored conference on global warming remedies, is essentially a repackaging of policies devised for other purposes and contains no assurances that emissions will not resume growing after the year 2000.

Nor does the plan set targets and timetables for control of carbon dioxide emissions—the principal warming gas—that most of Europe, Japan and Canada have pledged to stabilize or reduce early next century. U.S. emissions of carbon dioxide, produced when any fuel is burned, would increase by 15 percent under the plan.

Criticized by some European delegates as disingenuous, the plan was praised by other conference officials as a positive step for an administration that previously has talked more of scientific uncertainties than of remedies.

"We are united in the belief that despite large uncertainties, the potential threat of climate change justifies taking action now," Michael R. Deland, chairman of the White House Council on Environmental Quality, told the conference.

"If this is their program, it signifies a shift," said Mostafa K. Tolba, executive director of the United Nations Environment Program. "They are stabilizing" warming gases.

More than 130 nations are participating in the conference, which is supposed to meet intermittently over the next 18 months to draft a strategy to fight global warming. Tolba convened the nations after an international scientific panel concluded last summer that heat-trapping gases from industry and farming will raise world temperatures 2 degrees by 2025 and 6 degrees by 2100.

With the United States responsible for one-quarter of world carbon dioxide emissions, diplomatic pressure has been building for U.S. policies to match the commitments

of other countries. But because of the economy's reliance on fossil fuels—chiefly coal and oil—the administration has been slow to move beyond the research stage.

Yesterday's announcement by Deland speaks of a "comprehensive strategy," which shifts the focus of control efforts from carbon dioxide to other warming gases.

The strategy, outlined in a pamphlet called "An Action Agenda," includes the phaseout of chlorofluorocarbons (CFCs), a policy that Washington agreed to last summer as part of a treaty to protect the stratospheric ozone layer.

Provisions of the new Clean Air Act, which Congress passed last October, also are included in the plan. Under the act coal-burning utilities were to adopt energy-conserving measures to combat acid rain. The same measures would reduce carbon dioxide emissions. The act also sets tougher limits on auto and industrial pollution to reduce smog, which acts as a warming gas.

Deland said the plan would result in the emissions of global warming gases in 2000 "being equal to or below 1987 levels." He did not use the verb "stabilize," which advocates of tougher measures prefer to characterize more ambitious programs to permanently cap emissions at current levels.

Environmentalists accused the administration of "double-counting," noting, for example, that the CFC phaseout alone will account for 85 percent of the global warming gases to be reduced by the plan.

Willem Kakebeeke of the Dutch Ministry of the Environment said the U.S. program was "hiding a little bit" by taking credit for CFC phaseout and failing to target carbon dioxide for controls. "They should come out in the open and say what they are going to do with carbon dioxide."

Officials finally warm up to climate talks

By Ronald A. Taylor
THE WASHINGTON TIMES

After 11 years of talking, stalling and warnings, international representatives began negotiations yesterday on a treaty to avert global warming.

WARREN BROOKES

Debate hotter than the Earth?

Even as environmentalists ponder the devastation in the Persian Gulf, another of their major policy issues is under heated attack in the United States.

NASA's Marshall Space Flight Institute and the University of Alabama in Huntsville just released updated findings of the trend in global temperatures as measured by satellites since 1979 through 1990 and found — no trend. What's more the findings show that 1990 was only the fourth-warmest year in the 12-year record, and only 0.13 degree higher than the 1979-1990 mean. (See Chart and Table.)

SATELLITE TEMPERATURE MEASUREMENTS

Departures from the 1979-1990 mean

1979	+0.01 C.
1980	+0.15 C.
1981	+0.08 C.
1982	-0.14 C.
1983	+0.08 C.
1984	-0.19 C.
1985	-0.28 C.
1986	-0.14 C.
1987	+0.21 C.
1988	+0.19 C.
1989	0.00 C.
1990	+0.13 C.

Source: Marshall Space Flight Institute (NASA), University of Alabama in Huntsville

Additional Stories:

"U.S. Accepts Greenhouse Target" The Washington Times
(NY Times, 2-5-91 Page C9)

"In A Warming World, Who Comes Out Ahead?"
(NY Times, 2-5-91 Page C1)

The New York Times

Sununu vs. Scientists

FEB 10 1988

E 17

Leslie H. Gelb

The answer: John Sununu, White House chief of staff.

The question: Why are Administration officials like Secretary of State Baker and William Reilly, head of the Environmental Protection Agency, afraid to speak their minds about the greenhouse effect — those gases widely believed by scientists to be trapping heat and dangerously raising global temperatures?

And why are they all so quiet just when 130 nations are meeting near Washington on how to reduce emissions of greenhouse gases, principally carbon dioxide?

The curtain on these matters lifts slightly with the following piece of high liturgy issued in Mr. Baker's behalf:

"Even though officials with oil and gas interests are not as a rule required to recuse themselves from general policy actions that may have a financial impact on those interests, Secretary Baker has removed himself generally from global climate change questions out of an abundance of caution, on a case-by-case basis, to avoid the appearance of any impropriety."

This remarkable "abundance of caution" comes from the very former Texas oil man who actively and sensibly participates in framing Persian Gulf policy and national energy strategy, who himself placed global warming among his top diplomatic priorities two years ago and who serves a President remembered for his greenhouse oratory during the last Presidential campaign.

Mr. Baker, like most pros (and in this case like Mr. Reilly and a host of Administration environmentalists and scientists), backed away from the greenhouse cause when he saw Mr. Sununu's ferocity. John Sununu showed he would take no prisoners here when he ordered the dismissal of a State Department official foolish enough to take seriously the Bush-Baker pledges on global warming.

Mr. Sununu seems to find most specialists in energy and environmental policy to be hysterics, bolstered by bad scientists and unreliable economists. Regarding global warming in particular, he believes that scientists have failed to prove that there is a warming trend, that the recent increase in temperatures is being fueled by greenhouse gases or that temperature rises of 1 to 3 degrees centigrade would badly damage the global climate. He is also convinced that available solutions to the problem are far too costly, and that cheaper ones will appear in time to prevent calamity.

Perhaps Mr. Sununu, who has installed a global warming computer model in his personal computer, is

right in his skepticism. He and others argued that the dangers of acid rain were greatly exaggerated, and recent findings suggest they were correct. But such skeptics initially waved aside the ozone problem, and two years ago the perils of increasing ultraviolet light became so palpable that the world community mandated deep cuts in chlorofluorocarbons, or CFC's, to reduce holes in the ozone layer.

Arrayed against Mr. Sununu are people like Margaret Thatcher, solid professionals like those in the World Resources Institute in Washington and most of the scientific establishment. The hard-nosed chief of staff has held them all at bay and threatens to stymie the nations gathered in Chantilly, Va., with a transparent gimmick.

The Administration began the conference last week with a pledge to stabilize its production of greenhouse gases. But as everyone at the meeting well understood, that could be accomplished simply by keeping a prior commitment to reduce CFC's. The Administration proposes to do nothing

Tough greenhouse politics.

ing about the burning of fossil fuels like oil and coal, the main sources of carbon dioxide. In fact, U.S. production of carbon dioxide will significantly increase in the coming years, more so because of the new energy policy. By contrast, Western European nations have already promised steep cuts in fossil fuel burning.

What is disturbing here is not Mr. Sununu's public relations ploy, but his lack of practicality. He can retain all his skepticism about global warming, but the point remains that the very steps needed to reduce the supposed greenhouse effect are justifiable in their own right: carbon dioxide fouls the air. An oil-burning economy means continued dependence on imports. Destruction of forests harms life itself.

Has Mr. Sununu been enforcing Administration silence about such considerations on his own tack or in behalf of Mr. Bush? If Mr. Bush has interest in global warming besides campaign bluster, he might go to the Chantilly conference and hear how the alarm bells sound for himself. □

P.20

The Future of Nuclear Power

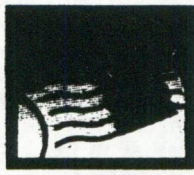
The opinion-page column "American Opinion on Nuclear Power," Jan. 4, correctly identifies some misperceptions about nuclear energy. Although nonelectric energy use has declined nearly 20 percent since 1973, electricity use has increased 55 percent, and this trend seems likely to continue.

The easy success in conservation of nonelectric energy is no excuse for failure to beef up the nation's electric-generating capacity to accommodate the inexorable growth in demand. Renewables won't contribute much to electrical production, but their contribution will also be needed. Natural gas and oil should be reserved for heating and vehicle fuel.

Not only is demand increasing, but much of the existing capacity is worn out, inefficient, or environmentally unsatisfactory and should be replaced by nonpolluting nuclear plants or advanced-technology coal plants.
R. M. Campbell *Cohasset, Mass.*

The article contains the unsubstantiated assumption that our energy future demands

the use of more nuclear power. This is doubtful, considering that even after 40 years of heavy government promotion and subsidy, nuclear energy still makes up only around 5 percent of world energy supplies.



LETTERS

Far more realistic is an energy future based on improved efficiency and the use of renewable resources such as sunlight, wind, and living plants.

The author apparently does not understand why nuclear power has been "successful" in some countries and not in others.

The relative openness of political systems is a primary reason. France and Japan traditionally have formulated their energy policy by centralized government fiat. In contrast, the US has offered a greater degree of public participation.

The economic competition nuclear has had to face in countries such as the US also led to the abandonment of nuclear power as a new generating option. Such economic litmus tests have only recently been undertaken in other countries. Time and time again nuclear power has been found to be

far more costly than alternatives.

Furthermore the nuclear programs in France and Japan are nowhere near as healthy as the author implies. In France, widespread opposition to nuclear waste dumps has forced that country into a one-year moratorium to address the growing public outcry. In Japan, public opposition has made it nearly impossible to site nuclear power plants in all but two of the country's 47 prefectures. Both countries are seeing their nuclear consensus crumble.

Nicholas Lenssen
Worldwatch Institute

Washington

Economic Effects of Alternative Climate Change Policies

EXECUTIVE SUMMARY

Prepared by

Center for Strategic & International Studies
Putnam, Hayes & Bartlett, Inc.
International Resources Group
The Brock Group
DRI/McGraw-Hill

January 1991

PREFACE

The purpose of this report is to contribute to informed policy choices on the part of U.S. decisionmakers. It addresses questions raised in a CSIS report prepared prior to the 1989 G-7 Economic Summit relating to the economic, competitive and foreign policy implications of policies to address potential global climate change (*Implications of Global Climate Policies*, CSIS, June 27, 1989).

The Steering Committee for the study was chaired by Douglas M. Johnston, Executive Vice President, CSIS, and consisted of Charles J. Cicchetti, Managing Director, Putnam, Hayes & Bartlett, Inc.; Charles K. Ebinger, Vice President, International Resources Group, Inc.; Murray Weidenbaum, Director, Center for the Study of American Business, Washington University, and former Chairman of the President's Council of Economic Advisors; Stanley W. Legro, Adjunct Fellow, CSIS, and former Assistant Administrator for Enforcement, EPA; Richard Fairbanks, Partner, Paul, Hastings, Janofsky & Walker, and former Assistant Director for Energy, Environment and Natural Resources, Domestic Policy Council; and Henry Schuler, Director, Energy and National Security Program, CSIS.

The Center for Strategic and International Studies is a public policy research institute whose mission is to advance the understanding of emerging world issues in the areas of international security, politics and economics. It does so by providing a strategic perspective to decisionmakers that is integrative in nature, comprehensive in scope, anticipatory in its timing and bipartisan in its approach. The Center wishes to thank the Global Climate Coalition for its support in helping fund this project.

Putnam, Hayes & Bartlett, Inc. is an international economic and management consulting firm committed to helping clients develop and execute economically sound strategies. The foundation of PHB's practice is solving client problems through rigorous use of effective analytical methods and tools.

DRI/McGraw-Hill provides a unique capability for quantitative analysis through the use of large-scale econometric models, extensive data banks and specialized computer facilities.

International Resources Group provides diversified planning, design, management and financing services to industry, government and international agencies.

The Brock Group provides strategic planning services in the areas of domestic and international political development, international trade and labor-management relations.

EXECUTIVE SUMMARY

INTRODUCTION

Global Climate Change Becomes A Major Domestic and International Environmental Issue

In a short period of time, global climate change has advanced to the forefront of environmental issues facing policymakers in the United States and across the world. Although there is still uncertainty over the precision of scientific forecasts relating to climate change (particularly regarding the rate, magnitude and geographical distribution of any changes), many in the scientific community and among the public have come to believe that rising emissions of so-called greenhouse gases (GHGs) will lead to an increase in global temperatures.¹ Some consider near-term action to reduce GHG emissions a hedge against the potential impacts of climate change, which could include sea-level rise and increased frequency of storms and droughts. Others believe that too much uncertainty exists to warrant action at this time. There is also concern about the lack of analysis of the economic effects of proposed policy options. While the debate continues, many industrialized countries have proposed steps to limit future GHG emissions, and international negotiations have been initiated to pursue a multilateral response with respect to global emissions.

Because of this heightened concern and the momentum of international activity, the United States finds itself under pressure from both domestic constituencies and other countries to accelerate the development and implementation of policies to reduce GHG emissions. Toward this end, U.S. policymakers are considering numerous proposals for independent U.S. action. Some members of Congress as well as environmental groups

¹ The greenhouse gases include carbon dioxide, chloroflourocarbons (CFCs), methane, nitrous oxide, ozone and other trace gases.

and others are urging the United States to undertake rapid reductions in the near term. Senators Wirth (S. 324) and Gore (S. 201) and Congresswoman Schneider (H.R. 1078) introduced comprehensive "omnibus" proposals during the 101st Congress. Each of the original Wirth and Schneider proposals would have established a U.S. carbon dioxide emissions reduction goal of 20 percent by the year 2000. Other congressional bills have offered less comprehensive proposals. A few individual states are also proposing action.

The United States is also being challenged to adopt substantial climate change policies on a unilateral basis as a means of facilitating international cooperation on this issue. Many industrialized countries have already adopted provisional reduction targets for carbon dioxide. While most of these countries have opted for stabilization of carbon dioxide emissions over the coming decade, some have sought more substantial reductions (e.g., Germany has aimed for a 25 percent reduction by the year 2005). Despite the variance in these goals, many in the United States and elsewhere argue that the U.S. should assume a leadership role with respect to the international process, and take commensurate actions.

Need for Economic Analysis

To date, discussion in the United States has focused primarily on the character of the threat and the benefits and uncertainties of reducing GHG emissions. As yet, very little quantitative economic analysis has been undertaken examining the effect of comprehensive U.S. action, such as that reflected in omnibus bills that have been offered;² therefore, there lacks a substantive foundation upon which policymakers can base their assessment of the potential domestic and international consequences of such action.

To help fill this need, this study quantitatively assesses the economic costs and emissions benefits of two climate change policy scenarios, each comprised of a broad range of policy options that are being proposed, including energy conservation, fuel switching, CFC reduction and reforestation. The study also examines some issues raised by the economic analysis with regard to the economic and political implications of undertaking additional U.S. greenhouse policies in advance of a multilateral agreement.

The study does not draw policy conclusions nor provide a basis for evaluating individual policies. **It was beyond the scope of this study to validate the technical feasibility of any proposed policy options.** Rather, it is designed to assist policymakers in drawing conclusions concerning the appropriate balance between risks, costs and potential GHG emission reduction benefits.

² Some analysis of this type is currently underway at both the Department of Energy and the Environmental Protection Agency, but has yet to be completed or released for public comment and review.

The study simulates economic and emissions effects using the DRI U.S. Quarterly Macroeconomic Model, the DRI U.S. Energy Model, and additional models and data provided by members of the study team. The study assumes a Federal Reserve monetary accommodation that dampens the short-term economic effect of the policies in response to changes in inflation and employment.

SCENARIOS REPRESENT LOW AND HIGH LEVELS OF INTERVENTION

The study team collected and analyzed two groups of policy options that represent comprehensive near-term U.S. action. Sources for initial consideration included state and federal legislative proposals, and reports from federal agencies and nonprofit environmental organizations. Except where otherwise noted, the study team selected policy options as originally proposed by their sponsors. An initial list of over 200 policy options was narrowed to about 20 proposals based on representativeness, the potential for significant GHG reductions and the existence of implementation details. The proposals selected for analysis fell into one of seven categories:

- Domestic reforestation programs.
- End-use conservation and energy efficiency programs.
- Transportation efficiency standards.
- Alternative electric power generation.
- Alternative transportation fuels.
- Programs to phase-out CFCs.
- Carbon taxes on fossil fuels.

The selection of specific policies for inclusion in the two scenarios was made on the basis of comparative cost-effectiveness analysis, as defined by cost per ton of cumulative carbon emissions equivalent removed. The policies that resulted in a lower cost per ton of GHG reduction and half of the aggregate reductions in GHG emissions are in Scenario 1. Scenario 2 includes most of the policies incorporated in Scenario 1, as well as more stringent CFC reductions and CAFE standards and several additional policies. Table ES-1 summarizes the two scenarios.

Table ES-1

POLICY ACTIONS FOR SCENARIOS 1 AND 2

Policy Action	Scenario 1	Scenario 2
Domestic Reforestation Programs	Subsidize trees in Conservation Reserve	Subsidize trees in Conservation Reserve
	End below-cost timber sales	End below-cost timber sales
	Plant one billion trees per year (volunteer program)	Plant one billion trees per year (volunteer program)
Programs to Phase Out CFCs	Phase out CFCs by 2000	Phase out CFCs by 1995
	Ban methyl chloroform by 2000	Ban methyl chloroform by 2000
	Freeze HCFCs by 2015	Freeze HCFCs by 2015
End-use Conservation and Energy Efficiency Programs	Lamp and bulb efficiency standards	Lamp and bulb efficiency standards
	Amend PURPA to add Qualifying Conservation Entities	Amend PURPA to add Qualifying Conservation Entities
	Standard requiring 60% improvement over 1986 appliance efficiency by 2000	Standard requiring 60% improvement over 1986 appliance efficiency by 2000
		Stricter building codes by 1992
Transportation Efficiency Standards	40% CAFE increase by 2000 (cars and light trucks)	65% CAFE increase by 2000 (cars and light trucks)
	Gas guzzler taxes and gas sipper rebates	Gas guzzler taxes and gas sipper rebates
	50 cents/gallon gasoline tax	50 cents/gallon gasoline tax
Alternative Transportation Fuels	Subsidize CNG buses	Subsidize CNG buses
		Railroad electrification
		Ethanol/methanol subsidies
Alternative Electric Power Generation	Include externalities in rate proceedings for new plants	Include externalities in rate proceedings for new plants
		Increase coal-fired plant turnover rate
		Dispatch taking into account externalities

The policies in Scenario 1 are: reforestation programs and a proposal to end below-cost timber sales from national forests; CFC use phase-out by the year 2000 and a freeze on HCFC production at 2014 levels, which begins in 2015; energy end-use efficiency standards; increased CAFE standards; gas guzzler taxes and gas sipper

rebates; an additional tax on gasoline and subsidies for compressed natural gas vehicles; and alternative power generation programs.

Scenario 2 includes the policies of Scenario 1 with the exception that CFCs are phased out in 1995 instead of 2000. In addition, Scenario 2 examines the implementation of stricter building codes to save energy. Transportation policies include CAFE standards stricter than in Scenario 1, electrification of railroads, and subsidized biomass-derived ethanol/methanol fuels. Finally, Scenario 2 includes additional power generation programs that incorporate the retirement of coal-fired electricity generation plants and that require utilities to incorporate assumed environmental externality costs into electric power dispatch.

RESULTS SUGGEST PROPOSED POLICIES MAY ONLY BE PARTIALLY EFFECTIVE

Base Case Reflects Average Annual Economic Growth of 2.1 Percent and Emissions Increase of 7 Percent by 2010

Interpretation of the economic effects of the selected policy options is only meaningful when compared against a base case simulation that represents current expectations. The study team chose a base case that closely parallels the DRI Spring 1990 U.S. Energy Review and a corresponding U.S. Quarterly Macroeconomic simulation.³ Under the base case, the economy grows at an annual rate of 2.1 percent, energy intensity declines at 1.0 percent per year, and total U.S. GHG emissions (carbon dioxide and CFCs) increase 7 percent by 2010. It should be noted that total GHG emissions *decrease* slightly through the end of this century as CFC use decreases, but that total emissions increase after 2000 as the decline in CFC emissions is offset by increases in carbon dioxide emissions (see Figure ES-1).

Scenario 1 Reduces GNP by \$560 Billion Over 30 Years And Emissions by 4.3 Percent Over 20 Years

As a result of the policies implemented under Scenario 1, the present value GNP decreases by \$560 billion (1990 dollars) from 1990 to 2020 compared to the base case. Annual U.S. GHG emissions in 2010 decrease by 4.3 percent below the 1990 base case levels (see Figure ES-1). Sectoral effects, which are minor, occur primarily in the energy

³

This base case simulation, unlike most others used recently in studying the economic impact of climate change policies, incorporates the effect of acid rain control legislation as defined by President Bush's Clean Air Act Amendments, the 1987 Montreal Protocol on substances that deplete the ozone layer and the further reductions of CFCs resulting from the tax on CFCs contained in the Omnibus Budget Reconciliation Act of 1989.

and transportation sectors of the economy.⁴ The results of the simulation relative to the base case indicate that in Scenario 1:

- Annual GHG emissions drop to 4.3 percent below 1990 levels by the year 2010.
- Expenditures on energy decline slightly.
- Investment in energy efficiency increases.
- Public utility investment declines as a result of lower electricity demand.
- International trade improves due to declining imports as the economy slows.
- Energy intensity of the economy declines by an additional 0.35 percent per year.
- The cumulative federal deficit declines to 73 percent of the base case level by the year 2010.

Scenario 2 Reduces GNP by \$840 Billion Over 30 Years And Emissions by 7.2 Percent Over 20 Years

In the Scenario 2 simulation, the additional policies cause present value GNP to decline \$840 billion (1990 dollars) from 1990 to 2020. Annual GHG emissions in 2010 decrease by 7.2 percent below the 1990 base case level (see Figure ES-1). Thus, the effects on the economy of Scenario 2 are generally more pronounced than under Scenario 1. The most significant departure from Scenario 1 is that coal production drops steeply as a result of the new electric power generation programs.

On the basis of incremental cost (1990 present value GNP reduction) per ton (cumulative emissions reduction), Scenario 2 costs about 11 percent more per ton of avoided emissions than Scenario 1. Because GNP does not represent an accurate measure of social cost, the incremental cost per ton is likely to understate the increased cost. To summarize, the results of the simulation, relative to the base case, indicate that in Scenario 2:

⁴ The finding that sectoral effects for the transportation industry are relatively minor may depend on assumptions made in modeling the effects of higher CAFE standards -- in particular, the assumption that the effect of higher vehicle prices on consumer demand will be fully offset by a perceived increase in vehicle quality. For details of the assumptions, see Appendix C, pp. 8 and 9.

study by the Congressional Budget Office (CBO) has concluded that a tax as high as \$100 per ton of carbon would fall short of stated goals.⁵ Our preliminary analysis of a similar carbon tax has yielded comparable results, particularly regarding economic impact.

In addition, the scenarios evaluated in this report have little effect on the price of fossil energy. Policies appear to provide few additional market incentives for the development of long-term alternatives to fossil fuels (the gasoline tax is an exception among those specific policy options evaluated).

The year-by-year absolute GNP reduction caused by the climate change policies could exceed the expected cost of the Clean Air Act amendments of 1990. Real GNP, discounted at 5 percent, decreases by about \$37 billion per year (1990 dollars) on an annualized basis for Scenario 1 and by about \$55 billion per year (1990 dollars) for Scenario 2. By comparison, the cost of amendments to the Clean Air Act are projected by the Administration to be less than \$22 billion per year.

The incremental emissions reductions obtained with the additional policies in Scenario 2 appear to be more costly than Scenario 1. This suggests the importance of weighing the policy alternatives on a cost-effectiveness basis. Employing a cost-effectiveness standard for constructing a package of policy options can provide a basis for selecting policies that rely upon the most efficient delivery methods. In particular, market-based incentives should be investigated. Pricing signals transmitted by market mechanisms rather than by command/control mechanisms are likely to be more efficient in reducing global emissions.

PROPOSED U.S. POLICIES HAVE INTERNATIONAL IMPLICATIONS

Although no in-depth evaluation was undertaken of the international economic and political implications of policies such as those modeled here, the results do raise issues relevant to the U.S. position in negotiations over an international response to global climate change.

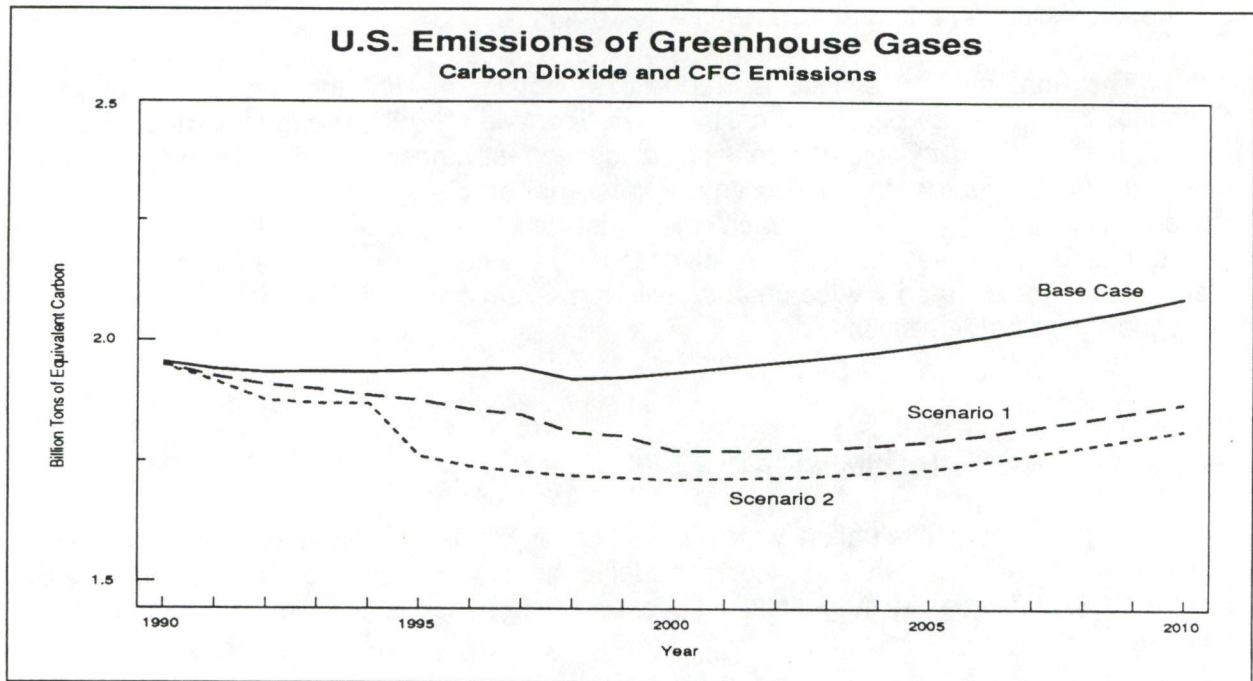
Unilateral U.S. Action Would Not Reduce Global Emissions Significantly

One argument for unilateral U.S. action is that because of the large contribution of U.S. GHG emissions to global emissions, such action is warranted in and of itself. Under this study's base case analysis, the U.S. contribution to world carbon dioxide and CFC emissions declines from 20 percent in 1990 to 18 percent in 2010 (the U.S. contribution

⁵ Congressional Budget Office, *Carbon Charges as a Response to Global Warming: The Effects of Taxing Fossil Fuels*, August 1990.

- Annual GHG emissions drop by 7.2 percent below 1990 levels by the year 2010.
- Energy costs increase significantly.
- Coal production declines dramatically.
- The energy intensity of the economy declines by an additional 0.33 percent per year from the base case.
- The cumulative federal deficit increases to 59 percent over the base case level by 2010.

Figure ES-1



Neither Set of Policies Achieves a 20 Percent Carbon Dioxide Reduction Goal

Neither Scenario 1 nor Scenario 2 achieves the 20 percent carbon dioxide reduction goal stated in omnibus legislation, although virtually all options likely to result in near-term emissions reductions are represented in either Scenario 1 or 2. That is, omnibus legislation does not adequately address how to reduce or even stabilize carbon dioxide emissions at current levels. It is likely that a carbon tax would also fail to achieve reduction goals. Although neither Scenario 1 nor 2 contains a carbon tax, a recent

to carbon dioxide emissions remains constant at 19 percent in 1990 and 2010). U.S. action alone would not significantly change this trend. Enacting comprehensive policies within the United States will only slightly reduce the U.S. contribution to world emissions from the base case: the cumulative reduction by 2010 in global emissions versus the base case is 0.9 percent in Scenario 1 and 1.1 percent in Scenario 2. Furthermore, this emissions impact could be reduced were U.S. reductions to be offset by an increase in emissions elsewhere in the world (such as might be caused by migration of production offshore to avoid the costs of environmental regulations).

**U.S. Participation Will Help
Facilitate a Multilateral Approach but Unilateral
Action Involves Significant Risks and Uncertainties**

A stronger case for unilateral actions by the United States is made by those who point to the political benefits resulting from a strong demonstration of the U.S. commitment to the international process. Although a range of actions are potentially available to demonstrate such a commitment, many feel the United States should play a leadership role by significantly reducing U.S. GHG emissions. This would be especially critical, it is argued, to securing the participation of the developing countries. Furthermore, the goal adopted by the United States and the policies that are selected could also set an important example internationally.

Although diplomatic benefits could accrue from any action taken by the United States, the results of this study suggest that the United States incurs a significant economic risk if it undertakes comprehensive actions in advance of an agreement that outlines the scope of any international initiative. This risk could be compounded by economic and political factors that might complicate the progress of multilateral negotiations. First, other countries have not proceeded far beyond the stage of making commitments to GHG reduction targets. Economic analysis to date has done little to clarify how expected patterns of energy utilization and economic growth worldwide can be altered to meet ambitious targets without aggressive government intervention. Second, international agreements will also depend on parallel commitments to action--involving matters such as monitoring, legal issues, technology transfer, etc.--as well as goal setting. In this regard, a host of difficult political and economic issues must still be negotiated. Finally, arriving at a multilateral consensus on global climate change policies will be complicated by the sheer number of international players, each with different economic, political and social agendas.

**Multilateral or Bilateral Action
May Offer More Cost-Effective Solutions**

Another factor to consider in implementing costly GHG emissions reductions in the United States in advance of a multilateral agreement, is that more cost-effective options may be available under a multilateral framework. Emissions reductions in developing countries may often be less expensive than equivalent reductions in the United States due to the

low-energy intensity and often unsustainable use of forest resources in these countries. More research is warranted to determine where such opportunities exist and to quantify their emissions reduction potential. Capturing these less costly alternatives through trading of emissions permits or through offsets requires at least a bilateral or multilateral approach for successful implementation. Hence, if the international community decides to seek reductions of global GHG emissions, it may make more sense to begin this process by exploiting low-cost options through an international agreement.

Other U.S. Actions Could Also Facilitate Multilateral Cooperation

Undertaking major domestic reductions of GHG emissions is not the only way that the United States could facilitate multilateral cooperation in the near-term. In particular, there are a number of actions that would be key to any international effort but that do not carry significant economic risks. These include: initiatives to improve technology transfer to developing countries; promoting anticipatory private sector involvement; identifying cost-effective policies, such as international emissions trading, that are viable in the context of international action; developing regional associations that could study and implement cost-effective regional response strategies; and targeting foreign aid and assistance at key areas that reduce or offset GHG emissions, such as energy efficiency improvements and control of population growth. Such actions have the advantage of addressing the long-term needs of developing countries, while allowing research and negotiation of scientific and economic issues to proceed within a flexible framework.

FURTHER TOPICS FOR STUDY

This study is a first step in systematically identifying the costs and effectiveness of GHG emissions reduction alternatives. However, further economic study is needed before policymakers can effectively address global climate change concerns. Additional areas of study include understanding and quantifying the benefits of global climate control policies, the costs of adaptation policies, the costs to society of GHG emissions, the costs of GHG reduction alternatives and the policies that can effectively and efficiently reach emission reduction targets.

Talk About a New World Order!

Implications of the new science of geophysiology.

Charles Darwin wrote in his autobiography "I rejoice that I have avoided controversies." So much for informed prediction.

Forewarned, I nevertheless offer another. The revolutionary sciences of our time, just as astronomy was in the 16th Century century and physics has been in the 20th, will be ecology and the study of Earth as a living whole.

One could see the signs a few months ago when *The Economist* carried a long story—sandwiched between reports on the collapse of trade talks and the Persian Gulf crisis—on the subject of Gaia. Gaia was the ancient Greek Earth goddess. It is also the name given by British scientist James Lovelock and his American collaborator, microbiologist Lynn Margulis, to a theory that sees Earth as a living system in which the nonliving realm is continuously shaped by the presence of life.

Not just species evolve in the Gaian view but species and their living and nonliving environment together. The theory's most controversial postulate is that life actively influences the physical environment in order to maintain conditions favorable to itself. Thus the apparent planning and sense of purpose that Darwinian natural selection produces—and which has always been so hard to grasp—is broadened to include the entire planet.

To Lovelock, Earth's living and nonliving matter are not as distinct as they seem. Consider, he says, a mature tree. When it is alive, nearly all of it is dead. It is a vast mass of dead wood surrounded by a thin living skin that is in turn protected by another dead layer, the bark. "The Earth is very much like that; you have the middle, molten, dead, . . . that same thin skin of living tissue and beyond it the atmosphere which is just like a bark of a tree, therefore not formally alive . . . but still a protective layer against the rigours of the environment, which for the Earth is space."

Gaia also means that the reductionist approach of most of modern science—breaking down systems into smaller and smaller parts and studying each one by one—cannot reveal what has happened on this planet since life began 3.8 billion years ago. During these years external conditions, especially the intensity of

the sun, have changed dramatically. Yet physical conditions such as climate, the salinity of the oceans and the composition of gases in the atmosphere have stayed within narrow ranges conducive to life. According to Gaia, this remarkable stability, which leaves Earth still the sole spot in the universe known to support life, is because of life's self-regulating mechanisms.

These mechanisms are akin to those of the body, which maintains a stable internal environment (a temperature of 98.6 degrees Fahrenheit, for example), in the face of large external changes. Such responses require no conscious intervention, for they are built in. The study of such systems in the body is physiology, a science that perforce looks at whole systems, not pieces. Hence the right approach to the study of Earth, according to Lovelock and Margulis is the new science of geophysiology.

Until a few years ago, the word geophysiology would have been dismissed as a contradiction in terms, an incomprehensible jumble of

rocks and living systems. But in the last few years, Gaia has moved from crackpot to mainstream science. There is still fervid debate, and Gaia's supporters are a minority, but the best single indicator of the power of a new idea in science is that it opens up new areas of research, and this Gaia is unquestionably doing. Moreover, research published two weeks ago revealed experimental evidence of one of the theory's major predictions. This is a climate-regulating mechanism involving plankton in the sea, a sulfur gas the plankton emit and clouds that form around the sulfur, cool the climate and thereby depress plankton growth.

Whether or not the Gaia theory proves correct in its present form, it has changed the course of science not only by spawning new kinds of research but by changing the way people think—even those who think the theory is wrong. The traditional view of life as something that passively adapts itself to an externally imposed physical environment is giving way to a recognition of closer coupling between the living and nonliving realms.

Gaia's most important implications, however, reach far beyond science. If it is in the main correct (still a big if) it would, I think, demolish the prevailing world view that humankind is not only above but separate from nature. That view is embedded in economics, law and political science as well as in most of the major religions, which teach that we are to exercise dominion over nature, which exists largely to serve our purposes.

Those whose faith leads them in that direction could continue to view humanity as the

peak of creation, but Gaia would likely force us all to discard that sense of separateness. As powerful as modern technology makes us, our one species (among perhaps 10 million) looks, in a Gaian perspective, like a small cog in a very large machine.

Moreover, the machine may be far more intricate than we have dreamed. Whether this would make it more or less vulnerable to human interventions—like species extinction, greenhouse gas emissions, or large-scale soil erosion—is unpredictable, but a greater sense of caution might well seem warranted. Ultimately, Gaia could force a transforming shift from a narrow conception of the welfare of our own species to an overriding concern for that of the planet as a whole.

The writer, vice president of World Resources Institute, writes this column independently for The Post.

THE NEW YORK TIMES, FRIDAY, FEBRUARY 22, 1991, D 1

A Disappointing Deal for Browning

By BARNABY J. FEDER

Browning-Ferris Industries had little to celebrate as it quietly reached a preliminary agreement last week to sell its state-of-the-art hazardous waste disposal site 70 miles east of Denver to the Concord Resources Group, a recently formed joint venture of the Consolidated Rail Corporation and the OHM Corporation.

Although the price was not disclosed, interviews with company executives and bankers suggest that it was 20 percent less than had been hoped for when the site was put up for sale last summer. The price was even slightly under an internal valuation by Houston-based Browning-Ferris, which has a reputation for conservative accounting.

The gap between Browning-Ferris's dream deal and the one it finally

A top-level disposal site brings a low-level price.

struck reflected in part the weak market for most types of corporate assets in this recession. But it also highlighted uncertainties peculiar to environmental businesses, especially those in fields like hazardous waste where the investment demands — as well as the regulatory and technology risks — are substantial.

Browning-Ferris had reason to believe that it was in an enviable bargaining position when it began the process of selling its Last Chance site, which takes its nickname from a nearby hamlet. The Environmental

Protection Agency has called Last Chance "the best designed land disposal site in the nation."

Moreover, analysts who follow environmental companies say that hazardous waste disposal, currently a \$3 billion to \$4 billion business, may be the most lucrative segment of the waste management industry over the next 20 years. The basic reason: As new regulations continue to expand the range of materials classified as hazardous waste, the number of legal disposal sites is declining.

Despite such prospects, Browning-Ferris decided last April to bail out of the hazardous waste business and concentrate on solid waste disposal and recycling. Browning-Ferris is the

second-largest solid-waste disposal company in the nation after Waste

Management Inc.

Browning-Ferris had tripped from one financial setback to another in hazardous waste, damaging its reputation with regulators and environmental groups. It was never able to overcome a history of shoddy operations at landfills it acquired in New York, Ohio, and Louisiana. When William D. Ruckleshaus, the company's chief executive, decided to retreat last spring, the company set aside \$295 million after taxes to cover the costs of discontinuing the business.

In Last Chance, buyers were being offered the company's one hazardous waste jewel. "I think they basically put it together as well as humanly possible," said Tanelle Roberts, the engineer overseeing the permit process for the Colorado Health Department.

Moreover, the new owner would be taking over at an ideal time, just as the last regulatory reviews were completed, wiping away any fear that previous operations had created unknown perils that could lead to fines, remediation expenses or closures.

Browning-Ferris's expectations were also colored by its pride in Last

way 36 Treatment Storage and Disposal Facility. It is the first — and so far only — new hazardous waste site to receive state and Federal operating permits under new regulations established by the E.P.A. in 1984. More than \$50 million had been sunk into the site since acquisition of its 5,700 acres began in 1980.

Last Chance is intended to handle a variety of liquid and solid wastes, including incinerator ash, sludges produced by other waste treatment operations, toxic metal plating sludge, contaminated soil and asbestos. Last Chance will also store and blend oils and organic solvents for

use in incinerators or for recycling.

Materials to be sent to the site must be pre-tested at a laboratory in Denver and can only be accepted if they come in a scheduled delivery. They also will be retested at the site. All wastes to be buried will be solidified. The permit calls for disposal in four-acre cells that are 40 feet deep, lined with alternating layers of plastic and compacted clay and ringed with leak detectors. The site has also been sculpted and managed to control rainwater.

Concord's Second Acquisition

The Last Chance deal came within days after Concord Resources, based in Pittsburgh, had announced its first acquisition, the purchase of Stablex, a small hazardous waste firm in Montreal.

"This is a great time to be buying hazardous waste assets," said Swep T. Davis, Concord's chief executive, reflecting on the leverage willing buyers have in a slow market.

"From 1984 to 1988, sellers could be very rigid on bidding specifications, which sometimes read like ultimatums," acknowledged Clay Lifflander, the Smith Barney, Harris Upham & Company banker who led the sales effort. "People don't like to feel like they are in an auction today. It's more like a negotiation."

The sales process began last June, when thick booklets describing the site were sent to those who had expressed an interest, along with a cover letter hinting that Browning-Ferris would welcome a pre-emptive bid. None came. Smith Barney executives began to realize that while the site clearly did not have any skeletons in its closet, it also had no record by which to judge Browning-Ferris's income projections.

Only potential bidders were allowed to see the projections, but there are some hints about the potential profits. At \$200 a square yard, a rough industry average price last year, the site has already been permitted to re-

ceive 2.5 million cubic yards of material, or \$500 million worth. And it has the capacity to receive 7.6 million more without violating any of its basic operating conditions.

Although it is the only permitted site in Colorado under the new regulations and is hundreds of miles from its nearest competitor, the problem for potential purchasers is calculating how much of Last Chance's income can be generated locally where its competitive advantage is strongest and how rapidly that demand might build.

Several Shortcomings

Industry experts said Last Chance has several potential shortcomings. It is a long way from the nearest rail line, meaning that its waste will come from relatively long-distance truck runs. Moreover, several of the largest

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that hearing, Stuart Eizenstat, who was a former director of Domestic Policy under President Jimmy Carter when the original CAFE law went into effect, said he still believes "CAFE standards are the most effective available policy for slowing the growth of oil consumption and oil imports."

He disputed the administration's principal argument against CAFE standards, which is that market forces should be permitted to determine how much consumers want to invest in fuel efficiency. The market, he said, "is imperfect because of the 'externalities' involved in the use of inefficient vehicles."

He maintained that market forces alone would not have produced a doubling of new car fuel efficiency between 1975 and 1985, and pointed out that without escalating CAFE standards, actual fuel economy has declined since model year 1986.

Addressing the safety issue, he said, "I believe that improved fuel efficiency can be achieved without detrimental effects on vehicle safety by using air bags and other safety technologies."

STUDY PUTS ANNUAL COST OF LIMITING GREENHOUSE GASES AT \$55 BILLION

A comprehensive policy designed to limit U.S. emissions of greenhouse gases could cost the economy as much as \$55 billion a year, a new report from the Center for Strategic & International Studies has found.

The study, which was presented earlier this month to the American delegation at the Intergovernmental Negotiating Committee for a Framework on Climate Change in Chantilly, Va., is based on two groups of policy options culled from state and federal legislative proposals and reports from federal agencies and nonprofit environmental organizations.

Options contained in the two scenarios for comprehensive U.S. action over the next 30 years include domestic reforestation programs, end-use conservation and energy efficiency programs, transportation efficiency standards, alternative electric power generation, alternative transportation fuels, programs to phase-out CFCs and carbon taxes on fossil fuels.

Both scenarios were compared with a base case that assumed the domestic economy would grow at an annual rate of 2.1%, that energy intensity declines by 1% a year and that total U.S. greenhouse gases (carbon dioxide and CFCs) increase.

Under the first scenario, which includes reforestation programs, a proposal to end below-cost timber sales from national forests, a phase out of CFC use by the year 2000, a freeze on HCFC production at 2014 levels, energy end-use efficiency standards, increased corporate average fuel economy standards, gas guzzler taxes, an additional tax on gasoline and subsidies for compressed natural gas vehicles, the CSIS report concludes that present value GNP would decrease by \$560 billion from 1990 to 2020 compared with the base case.

Scenario 1 actions, the report says, would result in a 4.3% reduction in greenhouse gases below the 1990 base case levels.

The study also concludes that if the policy options contained in the scenarios were adopted, investment in energy efficiency would increase, public utility investment would decline due to lower demand, international trade would improve through a slow down in imports, energy intensity of the economy would fall by an additional 0.35% a year and the cumulative federal deficit would fall to 73% of the base case by 2010.

Under the more stringent options contained in Scenario 2, including a CFC phase out in 1995, stricter CAFE standards than those endorsed under the first scenario, electrification of railroads, subsidies for biomass-derived ethanol-methanol fuels and additional retirement of coal-fired power plants, present value GNP would decline by \$840 billion by 2020 and annual greenhouse gas emissions would fall by 7.2% below the base case levels.

Policies adopted under Scenario 2 would, CSIS says, increase energy costs "significantly" and force an additional 0.33% decline in U.S. energy intensity from base case levels. The options would also result in an increase in the cumulative federal deficit by 59% over the base case by 2010.

"Neither Scenario 1 nor Scenario 2 achieves the 20 percent carbon dioxide reduction goal stated in omnibus legislation, although virtually all options likely to result in near-term emissions reduction are represented in either Scenario 1 or 2," the report says.

Further, the study says that even a carbon tax — an action that is not included in either of the two scenarios — would likely not enable the U.S. to achieve the 20% target.

"One argument for unilateral U.S. action is that because of the large contribution of U.S. [greenhouse gas] emissions to global emissions, such action is warranted in and of itself. Under this study's base case analysis, the U.S. contribution to world carbon dioxide and CFC emissions declines from

20 percent in 1990 to 18 percent in 2010 (the U.S. contribution to carbon dioxide emissions remains constant at 19 percent in 1990 and 2010)."

"U.S. action alone would not significantly change this trend. Enacting comprehensive policies within the United States will only slightly reduce the U.S. contribution to world emissions from the base case: the cumulative reduction by 2010 in global emissions versus the base case is 0.9 percent in Scenario 1 and 1.1 percent in Scenario 2. Furthermore, this emissions impact could be reduced were U.S. reductions to be offset by an increase in emissions elsewhere in the world (such as might be caused by a migration of production offshore to avoid the costs of environmental regulations)," the study says.

The report suggests that more cost-effective options to enacting legislation may be available to the United States under a multilateral agreement. "Emissions reductions in developing countries may often be less expensive than equivalent reductions in the United States due to the low-energy intensity and often unsustainable use of forest resources in these countries. More research is warranted to determine where such opportunities exist and to quantify their emissions reduction potential."

LAWMAKERS DETECT LITTLE IN STRATEGY TO ADDRESS GLOBAL WARMING

Congressional Democrats charged that the proposed national energy strategy would do little, if anything, to address the global warming issue, while renewing their accusations that the Bush administration is foot-dragging on actions to stabilize emissions of greenhouse gases.

At a hearing before House Energy subcommittee on health and the environment, Democrats charged that the strategy, with its heavy reliance on increasing production of fossil fuels, could actually exacerbate carbon dioxide emissions. Rep. Gerry Sikorski, D-Minn., pointed out that the strategy would not require use of energy efficient lighting, mandates tough efficiency standards only for about one-fifth of all new buildings, includes no efficiency standards for electric motors, and lacks corporate average fuel economy standards for new vehicles. Each of those measures, he said, would have resulted in substantial reductions of energy consumption and carbon dioxide emissions.

But Mark Kerrigan, DOE's associate deputy under secretary for policy, planning and analysis, insisted that the strategy would significantly decrease fossil fuel use compared to what otherwise would have been used. He said enactment of NES would result in "reducing the rate of growth" in carbon dioxide emissions and stabilizing carbon dioxide levels at or below current levels by the year 2030.

That did not satisfy panel Democrats, who pointed to much stronger commitments made by some of the world's other industrialized nations, including the European Community. Sen. Al Gore, D-Tenn., a persistent critic of White House global warming policies, who was invited to testify before the committee, called this month's pledge by the U.S. to stabilize emissions of greenhouse gases in the year 2000 "a total sham," and an "insult to the intelligence" of those reading the plan. But even Gore acknowledged that the pledge, made during a meeting of the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change (INC) earlier this month in Chantilly, Va., represented a "change in tone" for the administration.

Gore called the new administration policy "smoke and mirrors" because it counts the phasing out of chlorofluorocarbons that was agreed to by most nations in 1987. That document, known as the Montreal Protocol, calls for the elimination of CFCs, which are potent greenhouse gases, by 2000. The elimination of CFCs in that year will result in a dramatic decline in emissions of total greenhouse gases, even as the amount of carbon dioxide — the chief culprit in global warming — released to the atmosphere continues to rise.

Defending the administration statement, Robert Reinstein, deputy assistant secretary of state for environment, health and natural resources, said the fact the administration cut CFCs in response to another agreement did not mean that those cuts should not count.

Panel Democrats focused their criticism on the refusal of the administration so far to pledge any significant near-term reduction in carbon dioxide emissions, the chief culprit among greenhouse gases.

"By the administration's own reckoning, the policies that we will hear described today allow carbon dioxide emissions to rise by 15% by 2000," said subcommittee chairman Henry Waxman, D-Calif. "In other words we are moving in exactly the wrong direction — we are increasing, not decreasing, carbon dioxide emissions."

"This plan is a major embarrassment," said Rep. Peter Kostmayer, D-Pa.

According to Reinstein, the U.S. has avoided pledges similar to those made by the European

Some Scientists See No Danger in a Decade's Delay in Curbs on Warming

By WILLIAM K. STEVENS **B9**

A 10-year delay in taking action to curb global warming would mean little further increase in the level of warming predicted by the end of the next century, according to calculations by scientists who advise a United Nations panel dealing with climate change.

Controls deferred for a decade would achieve 95 percent of the reduction in warming by the year 2100 that would be achieved by imposing the controls immediately, the scientists say in a study appearing today in the British journal *Nature*.

The results suggest that "the urgency is probably somewhat less than some people have tended to make it appear," said Dr. Michael E. Schlesinger, a climatologist at the University of Illinois at Urbana-Champaign. He is the

author of the study along with another researcher at the university, Xingjian Jiang. The authors said a delay would give scientists time to pursue a "crash program" of research to reduce uncertainties about the severity of the expected warming.

Scientists Are Divided

Certain atmospheric gases, chiefly carbon dioxide, trap heat from the sun, much as a greenhouse does. Concentrations of the gases are steadily growing, mostly as the result of industrial and motor vehicle emissions. Scientists say this could cause the earth's surface temperature to increase by more than 5 degrees Fahrenheit by the end of the next century, with catastrophic effects on climate, crops, ecosystems and sea levels.

Some scientists supported the finding being reported today. Others, while acknowledging that it may be accurate so far as it went, said that the finding failed to take account of a number of factors, and that using it as a guide to policy could be dangerous.

The finding appears to support the Bush Administration's position that "it's better to get it right than to act precipitously," especially when the cost of action is high, said William K. Reilly, Administrator of the Environmental Protection Agency.

The Administration also believes research should proceed in tandem with "action that is justified for other common-sense reasons" in addition to global warming, said Michael Deland, the chairman of the White House Council on Environmental Quality. The White House maintains that environmental actions already taken will keep

United States emissions of heat-trapping gases from increasing for the next decade.

But Senator Al Gore, the Tennessee Democrat who has strongly opposed the Administration's position, said in a statement, "The longer we wait, the harder the necessary actions become." He said delay would be "irresponsible" given the "potential for disastrous consequences."

Dr. Schlesinger's group at Illinois, using a computerized mathematical model of the climate system, made the projections of future global warming adopted last year by the Intergovernmental Panel on Climate Change. This is a United Nations-sponsored group that is providing scientific advice for continuing international negotiations on a global warming treaty. The Illinois researchers calculated that if no steps were taken to limit emissions of carbon dioxide and other heat-trapping gases the average surface temperature of the globe would rise by 4 to 9 degrees Fahrenheit by the year 2100.

In the study being published today, they greatly broaden the possible range of warming expected by 2100 if no action is taken, placing it at 1.6 to 10.6 degrees. Much of the difference is accounted for by a lower assessment of the climate's sensitivity to heat-trapping gases. That assessment was made by Dr. Richard Lindzen, a meteorologist at the Massachusetts Institute of Technology, who has argued that the global warming threat is exaggerated.

The calculations being reported today are also based on a mathematical model. They indicate that whatever the degree of warming efforts to reduce it would be little handicapped by a 10-year delay in instituting controls, which would include such measures as reducing the burning of fossil fuels like coal and oil. The scientists assumed it would take 20 years to phase in the controls whether they were imposed now or a decade from now.

The results, the study report said, indicate that "the penalty is small" for a 10-year delay.

"I think it has to be reckoned as reasonable," Dr. Lindzen.

Are Factors Overlooked?

Other climatologists said that while the finding might be correct so far as it goes it overlooks several important factors. Some scientists say that the expected global warming may well proceed not gradually, as the Schlesinger calculations assume, but unevenly, with sudden spurts in temperature as climatic thresholds are reached. This possibility of sudden change makes it dangerous to wait, said Dr. James E. Hansen, a climatologist at the Goddard Institute for Space Studies in New York.

Dr. Michael Oppenheimer of the Environmental Defense Fund agreed. Moreover, both he and Dr. Hansen said, delay would make it more difficult and expensive to institute controls on heat-trapping gases if, after 10 years, they were deemed necessary.

It may be true, Dr. Oppenheimer said, that the amount of heat-trapping gases emitted during a 10-year delay would result in little extra warming. But, he said, there has not been much argument about this. "When people have argued about delay," he said, "they have never made a big deal about what its impact is on the climate. They have said that the more you delay, it's going to be that much tougher" to reduce emissions.

As more gases are allowed to build up, he said, more stringent measures than originally envisioned would be necessary to bring about even 95 percent of the reduction in warming that would be achieved if controls began now. This, he said, is because the build-up of gases would make it more difficult to rein in the rate of warming.

Mr. Reilly said that it was "conceivable" that improving technology could make it easier to reduce emissions in the future. He also said that the certainty about warming that would come from more research would be useful in overcoming the skepticism of some undeveloped countries about the need for controls.

Gas Tax Defeat Will Not End Md. Road Work, Mitchell Says

By Richard Tapscott
Washington Post Staff Writer

C4

ANNAPOLIS, March 20—Since January, Maryland Gov. William Donald Schaefer and state transportation officials have warned that road construction would be halted for two years unless the General Assembly approved a gasoline tax increase.

On Tuesday, as a House committee unanimously voted down Schaefer's tax plan to finance \$1.5 billion in road and transit programs for the next five years, his chief spokesman again regretted the loss of two construction seasons.

"If the gas tax goes down, there are no new roads and bridges for two years," Schaefer spokesman Paul E. Schurick said, "This means the program will be shut down for two more years."

Tonight, House Speaker R. Clayton Mitchell Jr. (D-Kent) disputed those statements, using figures provided by the Department of Transportation. By the department's reckoning, more than half the spending planned through 1996 still could occur, much of it this year and next.

"I got tired of the doom and gloom, that there wasn't going to be any construction," Mitchell said as he released the figures. "That's not true."

In Prince George's County, for example, the department said \$98.9 million in planning, acquisition and construction planned for the next 15 months could go on. About \$45.5 million may be deferred. Comparable figures for Montgomery County projects showed \$27.1 million in spend-

ing that may proceed while \$78.4 million could be delayed.

Mitchell said the figures were produced by the Transportation Department at his request early this month. The document lists "potential project deferrals" for each county, but also lists projects that could go forward. The department will have to decide how much of its current plan can continue and has the ability to postpone projects to match expected revenue.

On Jan. 7, former transportation secretary William K. Hellman said, "If there's not a revenue increase, there will be no new projects for 18 months." Hellman was chairman of a panel Schaefer appointed to help sell the tax increase to the legislature.

Schurick, asked tonight about the apparent discrepancies, said the construction program would be only half its original size and no new projects could be added beyond 1996.

"I didn't mean to say there's going to be absolutely no paving over the next two seasons," Schurick said. "It's a fine line, and I see some confusion. But I stand by my statement that the program is being halted."

Based on documents sent to Mitchell, some major road projects planned in the next two seasons are subject to delays, including \$37 million for reconstruction of Route 28 in Montgomery County and \$25.5 million to rebuild Route 214 in Prince George's County. However, other projects could continue with state or federal funds, among them widening the Capital Beltway from Route 650 to Route 1 in Prince George's at a cost of \$15.6 million.

SCIENCE AND THE CITIZEN

Cold Start*Policies on global warming and energy don't move critics* **p.14**

When delegates from 101 nations gathered in Chantilly, Va., in February for the first round of negotiations toward an international agreement on global warming, they were presented with what appeared to be a new U.S. initiative. It was a slick color brochure detailing "America's Climate Change Strategy." There was also word that the Bush administration would soon roll out its long-delayed national energy policy.

To some present, it appeared that the administration might finally be moving toward an integrated strategy on global warming and energy use. But that first impression proved misleading. The climate change strategy offered nothing new. The U.S. energy policy, which was announced in late February, was a direct descendant of Reagan era supply-side economics that barely paid lip service to energy conservation.

In the end, the Intergovernmental Negotiating Committee had precious little to show for two weeks' work in Chantilly. Reined in by White House Chief of Staff John H. Sununu, U.S. negotiators agreed only to the establishment of two working groups: one to consider what kind of "appropriate commitments" might be made to counter warming and one to think about how they might be implemented. "They have determined only the shape of the negotiating table," complained Michael Oppenheimer of the Environmental Defense Fund.

It was clear before the conference began that progress would be difficult if the U.S., which emits 20 percent of the greenhouse gases that warm the atmosphere, continued to oppose cutbacks in emissions. Several European countries, as well as Australia and New Zealand, had previously committed themselves to reducing emissions of carbon dioxide by 20 percent over the next decade. Meanwhile Canada and Japan had said they will only stabilize their emissions. The U.S. document simply explained that actions the federal government has already taken will result in its greenhouse gas emis-

*Genes for mortality,
new neutrino conundrums,
dioxin whitewash,
John Sununu up close*

sions in the year 2000 being "equal to or below the 1987 level." "No other country in the world, so far as I know, can make that claim," bragged President Bush's science adviser, D. Allan Bromley, to a Washington press conference.

The "strategy," however, is a prediction rather than a commitment, and it hardly represents a policy shift. The U.S. claim that its emissions in the year 2000 will be no greater than in 1987 is based on a new way of assessing greenhouse gas emissions that combines the future warming potential of many gases, not just carbon dioxide.

The gases listed in the new index of global warming potential include chlorofluorocarbons, which are already being phased out. Over the next decade,

other domestic pollution and efficiency measures will probably reduce or slow the growth in emissions of other polluting gases, such as methane, nitrogen oxides, volatile organic compounds and carbon monoxide. Only because of these previously decided actions is the U.S. contribution to greenhouse warming expected to remain constant for the next 10 years—and then only if the economy performs as expected. Under present policies, total U.S. greenhouse gas emissions will start to grow again after the year 2000.

The U.S. negotiators took political advantage of the new counting method by successfully opposing moves that would have entailed separate examination of carbon dioxide sources and sinks. Advocates of more radical action to curb greenhouse emissions criticize the approach. Forty-one senators proposed a resolution taking the administration to task. One of them, Al Gore of Tennessee, who has made global warming a personal crusade, called the strategy a "dishonest subterfuge."

The go-slow approach of the U.S. negotiators was underscored by a report from the congressional Office of Technology Assessment that was issued during the Chantilly conference. The OTA takes issue with the notion that it is impossible to make substantial cuts in carbon dioxide emissions without sacrificing public comfort and convenience. Such cutbacks, Sununu has argued, reflect an "antigrowth agenda."

The OTA concludes that the U.S. could within the next 25 years decrease its emissions of carbon dioxide by 35 percent from 1987 levels without major technological breakthroughs. The cost of such a course is uncertain, although the OTA admits it could be as much as 1.8 percent of GNP. But a more moderate set of options that would limit increases to 15 percent over 25 years would probably save money, the OTA believes. If no special effort is made, in contrast, the OTA estimates that U.S. carbon dioxide emissions will increase 50 percent by the year 2015.

The technical options that the OTA identifies for reducing emissions include improving generating efficiency and encouraging conversion to more carbon-efficient fuels such as natural gas, as well as making greater use of non-

Results of an Energy Strategy

The Bush administration projects that its energy initiatives will have the following effects, based on a hypothetical "current policy base." These computerized projections, however, include changes already mandated by the 1990 amendments to the Clean Air Act.

INCREASE:

- Domestic oil production by 3.8 billion barrels a day to 12 million barrels a day by the year 2010.
- Nuclear power generation to 21 percent of installed capacity by 2030, from 20 percent at present, preventing a projected decline in share.
- Natural gas consumption by one trillion cubic feet, or 3 percent, by 2000.
- The share of electricity generated from renewable resources by 10 percent by 2010.

REDUCE:

- Oil imports by 3.4 million barrels a day by 2010.
- Total U.S. oil consumption from 22.5 million to 19.0 million barrels a day by 2010.
- Barrels of oil consumed for each \$1 million of gross national product from 2.4 to 2.0 by 2010.

SOURCE U.S. Department of Energy

CONTINUED

fossil fuels. Also important would be increasing energy efficiency by the end-user, where the biggest savings would come from better building design and more efficient lighting and industrial processes. But in order to stimulate

consumers and companies to make use of the most efficient and least polluting technologies, such measures as taxes, tradable permits, regulations, incentives and information programs would be needed.

These kinds of recommendations are glaringly absent from the administration's long-awaited energy policy, which carefully sidestepped the term "policy" with the designation "National Energy Strategy." Almost all the earlier proposed regulations and incentives for improved fuel efficiency and increased use of renewable energy were whittled out in cabinet and subsequent White House reviews.

Tracking the Missing Carbon

One of the biggest uncertainties about the greenhouse effect is the mystery of the "missing carbon." Fossil-fuel burning adds about six billion tons of carbon to the atmosphere each year in the form of carbon dioxide, and deforestation and topsoil erosion may add three billion tons more. Yet the amount of extra carbon that appears in the atmosphere each year is only 3.5 billion tons. Another 1.5 billion tons dissolve in the ocean. The remaining four billion tons vanish without a trace.

Some researchers think that trees may be a missing piece of the puzzle. They cite research showing that forests, stimulated by increasing levels of carbon dioxide, could soak up far more carbon than previously predicted.

Last year Pieter P. Tans, a researcher at the National Oceanic and Atmospheric Administration, and his colleagues concluded on the basis of computer models that two or three billion tons of carbon dioxide are disappearing into an unknown terrestrial "sink" that lies in northern temperate latitudes. Meanwhile experiments by Boyd Strain, a botanist at Duke University, and others have demonstrated a "fertilization effect" of extra carbon dioxide—plants grow faster and remove more of the gas from the atmosphere.

This effect, acting on forests, could in principle explain the fate of at least some of the missing carbon. Some experiments have shown that plants grow relatively larger root systems when carbon dioxide levels are increased. If trees are growing larger roots, researchers would probably not have noticed—weighing a tree's roots is a difficult operation.

To test the idea, Richard J. Norby, a botanist at Oak Ridge National Laboratory, is growing trees in atmospheres of elevated carbon dioxide with their roots in the ground (see photograph below). After two years, he reports that white oaks are showing sustained increased growth with extra carbon dioxide. White poplars respond marginally, but their leaves become smaller, a possible compensatory response. Norby has not yet dug up any trees to see whether their roots have grown faster.

Even if trees are storing missing carbon in their roots, the effect is not likely to affect greatly the pace of rising atmospheric carbon dioxide, says Anthony W. King of Oak Ridge. But Tans is more hopeful: "I can be an optimist and say, 'Great, nature is helping us here—we might be able to delay climatic change by growing forests on a large scale.'"

—Tim Beardsley

Administration officials say such proposals were likened to Carter era legislation, which is the mark of political death in the antiregulatory White House. (Notably, the \$2.5 billion of tax credits the oil industry received last year seem to be exempt from such criticism.) One proposal that never made it into the energy strategy was a plan to increase substantially fuel-efficiency standards for automobiles. Other casualties include mandatory building-efficiency standards and production incentives for renewable energy sources. Although the strategy calls for research aimed at improving fuel efficiency, no strong incentives are provided.

More than anything, the energy strategy reflected the Bush administration's foreign policy and a continuing faith in supply-side economics. Against the promise of a successful campaign in the Persian Gulf conflict, which sent oil prices plunging to near pre-war levels, the energy plan called for increased domestic exploration, particularly in the Arctic National Wildlife Refuge, and deregulation of natural gas pipelines and electric utilities. The administration contends that domestic energy supplies can be increased sufficiently to hold imports to 40 to 45 percent of demand through the year 2010. "Don't kid yourself, the war is about energy," declares Senator J. Bennett Johnston of Louisiana, who is part of a bipartisan coalition sponsoring legislation that would mandate conservation and efficiency.

The global warming debate is now going on behind closed doors, until the delegates meet again in June. Meanwhile the energy policy will be taken up by a Congress that appears keen to play a part in the debate. Some 80 bills have already been put forward that would make up for the measures deleted by the administration, including a measure that would increase automotive fuel efficiency to 40 miles per gallon over the next decade.

The debate is likely to be rancorous. As one disgruntled Energy Department official put it: "In order to decrease reliance on fossil fuels, you either have to raise the price of gasoline or regulate efficiency. What we have is neither."

—Tim Beardsley

the president's New Hampshire primary victory in 1988. His reward was being made national co-chairman of the Bush campaign. He was tapped for the critical post of chief of staff soon after the election victory.

Now in the White House, Sununu puts in 13-hour workdays. And he clearly believes that his technical background is an important asset in Washington. In 1989 he told a meeting of the National Academy of Engineering that scientists and engineers—people who have a feel for problem solving and who “know the difference between a part per million and a part per billion”—have a public duty to become active in policy-making.

Nowhere has he more zealously applied his engineer's worldview to politics than on the issue of global warming. During the recent opening round of negotiations toward an international convention on climatic change in Chantilly, Va., Sununu and his staff kept U.S. negotiators on a tight leash, monitoring developments by telephone. Observers say it was Sununu who demanded that the word “appropriate” be inserted into the conference's final declaration on negotiating emission limits for carbon dioxide and other greenhouse gases.

Sununu insists he understands scientists' concerns on the question and is not opposed to lowering carbon dioxide emissions “as a matter of self-discipline.” But he is adamant that the science of climate prediction is not developed well enough to take actions that might cause economic pain.

Yet his desire not to burden industry sits uncomfortably with the conclusions of the intergovernmental panel on climatic change, a group that has made perhaps the most authoritative assessment of the science of global warming to date. The panel concluded last year that without remedial measures, global average temperature was likely to rise one degree Celsius above its present value by 2025 and three degrees by the end of the next century.

Such changes would severely disrupt agriculture, natural ecosystems and human settlements. The National Academy of Sciences was scheduled to release a report in March that underscores these scientific concerns and

argues that measures to slow emissions of greenhouse gases—such as improving energy efficiency—should be pursued now, even if they incur some short-term cost.

Sununu's basis for skepticism is simple: he doesn't trust the computer models used to predict climatic change. “What I have a problem with is the misrepresent—” Sununu stops and corrects himself. “—the gloom-and-doom approach to this that a lot of people have taken, based on some very preliminary analysis and modeling. They take models that are primarily two-dimensional across the surface of the earth and try to use them to characterize phenomena that are primarily driven by interactions in a vertical direction.”

His distrust of models, Sununu says,

comes from personal experience. (A persistent rumor maintains that he has a simple climate model that he runs on his personal computer. The models used by climatologists generally require supercomputers.) “I have a rule of thumb,” he says, “that if you can't predict the past with a model, you ought not to believe you can predict the future.”

Sununu also says he finds it of “particular interest” that about 20 times more carbon dioxide comes from natural sources—primarily vegetative decay—than comes from burning fossil fuels. “The amount they are trying to get the international community to agree to not emit, if you will, over a short amount of time is less than the noise in the natural emissions. They ought not to be making decisions that

affect the quality of life for billions of people based on something as marginally contributory as that.”

But Sununu's criticisms of the science behind the concern about global warming do not gloss over the fact that he simply does not like to be told what to do. Commenting on the Chantilly conference, Sununu says: “Everyone seems to want to come over here and tell us what they would like us to do. We're saying, we've done a great deal, for a lot of different reasons. The net impact was positive—go home and do it.”

When questioned about the administration's insistence on more research before taking deliberate steps to limit global warming, Sununu snaps that “we have put our money where our mouth is.” He claims the U.S. has put \$1 billion into climatic change research to ensure that “whatever we do is done intelligently.”

Nevertheless, a well-publicized recent report written by Nobel laureate Leon M. Lederman, now president of the American Association for the Advancement of Science, argues that dramatic increases in support are necessary to avoid damaging the scientific research enterprise. Asked for his reaction, Sununu responds: “I don't know who Leon Lederman is.” Instead he points out that the \$76 billion requested in the 1992 federal budget for research and development—\$8 billion more than this year—represents a “tremendous targeting of resources” aimed at nurturing the “fundamental strength we have in science and technology.”

Sununu offers no apologies for his bluntness. “Any strong statements on my part are controlled, deliberate and designed to achieve an effect,” he told journalists at the National Press Club last December.

Nor does the man who is so skeptical of greenhouse warming calculations hesitate to defend himself with statistics. “I have to interact with a member of Congress or a critical member of the administration or the press about 100 times a day. If I bat 99 percent in terms of having it be a very successful outcome all around, it means 365 times a year there's something that people can write a story about or exaggerate a story about.”

—Tim Beardsley

PROFILE: POLITICAL ENGINEER

p. 26 *John Sununu dominates science policy*

When the elders of science used to bemoan the lack of science advice in Washington, they probably didn't anticipate that John Henry Sununu would fill the gap. Hear him on global warming, for example: "Frankly," says the White House chief of staff, "I have the feeling that a lot of people focus on carbon dioxide because what they are concerned about is not global warming, but their own antigrowth agenda. A lot of people who are moaning and groaning about global warming are also the same ones who are moaning and groaning about nuclear winter."

Before Sununu came to grips with the issue, President George Bush in 1989 endorsed the goal of stabilizing carbon dioxide emissions because they had been implicated in global warming. Now, as Bush's chief enforcer of domestic issues, the engineer who became the governor of New Hampshire has become the principal obstacle to that plan. "Frankly, I think he's hurting the president," says William A. Nitze, whom Sununu ordered fired from his position at the State Department because he openly favored controlling carbon dioxide emissions.

With a combative style that has earned him a reputation for delivering scathing put-downs to political allies as well as opponents, Sununu has become the administration's de facto architect of much of domestic policy. In a little more than two years in Washington, "the Governor," as he is known to his staff, has eclipsed key agency heads and advisers as the arbiter of issues from energy and technology to the environment—especially global warming.

"It's my sense there's a majority of opinion within the agencies that would like to see the administration go further in the direction of stabilizing emissions," says Alden Meyer of the Union of Concerned Scientists, the U.S. coordinator of Climate Action Network. "But it's impossible to have a rational discussion of the subject when Sununu is in the room."

Sununu, who has called himself a "political counterpuncher," has demonstrated his expertise at infighting in well-publicized battles with William K. Reilly, administrator of the Environmental Protection Agency, over wetlands policy and climatic change. With Sununu, together with Office of Management and Budget director Richard G. Darman and Michael J. Boskin, chair-

man of the Council of Economic Advisers, clearly in control, Secretary of Energy James D. Watkins seemed to sit on the sidelines as a national energy strategy was shaped by the White House. And even presidential science adviser D. Allan Bromley has been forced to backpedal on statements about greenhouse warming.

Yet it is Sununu's ability to absorb and retain details of technical issues that has allowed him to exert such a wide influence over policy. Born to Lebanese and Salvadoran parents in Havana in 1939, he says he knew that he wanted to be an engineer from about the age of seven, when he was given a book called *Engineers' Dreams*. He grew up in New York City and earned bachelor's and master's degrees from the Massachusetts Institute of Technology.

Sununu had more in mind than being a bench engineer, however. While still an undergraduate, he co-founded an engineering company, Astro Dynamics, Inc., and as its chief engineer designed heat sinks and brushless motors. He also worked on life-support systems for astronauts for the National Aeronautics and Space Administration.

But in 1965 he returned to M.I.T., where he earned a Ph.D. in fluid dynamics in only nine months. In 1966 Sununu was appointed an assistant professor of mechanical engineering at Tufts University, where he worked on problems involving heat transfer, temperature control and fluid dynamics.

Sununu began his move into politics soon after he and his wife, Nancy, moved to Salem, N.H., in 1969 to take advantage of that state's lower taxes. "Nancy and I really loved the state and decided that we ought to get involved to try to keep it the way we loved it," he says. So, even though he was commuting to Tufts, he found time to join the Salem local planning board. He soon became chairman and reveled in bringing his analytical acumen to political problems. Over the next 12 years, Sununu became increasingly involved in politics. He served a term in the state legislature and staunchly defended the controversial Seabrook nuclear power plant.

Although he had lost several political races, in 1983 he was elected the 93rd governor of New Hampshire. In three subsequent two-year terms, Sununu won a reputation as a fiscal conservative. Sununu's entry into the national arena came when he helped to secure

Strict Energy-Saving Urged To Combat Global Warming

By Michael Weisskopf
Washington Post Staff Writer

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The National Academy of Sciences yesterday recommended a prompt and aggressive regimen of energy conservation measures to reduce the earth's warming trend, projecting negligible costs for what it called a "planetary insurance policy."

In the most authoritative U.S. assessment to date of policy options to combat the "greenhouse effect," the academy said that by more fully exploiting current technologies over the next 30 years, the United States could reduce by as much as 40 percent its emissions of industrial gases blamed for trapping solar heat and raising the Earth's temperature.

The academy blueprint included recommendations for: tax incentives or regulation to achieve a 30 percent increase in auto fuel efficiency; use of new, compact fluorescent bulbs to save 50 percent of the power used in lighting; more efficient motors to cut industrial energy demand by 30 percent; tougher standards for refrigerators and dishwashers to cut up to 30 percent of their energy use, and restructuring energy prices to more accurately reflect environmental costs.

While stopping short of setting specific limits on greenhouse gas emissions, as most European nations have done, the academy recommendations are more far-reaching than the Bush administration ventured in its proposed National Energy Strategy, and they are priced at a tiny fraction of White House cost estimates. The report is expected to provide ammunition for congressional critics of the administration's cautious approach to global warming.

"Despite the great uncertainties, greenhouse warming is a potential threat sufficient to justify action now," concluded a panel of the academy's Committee on Science, Engineering and Public Policy.

Presidential science adviser D. Allan Bromley said the panel's recommendations were "reasonable goals," but he reiterated the administration's opposition to energy taxes or "command and control" proposals, such as federally mandated efficiency standards for commercial buildings.

"The goals we have in mind are going to be achieved more effectively by people who believe they are doing it for their own benefit or the nation's benefit, rather than being forced by some centralized control mechanism," said Bromley.

Despite campaign promises to combat the greenhouse effect with the "White House effect," President Bush has stressed the scientific uncertainties and the need for more research. His advisers adhere to the gloomiest economic forecasts of a 3 percent decline in national income to achieve European goals of a 20 percent reduction in carbon dioxide—the principal warming gas.

With many of its members viewing global warming as the greatest environmental threat and calling for radical changes in the nation's energy structure, Congress asked for an assessment from the federal government's top advisory body on scientific and technical matters. The NAS named a 46-member panel consisting of scientists, economists and public-policy analysts.

In its report, the panel agreed with the administration that none of the major computer-generated climate models provides a "reliable forecast" of global warming. But the panel pointed to a "reasonable chance" that by the middle of the next century, when greenhouse gases are expected to double in concentration over pre-industrial times, global temperatures will increase 2 to 9 degrees Fahrenheit.

That estimate is within range of the general scientific consensus that temperatures will increase 4 to 8 degrees, forcing sea levels to rise and some plants to wither.

For Americans, who benefit from different climate zones and a dynamic farming system, the temperature rises are not likely to cause adaptation problems worse than "the most severe conditions in the past, such as the Dust Bowl," said the panel. But the threat of an unforeseen calamity is "plausible," said the authors, warranting policies to cut global warming gases as "insurance protection against the great uncertainties and the possibility of dramatic surprises."

The panel noted that measures to reduce the gases can be accomplished at "modest cost. In other words, insurance is cheap."

According to its plan, 3.2 billion tons of greenhouse gases can be cut from the present U.S. output of 8 billion tons per year. None of the measures to achieve such reductions would cost more than \$9 per ton, and some would actually save money by removing the need, for example, for new power plants.

In February, the administration had cited controversial forecasts that energy taxes as high as \$250 a ton would be needed to significantly cut global warming gases when it unveiled an "action agenda" that essentially repackaged policies devised for other purposes, such as the phase-out of chlorofluorocarbons (CFCs) to restore the protective ozone layer. CFCs also are a powerful global-warming gas.

Apparently referring to the "action agenda," the panel called for "not only several actions that satisfy multiple goals but also several whose costs are justified mainly by countering or adapting to greenhouse warming."

represents the reduction that would take place if all the measures were in effect now. By that measure, said Michael Deland, the chairman of the White House Council on Environmental Quality, the actions already taken by the Administration would amount to a 20 to 25 percent reduction.

The effects of any such measures do not suddenly materialize in one year, but rather come into play over a period of years, in which economic and population growth cause emissions to grow. This is not accounted for in the academy analysis, Mr. Deland said. Mr. Coppock, the director of the academy panel's staff, said this was true.

Environmentalists say the steps already taken by the Administration are not enough to achieve an absolute reduction in the "greenhouse" emissions in the United States, but rather would

merely allow them to stabilize in the short term while resuming their growth in the long term.

They also assert that some of the important steps recommended by the academy have been specifically rejected by the Administration. Among them are the increase in gasoline mileage standards for new cars to 32.5 miles per gallon; stronger Federal support for mass transit; and the eventual adoption of a system in which social and environmental costs would be included in setting the price of energy.

"No matter which way you slice it," Dr. Oppenheimer said, "what the academy is proposing is stronger than what the Administration has done." He said the academy's recommendations "go a long way toward meeting the goal of keeping the climate from going haywire."

Members of Study Panel

Special to The New York Times

WASHINGTON, April 10 — Following are the members of the National Academy of Science's panel on global warming:

- Daniel J. Evans, chairman of Daniel J. Evans & Associates, Seattle, and a former Governor and Senator from Washington.
- Robert McCormick Adams, Secretary, Smithsonian Institution, Washington.
- George F. Carrier, T. Jefferson Coolidge Professor of Applied Mathematics, emeritus, Harvard University.
- Richard N. Cooper, professor of economics, Harvard.
- Robert A. Frosch, vice president, General Motors Research Laboratories, Warren, Mich.
- Thomas H. Lee, professor emeritus, department of electrical engineering and computer science, Massachusetts Institute of Technology.
- Jessica Tuchman Mathews, vice president, World Resources Institute, Washington.
- William D. Nordhaus, professor of economics, Yale University.
- Gordon H. Orians, professor of zoology and director of the Institute for Environmental Studies, University of Washington, Seattle.
- Stephen H. Schneider, head of interdisciplinary climate studies, National Center for Atmospheric Research, Boulder, Colo.
- Maurice F. Strong, chairman, director general of the External Aid Office of the Canadian Government (resigned from panel February 1990).
- Sir Crispin Tickell, warden, Green College, Oxford, England.
- Victoria J. Tschinkel, senior consultant, Landers & Parsons, Tallahassee, Fla.
- Paul E. Waggoner, distinguished scientist, Connecticut Agricultural Experiment Station, New Haven.

Urgent Steps Urged on Warming Threat

By WILLIAM K. STEVENS B12

Special to The New York Times

WASHINGTON, April 10 — In a report that was welcomed by the White House and environmentalists, the National Academy of Sciences said today that the United States should act promptly to reduce the threat of global warming.

An academy panel recommended a variety of steps, including raising overall mileage standards for new automobiles to 32.5 miles per gallon from 27.5; increasing Federal support for mass transit and reforestation, and developing a new generation of safe and efficient nuclear power plants. The feared warming is expected as a result of the steady accumulation of waste industrial gases like carbon dioxide.

The steps necessary to address global warming have been a matter of fierce political contention between the Bush Administration and environmental groups. Even within the Administration, the Environmental Protection Agency has favored quicker action against global warming, which the President's chief of staff, John H. Sununu, has opposed.

The academy's report seems to be intended as an adroit political compromise between the various factions, and was praised on all sides.

Rudiments of National Policy

Although its recommendations are somewhat general, as would be expected in a consensus document, they point the way to a broad-based national program for reducing carbon dioxide emissions. They lay down the rudiments of a national energy policy, which the Administration has long resisted.

William K. Reilly, the Administrator of the Environmental Protection Agency, called the report "a step forward," although he said that he did not necessarily agree with everything in it and that his agency had not yet analyzed it in detail.

A senior Administration official, who spoke on the condition that he not be identified, said he was pleased that the report had not recommended "draconian changes." He also praised the report's cautious stand on the uncertainties of global warming, its cost-benefit analysis, its refusal to propose target dates and quotas for reductions of carbon dioxide emissions, and the importance it places on eliminating another powerful trapper of heat, chlorofluorocarbons.

Dr. D. Allan Bromley, the White

The Academy's Call to Action

Declaring that "despite the great uncertainties, greenhouse warming is a potential threat sufficient to justify action now," the National Academy of Sciences called for these measures:

- Adopt nationwide energy-efficient building codes.
- Improve the efficiency of the U.S. automotive fleet through the use of an appropriate combination of regulation and tax incentives.
- Strengthen Federal and state support of mass transit.
- Improve appliance efficiency standards.
- Encourage public education and information programs for conservation and recycling.
- Reform state public utility regulation to encourage electrical utilities to promote efficiency and conservation.
- Sharply increase the emphasis on efficiency and conservation in the Federal energy research and development budget.
- Utilize Federal and state purchases of goods and services to demonstrate best-practice technologies and energy conservation programs.

Source: "Policy Implications of Greenhouse Warming," National Academy of Sciences

House science adviser, said, "I am delighted with the report, as are all my colleagues in the White House. He said actions already taken by the Bush Administration would result in emission reductions on the order of those proposed by the academy.

The academy report "should put an end to the debate over whether it pays to act to slow global warming," said Dr. Michael Oppenheimer, an atmospheric scientist at the Environmental Defense Fund. "It makes a prima facie case for acting now. We can actually reduce emissions and save money at the same time."

'A Nimble Policy'

Even though the report does not set targets for reducing carbon dioxide, as environmental groups have long advocated, it was described as "a nimble policy" by a member of the panel, Dr. Jessica Tuchman Mathews, vice president of the World Resources Institute.

The panel said the prospect of global warming "poses a potential threat sufficient to merit prompt responses," even though it acknowledged that there was great uncertainty about its extent, timing and impact.

The academy panel said its proposed measures were all of "low cost," meaning they were cheap ways of reducing carbon dioxide and other waste gases. Low cost was defined as \$10 per metric ton of heat-trapping gases eliminated per year. The panel did not calculate the total value of the initial investment.

The panel said the United States "should resume full participation" in international programs to slow population growth. Population, said Daniel J. Evans, the chairman of the panel, "is the biggest single driver of atmospheric pollution." Mr. Evans is a former Republican Senator and Governor from Washington.

The panel encouraged development and testing of a new generation of safe, efficient nuclear power plants to replace those that burn coal.

Its report did not go as far as many environmentalists have advocated in reducing carbon dioxide emissions, concluding that "options requiring great expenses are not justified at this time."

The Administration says that steps already taken will allow overall greenhouse-gas emissions in the U.S. to stabilize in the next decade. But they argue that this is nevertheless consistent with the possible reduction of 10 to 40 percent that the academy said can be achieved if its measures are followed.

This is because the academy figure

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Climate Change: Prospects and Remedies

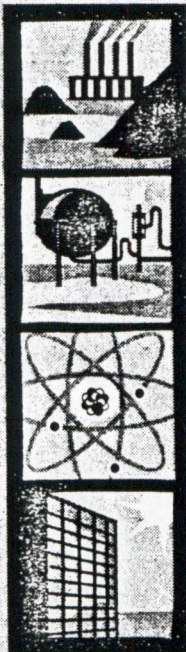
TRUTH AND CONSEQUENCES

The National Academy of Sciences says there is clear evidence and wide agreement among atmospheric scientists about several aspects of climate change:

1. The atmospheric concentration of carbon dioxide has increased 25 percent during the last century and is increasing about 0.5 percent a year.
2. The atmospheric concentration of methane has doubled during that period and is increasing about 0.9 percent a year.
3. Chlorofluorocarbons are increasing at about 4 percent per year.
4. Human activities are primarily responsible.
5. Global average temperature has risen by 0.5 to 1.1 degree Fahrenheit in the last century.

The following could happen:

1. If no effort is made to reduce emissions, greenhouse gas concentrations could continue to rise, doubling the preindustrial level by 2050.
2. This rise could ultimately increase average global temperature by 1.8 and 9 degrees Fahrenheit.
3. Further increases in temperature are likely because the oceans release heat more slowly than land. Ultimately, the temperature rise could be twice as high.



GREENHOUSE-DRIVEN ENERGY POLICY

The academy has recommended several steps to reduce greenhouse gas emissions by improving the performance of the nation's energy system.

Coal- and natural-gas-fired plants. Develop systems that have efficiencies approaching 60 percent.

Natural gas. Encourage broader use of natural gas by den-tifying and removing obstacles in the distribution system.

Nuclear power. Develop and test a new generation of nuclear reactors that are designed to deal with safety, waste management and public acceptability.

Alternative energy sources. Increase research and development on alternative energy supply technologies, such as solar, and design ways to use them in conjunction with existing technologies.

RECOMENDATIONS FOR REDUCING EMISSIONS

Potential carbon dioxide emission reduction in metric tons per year		
Suggested Action	Cost to Implement	Potential Reduction
Building energy efficiency	Net benefit	900 million
Vehicle efficiency (no fleet change)	Net benefit	300million
Industrial energy management	Net benefit to low cost	500 million
Transportation system management	Net benefit to low cost	50 million
Power plant heat rate improvement	Net benefit to low	50 million
Landfill gas collection	Low cost	200 million
Halocarbon-CFC usage reduction	Low cost	1.4 billion
Agriculture	Low cost	200 million
Reforestation	Low to moderate cost	200 million

Net benefit= cost less than or equal to zero.
 Low cost=cost between \$1 and \$9 per ton of CO2 equivalent
 Moderate cost = cost between \$10 and \$99 per ton of Co2 equivalent
 High cost= cost of \$100 or more per ton of CO2 equivalent

Source: "Policy Implications of Greenhouse Warming," the National Academy of Sciences.

Economic Scene

Peter Passell

The 'No Regrets' Greenhouse Fix

THE latest word on the greenhouse effect, from a National Academy of Sciences panel headed by Daniel Evans, a former Governor of Washington, will surely not be the last. But the panel's report, somnolently titled "Policy Implications of Global Warming," is surely a breakthrough — the first to bridge the canyon between alarmist science and what-me-worry economics.

The academy's synthesis can be summed up briefly as concluding that human adaption to warmer weather will likely be relatively painless. Outlined in 113 reader-friendly pages, the argument won't quite convince end-of-nature types to bed down with those looking forward to palm trees in Buffalo. Still, it is a safe bet that the report's approach, which one Bush Administration analyst dubbed a "no regrets" policy, will carry the establishment's imprimatur for some time to come.

Reduced to its journalistic essence, "no regrets" goes something like this:

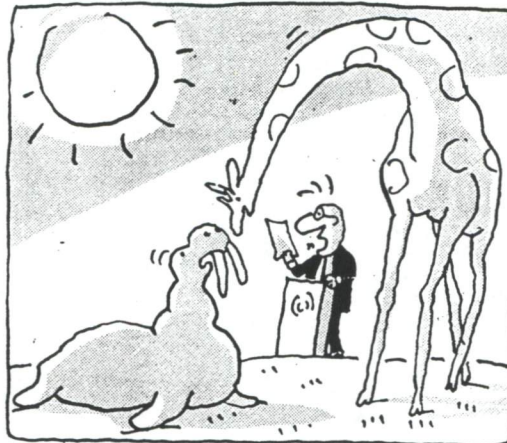
Atmospheric levels of greenhouse gases (carbon dioxide, methane, nitrous oxide, CFC refrigeration chemicals) are rising rapidly; projecting current trends, concentrations will be double their pre-industrial level by the year 2050. That virtually guarantees the planet will trap more solar energy and the earth will grow warmer.

But the plausible range of temperature change is as little as 2 degrees Fahrenheit to as much as 9. And even if the figure could be pinned down, it would not tell us much about the ensuing environmental and economic damage or the difficulty of adaptation. In agriculture, for example, hard-to-predict shifts in rainfall are likely to have far greater consequences than the direct effect of hotter summers.

Gradual weather change would probably prove only an expensive headache for humans. Tens of millions of Americans, after all, have coped with far more dramatic shifts in their voluntary move to the Sun Belt. But there is some possibility of discontinuous, catastrophic change — for example, a huge release of methane from the melting Arctic tundra that turned the cornfields of Iowa into a desert in a single generation. And there is little doubt that thousands of marine and plant species would be decimated by even a gradual warming.

What to do? The panel's "no regrets" strategy starts with emissions-reducing initiatives that would pay for themselves in greater economic efficiency. High on this list is energy conservation for buildings, vehicles and industrial processes.

But the panel, which included experts ranging from Stephen Schneider, a Government climatologist, to William Nordhaus, a Yale economist, would go further, buying a little insurance against an unexpectedly rainy (or, more likely, a very dry) day. This would surely include spending money to



Niculae Asciu

develop greenhouse-benevolent energy technologies that will be on the shelf and relatively affordable if they are needed. And it would probably also include reducing greenhouse emissions where there are only modest net costs. Prime targets: an accelerated phase-out of CFC's, which are damaging the ozone layer as well as warming the planet; a big effort to save tropical rain forests, which support diverse life forms as well as storing carbon.

"No regrets" looks like good politics as well as good policy. While every politician wants a piece of the righteous turf on this biggest of all environmental causes, few are eager to ask the voters to take the bus to work or shiver in their sweaters until the dangers are much clearer. But the approach may not prove as uncontroversial as it first appears.

Much of the energy-saving that the panel believes would pay for itself would require a fairly heavy regulatory hand. The report, for example, calls for higher mileage standards for cars — a move the Bush Administration has already declared to be veto bait. One must wonder, too, how the idea of testing a new generation of nuclear reactors would appeal to Congress.

But the panel's most problematic recommendations may be those it treats most lightly: the imperative for international cooperation. At very least that translates as aggressive support for population control in the third world. But it could also take money — lots of money — to induce poor countries to think greenhouse when they think economic development.

China, for example, now emits just 7 percent of the greenhouse gas created by human activity. But it emits six times as much the United States per dollar's worth of G.N.P. and a remarkable 18 times as much as Japan. Thus if Chinese living standards ever approach those of the West without radical improvements in energy efficiency and a technological overhaul of agriculture, the greenhouse game will be as good as lost.

THE WALL STREET JOURNAL WEDNESDAY, APRIL 24, 1991, B1



ENVIRONMENT

BY DAVID STIPP

Bad Things Come In Small Particles

AIR POLLUTION'S tiny particles are emerging as its worst culprit.

Scientists have long known that particles in diesel, cigarette and factory smoke are associated with health problems. But analyzing the harm they do compared with fallout from other air pollutants that occur with them has been tricky, says Joel Schwartz, an air pollution researcher at the Environmental Protection Agency in Washington, D.C. And few cities have kept the daily records of particle levels needed to make correlations with death rates or other indicators of health effects.

But in the past few years, enough daily data have become available for various cities, including London and Philadelphia, to make possible better correlations, says Mr. Schwartz. In analyses of such data over the past two years, he and colleagues have found that particles account for most of the higher mortality associated with heavy episodes of smoky pollution. The analyses also indicate that as many as 60,000 Americans die annually from inhaling particles at levels that don't exceed the maximum set by federal law. Other studies suggest that acidic particles are especially bad, says George Thurston, a researcher at the New York University School of Medicine.

"We saw steeper mortality effects on wheezers," such as people with asthma and emphysema, says the EPA's Mr. Schwartz. Other recent studies suggest particles also contribute to illness, such as lung cancer, in previously healthy people, he adds. "Ultimately, I think we'll have to revise" federal standards for particulate levels.

Manufacturers opposing the proposed laws question the study, asserting that the costs of complying with them would hurt businesses and cause layoffs. The MIT researchers counter that the mandates would yield a net increase in jobs by boosting the labor-intensive recycling industry.

Bank Aims to Fill Environmental Niche

BANKING and the color green will soon be more closely linked than ever.

A group of business people with backgrounds in banking and environmental services are forming a New Hampshire commercial bank to specialize in lending to environmental companies.

Small companies involved in recycling, alternative energy, toxic-waste cleanups and other environmental niches are sprouting everywhere. But bank loan officials often don't have the technical backgrounds needed to assess them for loans, says Ronald F. Reilly, a former Citicorp executive and president of the new **First Environmental Bank & Trust**, Portsmouth, N.H. Moreover, banks sometimes are leery of lending to companies delving into environmentally risky situations such as cleanups.

But with executives schooled in the environmental business, the new bank will be able to make sound loans, he says. The bank will cater to "socially conscious" depositors, including nonprofit firms and wealthy individuals, who want to make "green" investments backed by federal deposit insurance.

The bank's organizers plan to raise start-up capital of \$10 million in a stock offering and to begin operations in a few months.

From Composted Trash, Urban Gardens Bloom

NEWARK, N.J., is recycling garbage into food.

Like many U.S. cities, Newark collects leaves in the fall for composting as a way to reduce

trash. In what may be a unique twist, Newark is using its compost to make vacant lots and back yards bloom all over town.

That is, with the help of participants in its booming urban gardening program. For a dollar a year, residents can rent city-owned vacant lots for gardens, says Frank Sudol, a spokesman for Newark's Department of Engineering, which oversees the compost program. His department trucks the compost to urban gardens free. The compost is important, he adds, because Newark's rocky soil by itself isn't good for growing things. Urban gardeners using their own back yards also can order free compost.

Last year, some 800 community and back-yard gardens in and near Newark produced over \$735,000 of fruits and vegetables, says I.C. Patel, a county extension agent involved in the program. Mr. Sudol adds that it is building community spirit in many parts of Newark, with whole blocks competing to grow the lushest communal gardens.

Recycling Rules Could Spin Off Big Savings

MORE recycling of packages could save Massachusetts a tidy \$300 million a year.

That's the bottom line of a recent study by Massachusetts Institute of Technology researchers, who examined the economic effects of proposed laws on the recyclability of packages. Environmentalists are pushing such mandates in about a dozen states to foster markets for recycled materials. The Massachusetts version would require packages by 1996 either to be reusable five times, to contain 50% recycled materials or to be made of materials recycled at a 35% rate statewide.

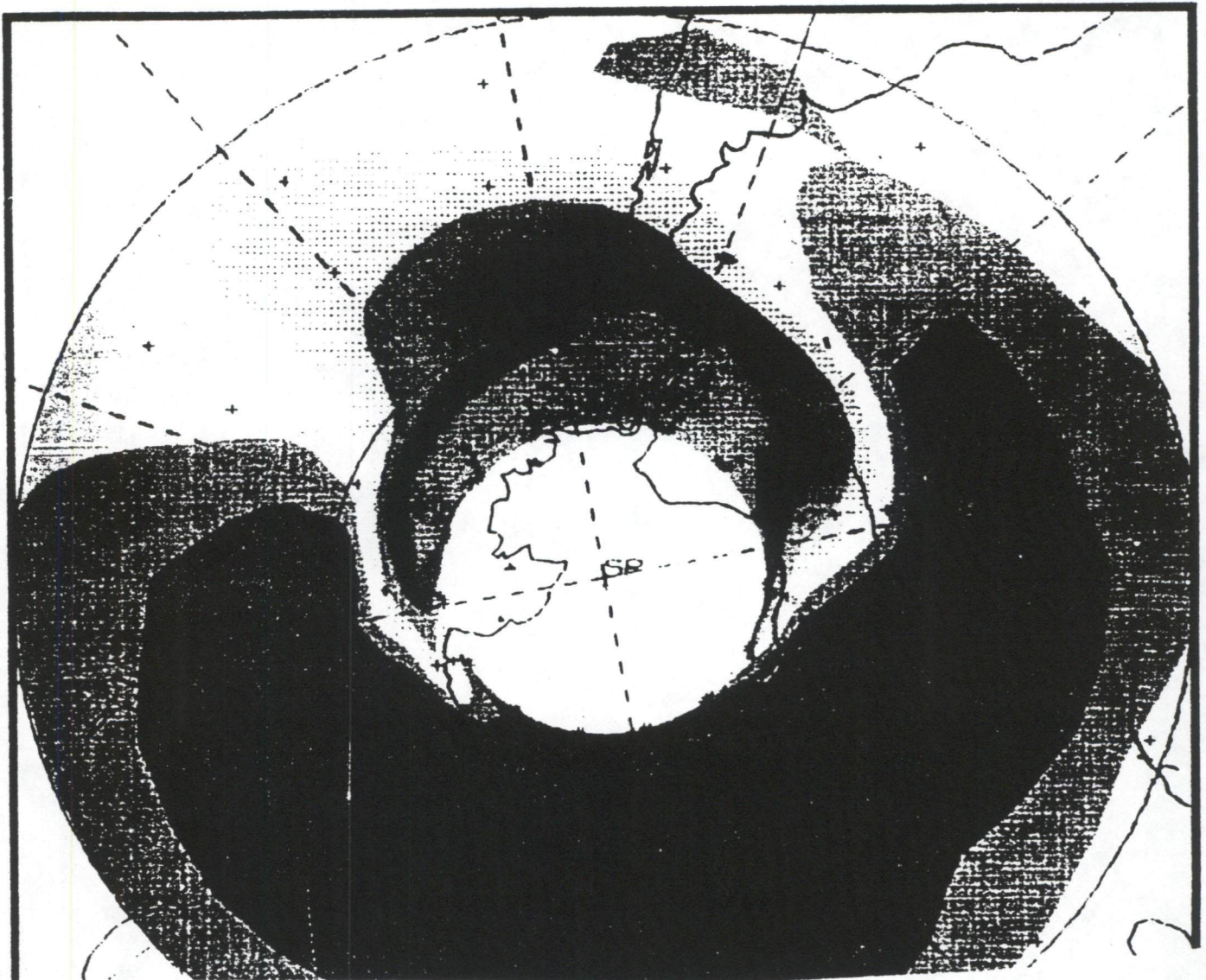
The MIT researchers calculated that the main benefit of recycling a ton of packaging under the proposed mandates would be to avoid \$265 in incineration and landfill costs. About half of that is the estimated cost of environmental harm not included in current disposal charges, such as health effects of air pollution from burning trash, says economist Robert Stone, co-author of the study. Various other benefits and costs were combined to arrive at an estimated net savings of \$175 million to \$300 million for Massachusetts taxpayers and businesses.

NASA Tech Briefs

Official Publication of
National Aeronautics and
Space Administration
Volume 15 Number 4

Transferring Technology
to Industry and
Government
April 1991

EARTH'S VANISHING OZONE



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"The commonwealth's proposal is a great disappointment and is bound to fail," argued George B. Henderson 2d, assistant US attorney. "There is no assurance that it won't select another site fraught with problems and the same difficulty with the host community."

Theodore J. Frier, spokesman for the Executive Office of Environmental Affairs, said later that the governor "anticipates that this moratorium has to be resolved one way or another in a couple of weeks."

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The internationally-acclaimed research of NASA scientist **Dr. M. Patrick McCormick** has sharpened the world's focus on ozone loss as a major threat to the planet's health. Using satellite-borne sensors, McCormick discovered a key atmospheric agent contributing to the "hole" in the polar ozone curtain that protects the Earth from the sun's dangerous ultraviolet rays. His finding represents a giant step forward in understanding global ozone depletion.

McCormick, head of the Langley Center's Aerosol Research Branch, discovered the existence of polar stratospheric clouds (PSCs), high-altitude clouds made of ice crystals and nitric acid which form over Antarctica in the winter. This previously unknown phenomenon is now recognized as a pivotal catalyst in the chemical reactions that are destroying the ozone layer. "Without PSCs, I am convinced you would not have an ozone hole," McCormick said.

The role of PSCs in ozone depletion is linked to the presence in the atmosphere of chlorofluorocarbons, man-made chemicals widely used as refrigerants and cleaning solvents. When these chemicals break down, they release chlorine gas which attacks the ozone. And chlorine has a voracious appetite — one atom can destroy hundreds of thousands of ozone molecules.

Normally, the chlorine is "locked" in stable compounds. But when PSCs are present, the compounds react on the cloud surfaces, freeing chlorine to attack ozone until the Antarctic temperatures warm in the summer and the clouds dissipate. Moreover, as PSCs condense, they remove nitrogen gas that protects the ozone layer, adding to its vulnerability.

The satellite instruments McCormick developed use a solar occultation technique, which involves measuring sunlight as it passes through the Earth's atmosphere. By analyzing the wavelengths of the light, McCormick can determine what types of gases and particles are present in the atmosphere. This study of the stratosphere from satellites began with the Stratospheric Aerosol Measurement (SAM) experiment flown on the 1975 Apollo-Soyuz

mission. The effort continued with devices aboard the Nimbus 7 spacecraft in 1978, the Application Explorer Mis-

sion spacecraft from 1979 to 1981, and the second Stratospheric Aerosol and Gas Experiment (SAGE II) aboard the Earth Radiation Budget satellite, still operating today after its launch from the shuttle in 1984.

The Langley scientist first identified PSCs when his SAM and SAGE experiments revealed there were extensive clouds in the coldest parts of the polar stratosphere. This finding was later confirmed by laser detection from aircraft missions led by McCormick, who is now working on a 1993 shuttle experiment that will employ space-based lasers to further probe the atmosphere.

In January, McCormick received the American Meteorological Society's prestigious Jule G. Charney Award, given in recognition of outstanding achievement in the atmospheric or hydrologic sciences. He previously earned the NASA Exceptional Scientific Achievement Medal, and his work on defining the role of trace gases and aerosols at flight altitudes was recognized by a U.S. senate resolution.

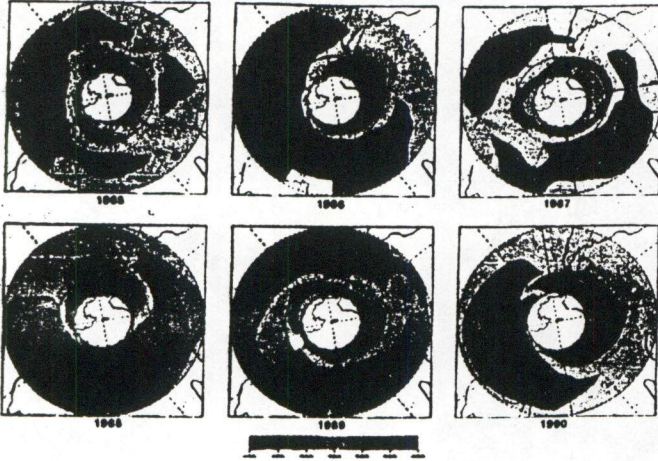
A NASA employee since 1967, McCormick currently serves on the NASA/World Meteorological Organization's Ozone Assessment Panel. He said studies show that the ozone hole in 1990 was severe for the third time in four years. The hole will continue to be a problem, he predicted, and he has called for the rapid development of safe alternatives to chlorofluorocarbons. □

NASA's
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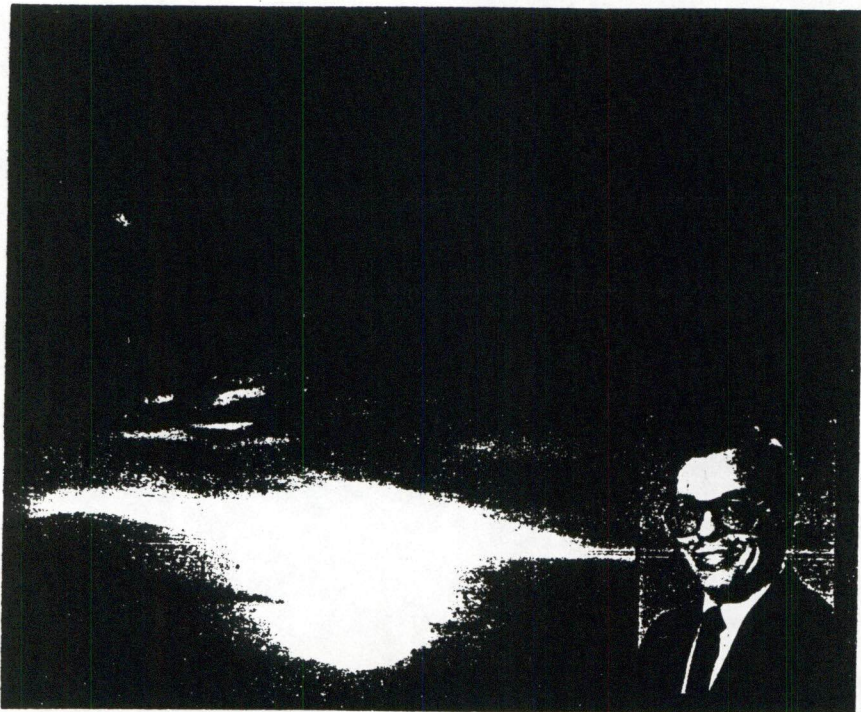
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SAGE II OZONE HOLE MEASUREMENTS



Satellite data revealed that the 1990 Antarctic ozone hole matched the record 1987 ozone depletion in depth, duration, and area.



Photos courtesy Langley Research Center

Dr. McCormick (inset) discovered unique high-altitude clouds that play a pivotal role in ozone depletion.

end

Jessica I. Mathews

'A Desperate Game of Catch-Up'

From ridiculed scare story in the early '70s to precedent-setting international regulation in the late '80s, the ozone layer seemed—until a few weeks ago—a clear-cut success story, proving that global environmental threats could be surmounted despite uncertain science, powerful commercial interests and deep international divisions.

But the recent finding that ozone loss over the Northern Hemisphere is twice as great as predicted means that protection of the Earth's life-giving stratospheric ozone must now be considered unfinished business, the outcome very much in doubt.

While the story has seemed to shift from crisis to problem and back again, underneath there has been a consistent trend. And though the final act is not yet written, there is a clear moral to be drawn.

Reduced to its essentials, here is what has happened so far:

The likelihood that chlorofluorocarbons (CFCs) destroy stratospheric ozone was suggested in 1973. By 1978 the United States had banned the use of CFCs in aerosols, though no other CFC-producing countries were prepared to follow suit. Potential substitutes for CFCs' many other

uses did not seem available at any price.

International discussions moved slowly. By 1985 a treaty framework was agreed to, but without actual controls on emissions. Then two stunning events rescued the negotiations from failure. British scientists discovered a completely unexpected ozone "hole" over Antarctica, and DuPont, the world's largest CFC producer, announced that it could develop substitutes within five years.

Less than two years later, the Montreal Protocol required a 50 percent cut in emissions. Within months the marketplace began to explode with CFC substitutes. Projected costs plummeted.

One year after that, CFCs were conclusively fingered as the cause of both Antarctic and global ozone loss. Exploration in the Arctic suggested that a hole might develop there. Global loss, greater than the models had predicted, was detected for the first time. By June 1990, the protocol was revised, now requiring a complete phaseout of CFC production in industrialized countries by 2000. Computer models predicted that if the treaty terms were met, ozone loss would

eventually climb to 3-4 percent per decade, then decline.

Now scientists have discovered that depletion in the latitudes over the United States has already reached 4-5 percent. According to the models, peak loss will therefore reach 10 percent per decade, and skin cancer deaths will rise dramatically. Since the models underestimate depletion, actual loss will likely be greater, though how much greater or what the eventual consequences will be no one knows. The treaty will have to be tightened yet again.

What this story tells us is that mankind is engaged in a desperate game of catch-up ball—against itself—without knowing how much time is left on the clock. By every measure, we have caused greater change to the planet in the last four decades than in the previous 10,000 years combined. Scientists are scrambling to unravel the secrets of enormously complex systems, while the systems themselves are changing due to rapidly growing human influence. It's a contest between our ability to understand the natural systems that sustain life on the planet and our capacity to change damaging activi-

ties, on the one hand, and the impacts of those activities, on the other.

Though the ozone treaty was achieved with blinding speed compared with most international negotiations, and was in many ways a tremendous achievement, we cannot draw too much comfort from the experience. Too much depended on the shock of the Antarctic hole. There will not be a relatively painless crisis each time we need quick international cooperation.

Even with the hole, the fate of the ozone layer now looks as though it could prove to be another of those situations where for a long time it is too soon to act because of too much uncertainty and then, almost overnight, it is suddenly too late. We need much better guides for making policy when science is uncertain and risks are irreversible.

Quicker ways of reaching international agreements are also essential. Weapons development moved faster than bilateral arms control talks for decades. We survived the resulting nuclear arms race, but multilateral talks are much tougher. We may not survive—or have greater cause for regret—if human-caused damage to the environment continues to outpace our ability to control it.

Countries' willingness to act in advance of an international consensus will make a great deal of difference. Without the U.S. aerosol ban in 1978, atmospheric concentrations of CFCs today would be more than double what they are. What once seemed to some an unwise unilateral response to a multilateral problem now looks like crucial leadership.

The choice often appears to be a tradeoff between short-term costs—the competitive disadvantage of acting alone—and the long-term costs of environmental damage. Usually, the former look large and solid while the latter are uncertain. The ozone experience demonstrates once again that the short-term costs are also unknown. Industry's natural habit is to resist change and to inflate its expected costs: CFCs seemed irreplaceable only because there had never been a need to develop substitutes. As the ozone treaty goes back to the drawing board, institutional changes that will enable governments and industry to respond more quickly to the next such problem ought to become a top priority.

The writer, vice president of World Resources Institute, writes this column independently for The Post.

THE NEW YORK TIMES, MONDAY, MAY 6, 1991

Site for Toxic-Waste Cave Stirs Texas Political Fight

Little-Known Company Bets on a Huge Payoff

By STEVE LOHR

Special to The New York Times

DAYTON, Tex. — Here on the verdant coastal lowlands of Texas, a little-known company is pursuing one of the most risky, politically sensitive and potentially lucrative goals in American business today — a permit from Federal and state authorities to build a huge hazardous-waste disposal site.

Beneath the rice fields, 30 miles from Houston, Hunter Environmental Services Inc. wants to bury toxic waste in mammoth caverns carved into a salt dome more than 60 million

years old; the subterranean salt formation is so large that were it above ground it would dwarf Mount Everest; the length of each proposed waste-storage cavern would be taller than the Empire State Building. Regulatory clearance for a large project like Hunter's is the holy grail of the \$25-billion-a-year waste services industry. Only a couple of such permits have been granted in the last few years, none for salt-dome sites.

THE WASHINGTON POST

MONDAY, MAY 6, 1991

**Two Assistants
Join the Exodus
From Energy Dept.**

Full Speed Ahead on Mexico?

President Bush wants negotiations with Mexico over a proposed free-trade agreement to be put on the fast track. That would let the Administration cut a deal Congress could not negotiate, only pass or kill. But last week, a coalition of 60 organizations — labor unions, environmentalists and border-state farmers — told Congress to go slowly. They are worried the fast track will end in a sour deal, one that allows companies to take advantage of Mexico's lax pollution laws. Will President Bush be able to stay on the fast track? Most analysts say yes.

THE NEW YORK TIMES, SUNDAY, MAY 5, 1991

Good Sense on Mexican Trade

President Bush has responded constructively to critics of his proposed free-trade pact with Mexico by pledging to protect U.S. workers and the environment. In a 70-page statement, the White House promises to retrain dislocated workers, preserve existing U.S. environmental standards and incorporate environmental reviews into the negotiating process.

These assurances are not airtight and establish some troubling precedents. But the response answers legitimate fears and paves the way for Congress to approve fast-track legislation, committing it to vote on trade pacts promptly and without amendments. As a matter of economics, free trade with Mexico is not all that important. But as a matter of politics, it could provide pivotal endorsement of market reforms under way in Mexico, Chile and the rest of Latin America.

The Bush pledges will, however, create some knotty problems. They promise generous assistance to workers laid off by the pact. But why do these workers deserve help any more than, say, construction workers who are laid off because of recession? And why do environmentalists warrant a place at the negotiating table rather than, say, human-rights activists? If trade pacts become hostage to single-issue pleaders, efforts to knock down

trade barriers and spur growth will be sabotaged.

The Administration has made intelligent compromises. It emphasizes training assistance, rather than cash grants, for dislocated workers in order not to blunt incentives to find new jobs. The plan would reimpose tariffs if Mexican exports in a particular industry surged; but the backtracking would only be temporary. And all potentially disruptive provisions would be phased in slowly.

On the environment, Mr. Bush is equally sensible. He guarantees that no U.S. standard will be negotiated away. But he refuses to guarantee, as some demand, that the Mexican environment go unscathed. Environmentalists are upset that the Bush plan doesn't promise a complete environmental analysis of the trade pact before negotiations are complete; and U.S. standards appear vulnerable to the process of settling disputes. Here, the Bush plan might be usefully amended.

In the present case, free trade makes economic and political sense for both Mexico and the United States. But some workers will lose their jobs. Mr. Bush's obligation was to construct a safety net for them, while securing the greater economic gain for everyone else. The Bush plan isn't ideal. And environmentalists have proposed some useful changes. But it's a well-constructed foundation.

THE WASHINGTON POST

SUNDAY, MAY 5, 1991

Mexican Trade and Jobs

OPEN TRADE with Mexico, according to one credulous lobbyist against it, would mean tainted meat and fruit loaded with pesticides pouring across the border. That's flatly wrong, but it also illustrates the nature of the debate. The Mexican trade agreement would do absolutely nothing to affect any of the present health and safety standards enforced at the border. President Bush repeated that assurance, along with many others, in his response last week to a series of inquiries from Congress. But the agreement and the struggle over it seem to have become a lightning rod for a lot of fears and suspicions in the air.

The core of the opposition is the labor unions and their anger at American companies that have gone south to Mexico, set up production and shipped their output back into the United States. Labor is correct in saying that a lot of companies have done that. But that's exactly the point—it has happened already, on a large scale under present law. Except for a small number of industries like textiles that are protected by import quotas, a free trade agreement would make very little difference. For most northbound trade, there is no hindrance but a negligible tariff.

The purpose of this free trade agreement is not to make large changes, but to lock in the present conditions of trade. From the American viewpoint, two remarkable presidents of Mexico have reversed longstanding national tradition to open up its economy and launch it into world competition. The

United States wants to ensure that those changes are irreversible, because it's a market of 85 million people. As for the Mexicans, they know that their reforms depend on access to the American market, and they think they see signs of rising protectionism in Congress. A free trade agreement would make some marginal improvements. But basically it would preserve a status quo that each side uneasily thinks the other might abandon for domestic political reasons.

Congress has raised a series of questions about labor standards and environmental protection. The administration replies that Mexican laws are not very different from this country's but enforcement has often been slack. To get the agreement, Mexico is now making a dramatic effort to tighten up. The result is that unscrupulous employers will have less latitude under the agreement to take advantage of, say, child labor in Mexico than they do today.

Since the Mexicans began to open up their markets in 1986, American exports to them have more than doubled, and the American trade deficit with Mexico has dropped by two-thirds. It's true that, as the labor unions put it, some American jobs have run away to Mexico. It's also true that they have been replaced by many more jobs here in the export industries, for a net gain of thousands of jobs. That's the basic case for open trade. It creates jobs and makes countries—including this one—rich.

TALKING POINTS ON GLOBAL WARMING

Current Status:

- Formal negotiations on a Framework Convention are now taking place under the auspices of the United Nations General Assembly. President Bush hosted the first negotiating session in Washington in February 1991.
- The next negotiating session will be held June 19 - 20, 1991. The Convention is expected to be ready for signature at the June 1992 U.N. Conference on Environment and Development in Brazil.
- Curtis "Buff" Bohlen, Assistant Secretary of State for Oceans and International Environmental and Scientific Affairs, and Bob Reinstein, Deputy Assistant Secretary of State for Environment, Health and Natural Resources have led the U.S. Delegation at these negotiation sessions.
- The technical basis for these negotiations is the interim report of the Intergovernmental Panel on Climate Change (IPCC) adopted at the Second World Climate Conference in November 1990. This report indicates that global temperatures will rise 2 to 5 degrees C over the next century if no actions are taken to reduce emissions.
- Many countries participating in the negotiations advocate the adoption of targets and timetables for carbon dioxide emission reductions.

U.S. Position:

- The U.S. has championed a comprehensive approach to global climate change that incorporates all greenhouse gas emissions, including their emission sources and potential sinks. Each pollutant would be assigned a global warming potential (GWP) index in order to develop a common currency to analyze the impact of different actions.
- The advantages of this approach was emphasized in the Administration's "Action Agenda" released at the first negotiating session of the Framework Convention. This document summarized the beneficial impacts of several recent U.S. commitments. These include:
 - Implementation of the Clean Air Act;

- The phase-out of CFCs;
 - Implementation of several DOE efficiency and renewable energy initiatives;
 - An EPA rule to control VOC and methane emissions from landfills.
- The "Action Agenda" predicts that these actions will cause U.S. greenhouse gas emissions in 2000 to be at or below 1987 emission levels.
 - If implemented, the National Energy Strategy would further reduce emissions because of additional energy efficiency measures, and its increased emphasis on lower emitting fuels, such as natural gas, nuclear power, renewable energy, and the use of alternative fuels in the transportation sector.
 - DOE estimates that the NES would allow us to hold emission levels beyond the year 2000 to a range close to current levels.
 - If the NES is not implemented, however, greenhouse gas emissions, as measured by the GWP, would increase significantly beyond 2000 due to increased coal use for electricity generation, and the growth of auto emissions.

U.K. Position:

- In preparing for the June negotiation session, the U.K. has shared draft negotiation text. In that text, the U.K. endorses an "Incremental Comprehensive Approach."
- Because of scientific uncertainties over the GWP of the different greenhouse gases, and the incomplete understanding of the sources/sinks of all greenhouse gases, the U.K. proposes a gradual phase-in of the comprehensive approach.
- Under the U.K. approach, nations would be invited to make commitments on emissions covered by those greenhouse gases for which a GWP index is accepted (called "Annex A"). Scientific research would go forward on other greenhouse gasses, which would be added when knowledge and agreement permits ("Annex B").

Plumes from Deep Shape Earth and Climate

By WALTER SULLIVAN

C1

GEOPHYSICISTS are constructing a new and striking history of the earth's geological past, and in particular of the great engine that pushes apart the sea floor and reshuffles the continents.

The new picture has emerged from the study of "superplumes" of hot material widely believed to have risen 1,800 miles to the ocean floor from near the earth's molten core. A research ship equipped to drill deep into the ocean floor has recently brought back new evidence of the work of one of these superplumes — great aprons of lava that were spewed across the floor of the Pacific Ocean.

The activity of the superplumes may have had profound consequences for the earth's climate and life forms. During the most recent outburst of a superplume, some 120 million years ago, carbon dioxide gas was probably released in the volcanoes and would have built up in the atmosphere, producing a super greenhouse effect and setting off a vigorous worldwide bloom of plant plankton in the oceans. When the plankton blooms died and settled to the ocean floor, some experts believe, they provided the starting material for much of the world's oil.

That superplume also appears to have spewed out lava beds of such size — one is twice the area of Alaska, and up to 25 miles deep — that the oceans were raised and flooded much of the land. The superplumes, according to current thinking, are not the only force that makes the sea floor spread and the continents drift apart. But they could well give the moving floor a powerful shove, accelerating its usual glacial movement. Indeed the rate of continental drift appears to have tripled during the mid-Cretaceous period when the superplume was active.

This period has long been recognized as a period in which waters rich in sea life flooded the continents, shedding to the bottom organic debris that formed such features as the white cliffs of Dover. The chalk of such cliffs, "creta" in Latin, gives the Cretaceous period its name.

The underwater eruptions of the most recent superplume, according to newly determined dates, reached a peak about 120 million years ago. By about 60 million years ago, the superplume had subsided and conditions have since remained normal, although Dr. Roger L. Larson of the University of Rhode Island said that the next such superplume could be "just around the corner," geologically speaking.

Evidence for such stirring events was presented at two meetings last month, one of the American Geophysical Union in Baltimore and another in Pasadena, Calif., marking the 100th anniversary of the California Institute of Technology.

At the Baltimore meeting, Dr. Larson proposed that conditions initiated by the last "superplume" were responsible for creating half the world's oil, chiefly in the Persian Gulf. He suggested that an

earlier superplume, which erupted 250 million years ago in the Carboniferous period, created the hot, swampy conditions that produced most of the world's coal.

At the same time as the most recent "global burp," the superplume of 120 million years ago, there occurred a well-documented event in the history of the earth's magnetic field, a strange suspension of its intermittent reversals. The earth's field sometimes reverses itself, with the north pole becoming the south and vice versa. The reversals occur at irregular intervals of thousands or millions of years for reasons that are still not understood.

But for a perplexing 41 million years in the mid-Cretaceous period the field remained normal. A similar long period, but with reversed polarity, apparently occurred during the Carboniferous period.

The reason for such magnetic quiescence is unknown, but it must lie in the core, Dr. Larson said. One possibility, he suggested, was that a sudden release of heat from the core, forming the inferred superplume of the mid-Cretaceous period, could have induced faster circulation in the core and disrupted the process responsible for reversals.

The Earth as an Apple

The earth is often likened to an apple. The molten core and its solid kernel are enveloped in a rocky mantle comparable to an apple's pulp. The earth's crust is hardly much thicker, relatively speaking, than an apple's skin.

From study of the shock waves transmitted deep through the earth from earthquakes, it appears that between the iron core and the rocky mantle is a transition zone about 100 miles thick. There, according to tests reported in March by scientists from the University of California at Berkeley, molten iron under extremely high pressure interacts chemically with silicate rocks like those in the mantle.

The transition zone, some believe, may also contain slabs of sea floor material that have sunk all the way from the surface. One goal is to see if any such material is brought up by

the plumes, demonstrating that there is complete circulation of the mantle.

The original plume concept, less dramatic than that of "superplumes," was proposed in 1971 by Dr. W. Jason Morgan of Princeton University. He envisioned the earth as containing some 20 columns of hot, molten rock rising at inches or feet per year beneath key volcanic islands like Iceland and Hawaii. Each plume, like a thunderhead, would rise as a narrow column. Then, as it neared the surface and became less compressed, it would spread like a mushroom.

The plumes would carry upward

The plateaus created by superplumes may have made the sea level rise.

the heat generated by radioactivity in the mantle and, possibly, in the core. There is now little doubt among earth scientists about the existence of such plumes. The debate concerns the depth of their origin. What now appears a minority believes the plumes originate in the upper region of the mantle, rather than its base.

Analyses of earthquake shock waves show that between those two parts of the mantle, at a depth of 400 miles, there is a fundamental change in composition. The change could represent the transition to a more compact form of rock in response to the greater pressure, or it could mark a change in chemical composition.

Speedy Continental Drift

At the Baltimore meeting it was evident that most in attendance believed the two parts of the mantle are chemically similar, that sea floor slabs that disappear into the deep ocean trenches sink all the way to the bottom of the mantle and that at least some plumes originate there. This was acknowledged by the leading skeptic, Dr. Don. L. Anderson of the Caltech Seismological Laboratory. He was outgoing president of the sponsoring organization, the American

Geophysical Union, and this year's winner of its highest honor, the Bowie Medal.

Dr. Anderson conceded that great changes occurred during the mid-Cretaceous period. The speed of con-

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L.A. Floats New Plan To Curb Basin's Smog

By Scott Armstrong

Staff writer of The Christian Science Monitor

LOS ANGELES

P.7

IN what would be the most ambitious free-market experiment of its kind, authorities here are considering setting up a "smog exchange" to try to clean up the nation's dirtiest skies.

Businesses would be allowed to spew a certain level of pollutants and could buy or sell smog shares depending on whether they were ahead or behind in meeting their limits. The right to pollute would become a commodity like soybean futures.

The move would mark a dramatic departure from conventional efforts to control smog by regulating individual pollutants.

It would provide a far-reaching test of the ability of market incentives to curb pollution - a prospect that excites big business, worries some environmentalists, and has the rest of the country watching to see what the nation's premier laboratory for smog-busting will do.

"This goes to the heart of clean-air policy in this country," says Larry Berg, a political scientist and member of the board of the South Coast Air Quality Management District (AQMD), the local authority studying the concept.

Emissions trading is an idea that has been around for years but is only beginning to emerge. The federal Clean Air Act passed last year includes a program allowing pollution trading among utilities that produce sulfur dioxide, a source of acid rain.

Several cities operate pollution "offset" programs. Under these, a firm wanting to build a new plant is required to reduce smog in an area to make up for pollution the expansion would create. It can do this by buying smog rights from another company that has closed or cut emissions.

The market being considered by the AQMD would go way beyond this. It would institute smog trading among as many as 24,000 factories, refineries, bakeries, and other facilities that produce nitrogen ox-

ides and hydrocarbons - two key components of smog - in the four-county Los Angeles basin.

It would be the world's first mass market for pollution trading.

A special committee appointed by the AQMD has been studying the idea for months. It is expected to make a recommendation to the AQMD board around the end of the year.

If adopted - and AQMD officials say it has a good chance - the agency would scrap nearly all the regulations it has been devising for these polluters for the next 20 years to help meet federal air-quality standards.

Until the trading concept is approved, however - something that would require a nod from both the state and US Environmental Protection Agency - AQMD will continue to work on its conventional rules. EPA officials, who are interested in market-based approaches to reducing smog, have been cautiously optimistic about the new approach so far.

UNDER the trading scheme, the agency would establish a benchmark level of pollution that each company could emit, represented by a certain number of shares. Each year the firms would have to reduce their nitrogen-oxide emissions by 5 percent and hydrocarbons by about 7 percent.

To do this, they could either install new technology, close a plant, or purchase shares from another company that had reduced emissions beyond its requirement.

Big business considers the current regulatory approach too costly: Estimates of complying with the AQMD's present 20-year plan run from \$4.9 billion to \$10 billion a year.

Instead of mandating a technology or process, such as the current rules do, emissions trading would allow companies to choose how to meet limits. There would be a financial incentive for them to clean up stacks, since they could accumulate valuable shares by surpassing prescribed limits.

"It would make it profitable for them to reduce emissions," says Robert Wyman, an attorney representing a group of oil, aerospace, and other companies that favor the idea.

Yet there is concern about what emissions trading would mean for small businesses. They might be tempted to sell shares and close down, or they may not have the financial resources to compete with big companies in buying pollution rights. To avoid this, AQMD is looking at establishing a "smog bank" that would offer pollutions rights to small firms at reduced rates.

Environmentalists are divided about the idea. While some believe in the concept of market incentives to control pollution, they want to see how AQMD fashions the program before going along. One enticing aspect: Environmentalists could buy up smog shares and keep them out of circulation to help lessen pollution.

"This is either the revolutionary system that is going to clean up the air in Los Angeles, or it is the savings and loan fiasco of environmental regulation," says Tim Little of the Coalition for Clean Air.

Critics wonder whether emissions trading can be enforced. If a refinery could not meet its limit and bought pollution rights from three auto-body shops, regulators would have to verify there had been actual smog reductions, not just shuffled paper.

There are other problems, too. Ozone-forming gases released by a bakery may not be as damaging as ones from a plating plant. Thus, says Dr. William Carter, a chemist and member of an AQMD advisory board, trades can't be based solely on the amount of pollutants given off.

Management District officials believe they can devise a workable market but acknowledge enforcement is the Achilles' heel. Jack Broadbent, AQMD program manager for market-incentives development, calls it the "overriding consideration," though the agency will also evaluate the plan based on cost, impact on jobs, and other factors.

While emissions trading might reduce overall smog, a factory that buys rights to pollute could endanger the health of residents in a local area. Mr. Broadbent says "threshold" levels may have to be established to avoid local pollution "hot spots."

All of this underscores the complexity of shaping a market in dirty air - at least one politically acceptable.

As a dubious Larry Berg puts it: "We better get to the bottom of all this before we move forward."

tinental drift increased threefold, he said in an interview, and new analyses indicate a migration of the planet's spin axis.

The cause, he believes, was the breakup of the supercontinent, Pangea, to form the continents of today, initiating large-scale "subduction" in which the sea floor descends into the earth, as occurs now around much of the Pacific. The formation of plumes could have been triggered from above by the reorganization of the earth's rigid plates as they drifted apart, he said. He believes the plumes formed at the base of the upper mantle, 400 miles down, rather than far deeper.

After the concept of continental drift, or "plate tectonics," was accepted in the 1970's, geophysicists suggested that the midocean ridges that formed as continents pulled apart could have displaced enough water to cause the rise in sea level known to have occurred during the Cretaceous period. Another explanation for the sea rise has now become available: the vast extent of the underwater plateaus formed at this period.

New dates for these outpourings of lava and new estimates of their volume were presented at the Baltimore meeting. These were based partly on samples extracted from the plateaus by the Joides Resolution, the oceanographic vessel operated by the Ocean Drilling Program, an international effort based in Texas. Beneath midocean water depths the ship is able to drill through thousands of feet of sediment and into the underlying rock.

The largest submarine plateau on earth now appears to be the Ontong-Java Plateau, straddling the Equator east of New Guinea and north of the Solomon Islands. Last year the Joides Resolution drilled five holes into that rise. Analysis and dating of the cores from these holes, and of those from three already drilled by the ship's predecessor, the Glomar Challenger, have made it possible to document the history and development of the plateau.

The 'Rolling Thunder' Process

The Ontong-Java plateau, more than twice the area of Alaska, has been shown by seismic sounding to be more than 25 miles thick at its center. It was formed by extraordinary outpourings of lava between 120 million and 125 million years ago. Since then, as it was slowly carried north by motion of the sea floor, it has accumulated a covering of ocean sediment, mostly chalk and ooze, more than 3,000 feet thick.

A plateau formed more recently in North America, some 14 million to 16 million years ago, and blanketed Washington and Oregon with 77,000 cubic miles of basalt. Far more extensive were the Deccan Traps deposited on western India 65 million years ago.

At the Baltimore meeting Dr. Malcolm S. Pringle of the United States Geological Survey estimated that the volume of the Ontong-Java Plateau is 50 times greater than that of the Deccan Traps. In a process that he called "rolling thunder," he said that eruption of the four large plateaus of the Southern Hemisphere proceeded systematically from east to west. The eruptions began 135 million years ago with the Parana-Etendeka Platform in the South Pacific and ended 115 million years ago with formation of the Kerguelen Plateau in the southern Indian Ocean.

Dr. Larson has estimated the amount of lava spread onto the earth's surface by these mid-Cretaceous eruptions, assuming that half the South Pacific plateaus had already descended into the earth as the sea floor was drawn down into deep ocean trenches. He calculates that oceanic eruptions, including those along midocean ridges, increased 50 to 75 percent during the mid-Cretaceous period. That of the Ontong-Java lava, he believes, was almost 40 million cubic miles.

A major contribution of Dr. Anderson's laboratory has been studying earthquake tremors whose paths traversed deep parts of the earth. Because hot rock transmits such waves more slowly than cold rock it has been possible to estimate temperatures throughout the interior.

Two members of his group at Caltech, Dr. Toshiro Tanimoto and Dr. Yu-Shen Zhang, reported a critical finding from these studies. It has long been known that lava is rising into the midocean ridges as the oceans spread apart. When such spreading was first proposed in the 1960's it was argued that this intrusion of lava is pushing the sea floor plates apart and is the cause of continental drift.

Later it was proposed that the oceans are being pulled apart as the sea floor, having migrated far from the region of its volcanic birth and having accumulated a heavy burden of sediment, sinks by its own weight into the depths of the earth's mantle. An analogy would be a bath towel thrown into a filled tub. When one end becomes soaked and heavy it drags the rest down. Dr. Tanimoto and Dr. Zhang, on the basis of seismic data, found that hot material was rising into the ridges from depths less than 60 miles.

Yet they were able to trace the hot plumes under Hawaii, the Azores and Iceland to depths greater than 100 miles. Below that, they explained, the plumes became too narrow for detection by their method. Thus it has not so far been possible to settle the plume argument by determining their depth, but the findings favor the "pull" rather than "push" theory of plate motion.

Plume advocates believe such rising material plays a role in continental drift, creating a flow beneath the spreading ocean floor that gives its rigid plates an extra push. They also believe that a plume may push up a large region of the earth's surface. G. F. Davies of the Australian National University proposed that a region 5,000 feet higher than the rest of the sea floor, extending 6,000 miles from French Polynesia almost to Japan, is a remnant of the mid-Cretaceous superplume.

He also pointed out that rock from plumes such as the one that formed Hawaii displays far more variability than that along midocean ridges, presumably because plumes scavenge material from the base of the mantle. Sea-floor rocks have been subject to elaborate analyses in search of clues to their origin, including traces of sea floor that descended into the interior long ago.

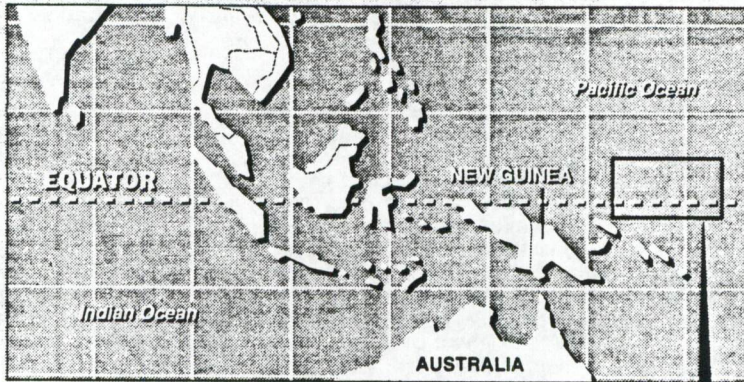
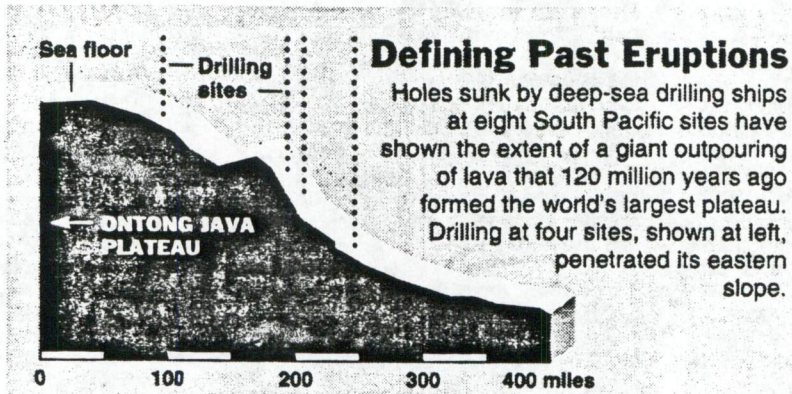
A number of papers presented in Baltimore sought to estimate how much volcanic carbon might have reached the mid-Cretaceous atmosphere, combining with oxygen to produce a "super greenhouse effect." A report by Dr. Ken Caldeira and Dr. Michael R. Rampino of New York University estimated that carbon dioxide in the air could have been 20 times the pre-industrial value, raising global temperatures about 18 degrees Fahrenheit.

Dr. M. A. Arthur of Pennsylvania State University put the carbon dioxide level at 8 to 12 times normal. Much of this was said to have come from coastal volcanoes enriched with carbon derived from sediment in sea floor descending beneath them.

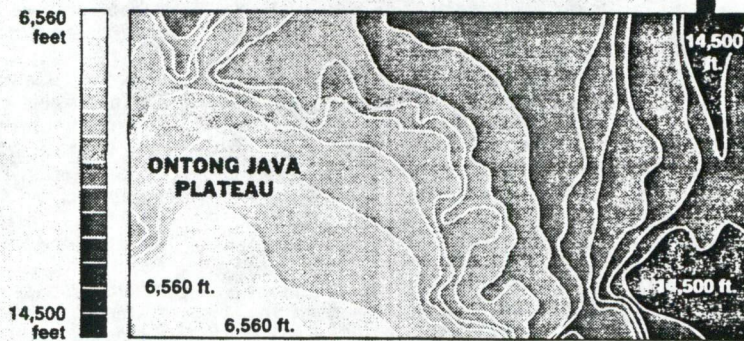
In the May 30 issue of *Nature*, French scientists reported that Mount Etna is a rich source of carbon dioxide, not only from its crater but also via diffusion through its flanks. An accompanying commentary proposed that, before the industrial revolution, the world's volcanoes contributed 35 to 65 percent of what was needed to balance the loss of carbon in sedimentation.

One hope for determining whether the upper and lower mantle differ chemically is analysis of specimens blasted from deep in the earth by the eruptions producing diamonds. Last month American and French scientists reported analyses of 324 fragments from such a formation at Jagersfontein, South Africa.

The samples had been altered by the extreme pressure assumed to occur at depths as great as 300 miles. They contained minerals supposedly derived from sinking sea-floor slabs, but were not sufficient to determine whether those slabs had collected on the bottom of the upper mantle or were on their way to the bottom.



Part of the plateau, mapped below, rises sharply from a depth of about 14,000 feet to within 6,600 feet of the surface.



Source: Ocean Drilling Program

Megan Jaegerman/The New York Times

Jessica Mathews

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Gorilla in the Greenhouse

Up and down the East Coast, gardeners are baffled by flowers blooming two months and more ahead of schedule. In my own garden, October chrysanthemums were in bloom on the Fourth of July. Greenhouse warming leaps, unbidden, to mind. One cannot help wondering whether the plants are sensing a climate pattern ahead of human temperature measurements.

Measurements also show a warming trend, but not quite so dramatically. Globally, 1990 was the warmest year since measuring began in the 1850s. The 1980s were the warmest decade in that period—about half a degree warmer than the preceding 40 years. The six warmest years in the last 140 were '90, '88, '87, '83, '89 and '81. The snow is melting earlier in Alaska, and Arctic sea ice is retreating.

These are some of the reasons Europe is impatient to begin controlling greenhouse gas emissions. There are still many puzzles and uncertainties, but the science of global warming is far more robust than most Americans, including the president, have been led to believe.

Bush has allowed John Sununu to overpower conflicting views within the administration. The chief of staff's obsession with the subject is by now well-known. It is so strong that several top officials have decided that there is no point in contesting the issue. Secretary of State James A. Baker III took the extraordinary step of opting out by legally recusing himself on the grounds of a conflict of interest due to his personal oil and gas holdings. (He has never explained why such a conflict would not extend to Middle Eastern diplomacy.)

At the G-7 summit last week, the United States was alone in preferring environmental rhetoric to action. The strength of European annoyance was revealed by unusual on-the-record complaints about the U.S. posture. "The U.S. wants to avoid anything other than generalization. Everybody else wants to make a commitment," was how one European official, quoted in the Los Angeles Times, put it.

Heretofore, Britain has always acceded to U.S. pressure to block international greenhouse commitments, but it has served notice that it will no longer. After being rebuffed in a recent effort to find a compromise between the United States and the European positions, British Environment Secretary Michael Heseltine learned that Sununu had dismissed him as a freelancer who did not reflect his government's views.

Heseltine fired back a letter to the White House described by British government sources as "unusually tough and personal," enclosing a speech just delivered by Prime Minister John Major. Apparently unconcerned by the possibility of a direct conflict with the United States one week before the summit, Major made clear that the rest of the world views the United States as the 800-pound gorilla of global carbon dioxide emissions, responsible for a quarter of the world's total, as compared with the European Community's 13 percent. In several not-so-subtle references to the United States, Major emphasized Britain's intention to control its emissions "if others do their part."

Without Britain or Japan in its corner, the United States' principal allies in resisting greenhouse commitments in the broader global negotiations are Saudi Arabia and the Soviet Union. Saudi Arabia opposes any plan that might lower consumption of its only product. The Soviet Union cannot cope with additional requirements of any kind, though improved energy efficiency would greatly benefit its economy. The rest of the world finds it hard to see why the United States belongs in this company. The consensus view held by Europe, Japan, Canada and a growing number of developing countries is to ready a treaty, including emission-control goals, for signing at next June's U.N. Conference on Environment and Development, the so-called "Earth Summit."

This last of the major U.N. conferences of the century could pose a problem for Bush if the climate negotiations continue to make progress despite U.S. opposition. The Brazil meeting would provide an unparalleled photo opportunity on the brink of the presidential campaign if several agreements are ready for signing and most of the world's leaders attend. Or the president could be forced to stay home to avoid embracing a treaty he has resolutely opposed, offering his Democratic opponent a powerful argument that the "environment president" turned out not to be one.

There is not much time left to adjust the U.S. stance. It was just six years ago that scientists

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Los Alamos radiation probe OKd after brain cancers

^{P. 4}
LOS ALAMOS, N.M.—Federal and state officials said they will try to determine whether radiation released by the nuclear laboratory that dominates this community is linked to brain tumors in residents. The U.S. Department of Energy and the New Mexico Department of Health said Monday the study has two goals: to evaluate radiation released from the Los Alamos National Laboratory and to determine whether an excessive rate of brain cancer exists in the city of 18,000. A non-scientific survey by a local sculptor found more than 40 possible victims. A physician who examined medical records of 23 of them found nine with primary brain malignancies, meaning the cancer began in the brain.

THE WASHINGTON POST A24 SUNDAY, JULY 14, 1991

Britain Censures U.S. Global Warming View

Cabinet Secretary's Letter, Prime Minister's Speech Indicate Break With Previous Policy

By Glenn Frankel
Washington Post Foreign Service

LONDON, July 13—Britain has sent a strongly worded letter to the White House criticizing the American position on global warming and signaling that Britain will no longer side automatically with the United States on the issue at such international conferences as this week's Group of Seven summit here, according to informed British sources.

They said British environment secretary Michael Heseltine sent the letter to White House Chief of Staff John Sununu earlier this week. It accompanied a copy of a speech Prime Minister John Major gave Monday in which he called on the United States to join Britain in setting limits on carbon dioxide emissions, an issue the Bush administration so far has resisted taking action on.

Major, at a conference organized by the Sunday Times, noted that the United States accounts for 23 percent of the world's CO₂ emissions—by far the largest polluter—and said, "The world looks to them for decisive leadership on this issue, as on others." He also said that while more research was needed on the issue, "research cannot excuse inaction—the threat is too serious."

The speech marked a sharp break with the policy of his predecessor, Margaret Thatcher, whose government gave virtually automatic support to the United States when global warming and other environmental issues arose at conferences.

The speech and the Heseltine letter are the latest round in a British campaign to compel the Bush administration to reconsider its stand on global warming. Heseltine, who

became environment secretary after helping engineer Thatcher's downfall last November, traveled to Washington last month to try to convince the White House that it had become isolated from the rest



More research on emissions is needed, says Prime Minister John Major, but "research cannot excuse inaction—the threat is too serious."

of the world community on the issue and to offer Britain's help in arranging a compromise.

Heseltine saw a number of senior administration officials, including Sununu, Office of Management and Budget Director Richard G. Darman and Environmental Protection Agency Administrator William K. Reilly. Sources said his most contentious meeting was with Sununu, who has insisted that scientific evidence is not yet conclusive in documenting the so-called "greenhouse effect" and who has taken the lead in opposing setting a U.S. target for the reduction of carbon dioxide emissions.

Sources said Heseltine came away from his meetings with U.S. officials disappointed by their apparent unwillingness to recognize that they face a serious political problem on the global warming issue. His disappointment was compounded after he returned to London and heard that Sununu had attacked him at a White House meeting by saying the environment secretary did not know what he was talking about on the emissions issue and that Heseltine was a freelancer

who did not accurately reflect the Major government's position.

But Major's speech, which also called for the establishment of a British equivalent of the EPA, made clear the prime minister and the environment secretary are largely in agreement on the issue.

"In the past, Britain covered for the U.S. and served as the honest broker between the U.S. and Europe," said Daniel Becker, director of the global warming and energy program for the Sierra Club. "Major's speech signals the end of the road. It shows the extent to which the United States is now isolated on this issue."

At their Paris summit two years ago, the leaders of the Group of Seven major industrialized nations promised "decisive action" to curb global warming. Major, who is hosting this year's summit, has promised he will raise the issue again this week. He has also said he will ask the G-7 leaders to pledge to attend next year's environmental summit in Rio de Janeiro. The United States in the past has been reluctant to send high-level officials to such sessions because it has often taken an

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unpopular and isolated position on the issues under discussion, administration officials have said.

Britain has committed itself to stabilizing carbon dioxide emissions at their present level by the year 2005, while other European Community members say they will do so by 2000. The United States has set no target, and U.S. environmental groups contend that current administration policies would lead to a 15 percent increase in emissions by 2005.

Officials in Heseltine's ministry confirmed the sending of the letter, which was first reported in the Times of London. Although they would not divulge its contents, officials said the Times article, which characterized the letter as "unusually tough and personal," was substantially accurate.

One British source said the speech and the accompanying letter amounted to "not a rupture" between Britain and the United States, "but a toughening of the posture."

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FACT SHEET

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

- o Bush Administration policies, including measures enacted in the Clean Air Act and proposed in the National Energy Strategy, are projected to maintain U.S. greenhouse gas emissions through the year 2030 at current levels, even accounting for growth in economic activity. The NAS study calls for a 10 to 40 percent reduction in greenhouse gas emissions at a constant 1990 activity level. Using the NAS static assumptions ("no-growth") approach, which does not factor economic growth into the greenhouse emissions calculation, Administration policies will yield greenhouse emissions reductions comfortably within the range advocated by the NAS study.
- o Targets and timetables for the future reduction or limitation of greenhouse gases as an aggregate, or of carbon dioxide alone, are not advocated by the NAS study.
- o Elements of the comprehensive approach, endorsed by the Administration, are highlighted. The study considers climate change in terms of all greenhouse gases (using CO₂ equivalent), not CO₂ alone, and the contribution of CFCs, which are important greenhouse gases.
- o The Administration's policies address all greenhouse gases. Precursors of ozone and nitrogen oxides are controlled in the Clean Air Act. Methane will be reduced by proposed rules on landfill emissions. CO₂ will be reduced by various energy efficiency measures and by the powerful incentives from the Clean Air Act's caps on utility emissions plus the flexibility allowed in achieving those caps. CO₂ will also be reduced by tree planting. CFCs will be phased out by the Clean Air Act's provisions. A tax on production during the phase-out will accelerate these reductions.

- o Efforts to limit deforestation, and modest domestic and international reforestation efforts, are recommended in the NAS report. The Administration has proposed a multi-year reforestation proposal to plant one billion trees per year on 1.5 million acres, and to improve forest management practices. The United States also supports debt-for-nature swaps, and is active in pushing for a global forestry agreement.
- o A strong research program is endorsed by the NAS panel as an important element of our response to the possibility of greenhouse warming. The U.S. is currently investing almost \$1.2 billion in our global climate change research program, which includes studies of the scientific, social and economic questions surrounding climate change and possible policy responses.
- o Research and development priorities cited by the NAS study in areas such as solar energy and other alternative energy sources, and energy efficiency are receiving additional resources in the President's FY 1992 budget. The budget includes strong efforts in biomass resources, and expansion of solar and other alternative energy research efforts through cost-shared collaborative ventures.
- o The study recommends R&D into the possibilities for adaptation and the need to study geoengineering options. Because natural sources account for 96 percent of the annual CO₂ flux, it makes sense to investigate these options -- although it would be premature to pursue them at this time.
- o Continued development of nuclear power is strongly advocated by the NAS study. The President's National Energy Strategy supports the development of a new generation of safe nuclear reactors.

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

Global Warming: A New Warning

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

By RICHARD LACAYO

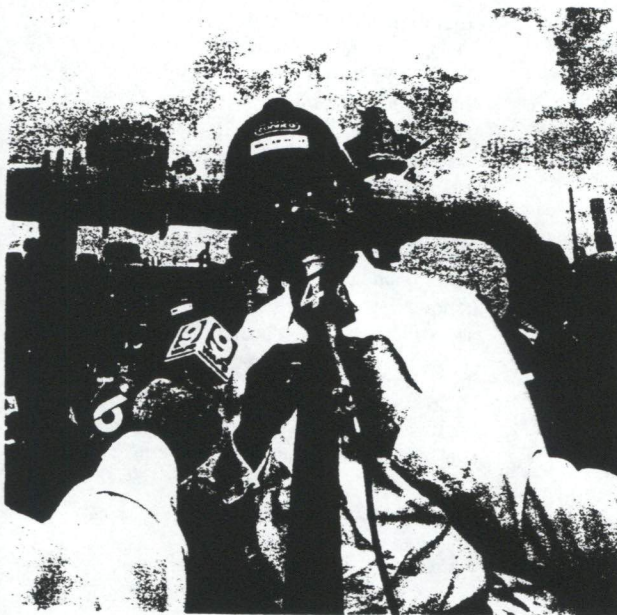
It may not be easy to determine if the greenhouse effect is causing a worldwide rise in global temperatures, but the heated atmosphere around the White House has been unmistakable whenever that topic—or any other environmental question—was raised. From the earliest days of the Bush Administration, there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

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

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

Then the panel laid out the action it wants, the first time a scientific body has issued recommendations on the subject. Basically, they add up to taking out what the panel called “insurance” against the worst-case scenario of global warming. Among other things, the commission urged the White House to toughen the inadequate energy plan that it unveiled

in February. To achieve a 30% increase in automobile fuel efficiency, the panel called for “tax incentives” or regulation, the latter a notion that makes the President flinch. The report also suggested raising overall automobile mileage standards from the current level of 27.5 to 32.5 m.p.g. The President has so far resisted that move, though members of the



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

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

panel met with him privately at the White House last week to urge the idea.

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

The faction led by Darman and Sunu-

nu, however, could point with to some parts of the study. For the commission declined to set explicit target dates or percentages for the reduction of CO₂ emissions, steps, which have been taken by many European nations, are firmly opposed by the Administration. Moreover, the U.S. has already adopted some of the other measures that the report urges, including investing in global climate research (to the tune of \$1 billion) and planting millions of trees that can become storehouses for CO₂. Though Bush undertook those actions for other reasons, they double as defenses against global warming. The panel also used a cost-benefit analysis that takes into account the price of implementing its recommendations, an approach that Darman and Sununu favor.

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

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

counterproposal that Walpole and Norfolk residents made when the governor proposed a scaled-down landfill for the Walpole site.

Rep. Francis H. Woodward (D-Walpole) said that while "I am not sure the judge will lift the moratorium," Walpole and Norfolk residents "would be happy to have the opportunity under the governor's proposal to bring our ideas to the table with everybody there, rather than talking to one side at a time."

No data were available yesterday as to just how many more projects may be put on hold because of Mazzone's order, but a study by the Metropolitan Area Planning Council concluded that in 42 of the communities that are part of the MWRA water and sewer district, 5,215 housing units and 49 commercial properties would be slowed or halted because of the ban. The figures do not include Boston's projects.

One project put on hold is the Seawinds in Quincy. Gary Roman, an official with the realty interest of a Holyoke bank that acquired the eight-story residential building through a foreclosure, said that he has been denied occupancy permits because of the ban at a time when he has buyers for 55 of the 123 units.

"I just want it solved"

"I don't blame anybody. I just want it solved," he said. "We're a bank. These are troubled times for banks. It's not the time for us to be sitting there with something we can't sell when we have ready buyers."

Roman noted that it will also affect the city of Quincy because although the bank intends to pay its tax bill on the property, it also intends to seek an abatement.

"The building is worthless as is," he said.

Several people on Beacon Hill who have been following the landfill siting dispute for several years said privately that Weld is setting a very dangerous precedent by siding with Walpole and abutting communities at the expense of more than 40 others that will see economic opportunities limited by the sewer ban.

"I think his political inexperience is showing," one source said. "All this for a campaign promise? He's already broken his promise not to cut local aid. Now, he's choosing to keep this one? I think the message it sends is that if you make a big enough stink, we'll back off."

Sources also said that a "backup" bill to transfer the Walpole land to the MWRA is being drafted by Sen. William MacLean (D-Fairhaven), whose district does not include communities that get their water and sewer services from the MWRA. Sen. Christopher Lane (R-Medfield) has prepared a bill to site the landfill at Rowe Quarry but said yesterday he will file it only if MacLean files his bill.

Rep. Kevin Fitzgerald (D-Boston), a member of the House leadership, said there will be meetings among lawmakers this week to decide what steps to take next.

"Clearly, we share in the blame," Fitzgerald said. "Now, we have to figure out just what we're going to do to get this resolved once and for all."

Communities listed

Following are the communities affected by the US District Court's ban on new sewer connections for commercial and industrial users and for residential permits of 2,000 gallons a day or more:

Arlington, Ashland, Bedford, Belmont, Boston, Braintree, Brookline, Burlington, Cambridge, Canton, Chelsea, Dedham, Everett, Framingham, Hingham, Holbrook, Lexington, Malden, Medford, Melrose, Milton, Natick, Needham, Newton, Norwood, Quincy, Randolph, Reading, Revere, Somerville, Stoneham, Stoughton, Wakefield, Walpole, Waltham, Watertown, Wellesley, Westwood, Weymouth, Wilmington, Winchester, Winthrop and Woburn.

EHD

Global Warming Continues, but Cause Is Uncertain

Buildup of Pollutants in Earth's Atmosphere Studied; Definitive Evidence Is Lacking

By William Booth
Washington Post Staff Writer

The average temperatures on earth in 1990 were the highest since record keeping began, continuing a warming trend first detected in the 1980s.

The world's two leading authorities on global surface temperatures reported these findings jointly yesterday, but said it is not clear that the cause of the warming is the buildup of pollutants in the atmosphere.

The analyses were done by the British Meteorological Office and the National Aeronautics and Space Administration's Goddard Institute for Space Studies in New York, using a network of thermometers on land and sea.

Most climate experts say they lack definitive evidence that the observed global warming is caused by pollutants such as carbon dioxide, a gas that has been steadily increasing in the atmosphere because of the burning of forests and fossil fuels, and which acts like a blanket to trap heat close to the earth's surface.

The observed warming may instead be some completely natural, though poorly understood, phenomenon. But there is a growing feeling among many researchers that the warming trend may be fueled by human pollutants.

"I have been skeptical about saying it's an enhanced greenhouse effect," said Jim Angell, a climate expert at the National Oceanic and Atmospheric Administration's Air Resources Laboratory in Silver Spring. "But it's getting harder to defend that skepticism."

While uncertain over the cause of the warming, both the British and American researchers yesterday agreed that 1990 beat out 1988, which was previously the hottest year on record. Indeed, six of the seven warmest years in over a century occurred in the 1980s. In descending order the seven warmest years on record are 1990, 1988, 1983, 1987, 1944, 1989 and 1981.

Angell and his colleagues, however, believe that it may take another decade to know for certain whether pollutants are causing the warming.

Based on computer simulations on how the planet operates, an international group of researchers sponsored by the United Nations predicted that the average global temperatures would increase between 2 and 6 degrees Fahrenheit by the end of the 21st century, if gases such as carbon dioxide continue to accumulate at projected rates.

The United States will host an international meeting in February to discuss possible responses to global warming. In past discussions, the Bush administration has resisted attempts to reduce carbon dioxide emission, arguing that more research is needed to prove that warming will occur.

James Hansen, head of NASA's Goddard Institute, stressed that a single record-breaking year was meaningless. Rather, he said, scientists were most interested in—and concerned about—what they view as a warming trend.

The warm weather was most evident over the United States and southern Canada, Europe, western Siberia and the Far East.

Readings taken with weat

loons launched by Angell and colleagues at NOAA confirmed that 1990 was the warmest year not only at the earth's surface but in the planet's atmosphere, from about 5,000 to 30,000 feet. Similarly, Angell said, the warming trend of the 1980s was also observed in the atmosphere.

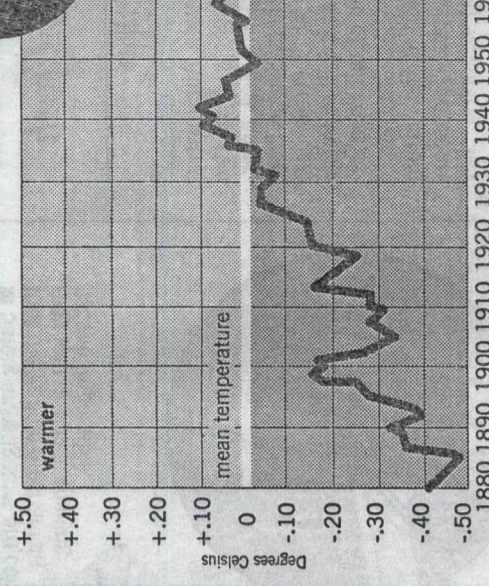
Satellite data collected by Roy Spencer at NASA's Marshall Space Flight Center in Huntsville, Ala., also confirmed that the atmosphere was warm in the 1980s. However, Spencer's satellites showed that 1990 was not the hottest year, but the fourth warmest. Spencer is not sure why his temperature record is different.

Spencer said scientists don't really understand natural fluctuations in climate. Records have been kept only since the late 1800s. Indeed, there was a distinct warm peak in the 1930s and 1940s, which gave way to 20 years of relatively cool temperatures, followed by the warming of the 1970s and 1980s.

If it was a purely scientific thing, say I'm not convinced. I'm skeptical," Spencer said. "But I'm just not a policy-maker. There

A WARMING PLANET

This chart looks at average annual global air temperature since the 1880s. The zero line, shown in white, represents the mean temperature on the planet. The erratic black line shows how far average global temperature was above or below the mean each year.



SOURCE: NASA's Goddard Institute for Space Studies.

THE WASHINGTON POST

is so little proof, but the possible consequences are so severe." Last year also had by far the lowest annual snow cover ever recorded for the Northern Hemisphere, according to analyst David Robinson of Rutgers University. Robinson said he is not sure whether the decreased snow cover was a result of higher temperatures, or the cover actually contributed to the warming. The less snow cover, the more the earth's surface heats up. The more snow cover, the more sunlight is reflected back into space.

Southeastern Sky to Be Dressed

By Curt Stuelee

CORRECTIONS

A Boston Globe article published in the business section misstated the name of Bart...

Hopeful E.P.A. Report Fans a Debate as Talks on Warming Near

By WILLIAM K. STEVENS *AS*

The Environmental Protection Agency says that at a time when most other countries have only pledged to take action, the United States has already taken steps that will keep emissions of heat-trapping atmospheric gases at current levels for the next two decades.

The conclusions are playing a crucial role in the United States' preparations for an international conference in Washington next month to negotiate a treaty to control emissions of the gases, which scientists say could cause a catastrophic warming of the Earth in the 21st century unless something is done to curb them.

More than 20 industrialized countries have committed themselves to stabilizing or reducing emissions of carbon dioxide, the gas that would play the largest role in the warming. The Bush

Should there be goals on carbon dioxide? And at what cost?

Administration has opposed such a target for carbon dioxide, arguing that the extent of the problem is too uncertain to justify painful and costly control measures now.

Reliability Is Questioned

The E.P.A. study is already generating argument. Some critics question its reliability and assail it as a ploy to justify what they see as the Administration's go-slow policy on global warming. They say that even if the findings are reliable, enough of the gases are already in the atmosphere to require stronger action. Scientists say, further, that a substantial reduction in emissions will be required if the global concentration of the gases is to be stabilized at current levels.

But William K. Reilly, the E.P.A. Administrator, said in an interview that the study showed that the United States had already acted to stabilize its overall contribution to warming. Mr. Reilly has long advocated emissions targets, provided they encompass all the implicated gases, not just carbon dioxide.

Atmospheric concentrations of the gases are steadily rising as a result of human activity. Scientists say that because they trap heat much as a greenhouse does, they could cause drastic climatic changes in the next century.

Some experts on the international politics of global warming say the findings of the agency's report could prompt the United States to drop its objection to targets. In this view, Washington might recapture leadership on the issue of global warming if it proposed an overall target that included all the gases implicated in global warming — a target that the E.P.A. study suggests it could meet.

Sununu Opposes Targets

"If they don't do it, they're going to have a very hard time getting back in the game seriously, in terms of playing a leading role in shaping an international approach," said William Nitze, a former State Department official who was responsible for coordinating Government policy on global warming and who represented the United States in international meetings on the subject. He left the Administration last September to become president of the non-profit Alliance to Save Energy, based in Washington.

Whether the Administration will now embrace targets in light of the report's finding remains to be seen. The idea has considerable support among officials of Government agencies who are discussing what the United States' stance should be, Administration officials say. But higher officials, including John H. Sununu, the President's chief of staff, have successfully opposed any targets in the past. Mr. Sununu said through an aide that he was aware of the report but would not comment on it.

Mr. Reilly says that while the study is not yet "fully researched" or scientifically vetted, "it's the best we have."

He said: "In the coming weeks, we will be reviewing it with other agencies to see whether this represents a realistic scenario. I think it does."

Recently adopted measures that the E.P.A. study says will limit the United States contribution to the greenhouse effect include these measures:

¶ Provisions of the new Clean Air Act amendments that will slow carbon dioxide emissions.

¶ A plan, adopted as part of the 1990 farm bill, that aims to plant a billion trees a year for 10 to 20 years. Trees absorb carbon dioxide.

¶ Recent energy-saving measures mandated by the Department of Energy, including efficiency standards for appliances, the development of energy-saving building codes, and initiatives to expand hydroelectric power, promote solar energy and stimulate greater efficiency by the electric-power industry.

¶ The phasing out of chlorofluorocarbons, or CFC's. These chemicals, used as refrigerants, solvents and propellants, are being abandoned primarily because they destroy the ozone layer

that protects living things from ultraviolet radiation. But they also are even more powerful and long-lived heat-trappers than carbon dioxide.

According to a report on the study by Alex Cristofaro, director of the agency's air and energy policy division, researchers calculated the effect of the recent Government measures on emissions of the various greenhouse gases. It converted all the gases to carbon-dioxide equivalents, in terms of heat-trapping capacity.

It found that the United States contribution to the greenhouse effect, expressed in carbon-dioxide equivalents,

would be about the same in 2000 as in 1987, and that it would either drop slightly or show an increase of about 4 percent by 2010. This could change, the study said, if the new Government measures do not materialize as expected or if the economy grows faster than expected.

Can It Be Painless?

One Government official, who spoke on condition that he not be identified, said that the study's conclusion means that "the problem is possibly less intractable than it might appear at first glance." He said it suggests that "we could quite painlessly" take further action to limit greenhouse emissions over the next few years.

Environmental skeptics doubt that a United States pledge to stabilize its overall greenhouse emissions by the year 2000 would be a sufficient response. "It would still be a considerably weaker position than that adopted by the Europeans," said Michael Oppenheimer, a senior scientist and expert on global warming at the Environmental Defense Fund, an environmental research and advocacy group.

He said the Europeans have committed themselves to capping or reducing carbon dioxide emissions. "In addition," he said, "they will do the same as we're doing with CFC's, namely, elimi-

CONTINUED

nate them." Most of the world's nations have agreed to halt production of CFC's by the end of this decade.

The E.P.A. study shows that carbon dioxide emissions in the United States would continue to grow over the next two decades, even though this nation's overall contribution to the greenhouse effect would stabilize.

Moreover, Dr. Oppenheimer said, overall greenhouse emissions by the United States would resume their growth after C.F.C.'s have been eliminated if no further action is taken. "In my opinion," said Dr. Oppenheimer, "the U.S. is trying to pull the wool over everyone's eyes under the guise of stabilizing greenhouse emissions."

Mr. Reilly, a career environmentalist before he joined the Bush Administration, has consistently advocated targets to stabilize or reduce overall greenhouse emissions. By setting overall targets, he argues, individual countries are afforded more flexibility in dealing with the problem.

Some European countries, for instance, are proposing to tax the use of fossil fuels like oil and coal, which produce carbon dioxide. This would not be politically acceptable in the United States, Mr. Reilly said, in light of the rejection last fall of a 25-cent-a-gallon gasoline tax. "Congress and the public wouldn't hear of it," said Mr. Reilly.

Global Warming: Search for the Signs

Climatologists seek the tell-tale fingerprint that a greenhouse effect would leave.

C1 By WILLIAM K. STEVENS

AN ever-lengthening string of extraordinarily warm years has renewed fears of the greenhouse effect — the trapping of the Sun's heat by gases that a rapidly industrializing world is pouring into the atmosphere. Responding to the alarm, delegates from around the globe will gather next week outside Washington to negotiate a treaty limiting the gases.

But as the delegates converge, most scientists are far from ready to announce that greenhouse warming has arrived, since the warming recorded over the last decade could also be part of a natural climatic change.

Instead, they are struggling to answer a crucial question: how can a greenhouse warming of the climate be recognized and distinguished from natural warming? They are focusing their detective efforts on various subtle changes that a greenhouse warming would be expected to induce. These signs are known collectively as the greenhouse "fingerprint."

The task, climatologists say, is by no means as easy and straightforward as it might seem.

They know that certain gases, chiefly carbon dioxide, chlorofluorocarbons and methane, admit the Sun's energy but block heat from escaping back to space. They know that the gases are steadily building up, largely through the burning of fossil fuels. And they know that the average surface temperature of the Earth has indeed been rising for the last decade. In 1990, at a shade under 60 degrees Fahrenheit, it was the highest since global measurements began in the late 19th century.

But as provocative as all this evidence is, the scientists believe, it in no way establishes a cause-and-effect relationship between the greenhouse gases and the recent rise in the average global temperature. The rise is consistent with greenhouse warming, they say, but not enough to prove a connection.

If the greenhouse effect is indeed warming the planet as scientists predict it will, this will ultimately become so obvious that "a kid on the street can tell what's going on," said Dr. Tim P. Barnett, a climatologist at the Scripps Institution of Oceanography in La Jolla, Calif. It will become obvious, scientists say, be-

cause the rate of warming is expected to outstrip that of any climatic change in the last 10,000 years.

But the greenhouse "signal," in fact it is there now, is still so small on a global scale that it is obscured by the "noise" of the many other factors that influence climate. These other factors, the climatologists say, could well be the cause of the overall global warming observed in the last decade. Or, equally possibly, they could have produced an overall cooling that partly offset an even larger greenhouse warming than the rise in average global temperature might suggest.

The Whorls of a Fingerprint

Some climatic features that might indicate global warming:

GLOBAL TEMPERATURE PATTERNS

Scientists say continents would warm more than oceans and sub-arctic latitudes more than tropics in the Northern Hemisphere. The lower atmosphere would warm while the stratosphere cooled.



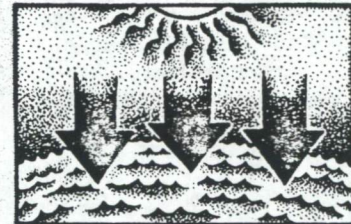
ATMOSPHERIC WATER VAPOR

Water vapor would increase with the warming and intensify it by amplifying the effect of greenhouse gases. Moisture would rise more in the tropics than in higher latitudes.



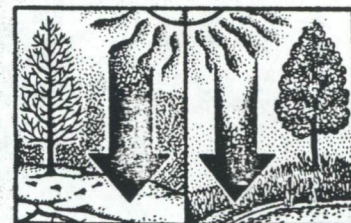
SEA SURFACE TEMPERATURE

The sea surface temperature is expected to rise fairly uniformly with greenhouse warming, while naturally occurring temperature changes vary more from one part of the globe to another.



SEASONALITY

The relative intensity of the seasons is expected to change with greenhouse warming. The warming effect would be more evident in the winter than in the summer, particularly at high latitudes.



To help resolve these uncertainties, the climatologists are trying to develop a diagnostic set of features that would indicate a greenhouse-caused warming.

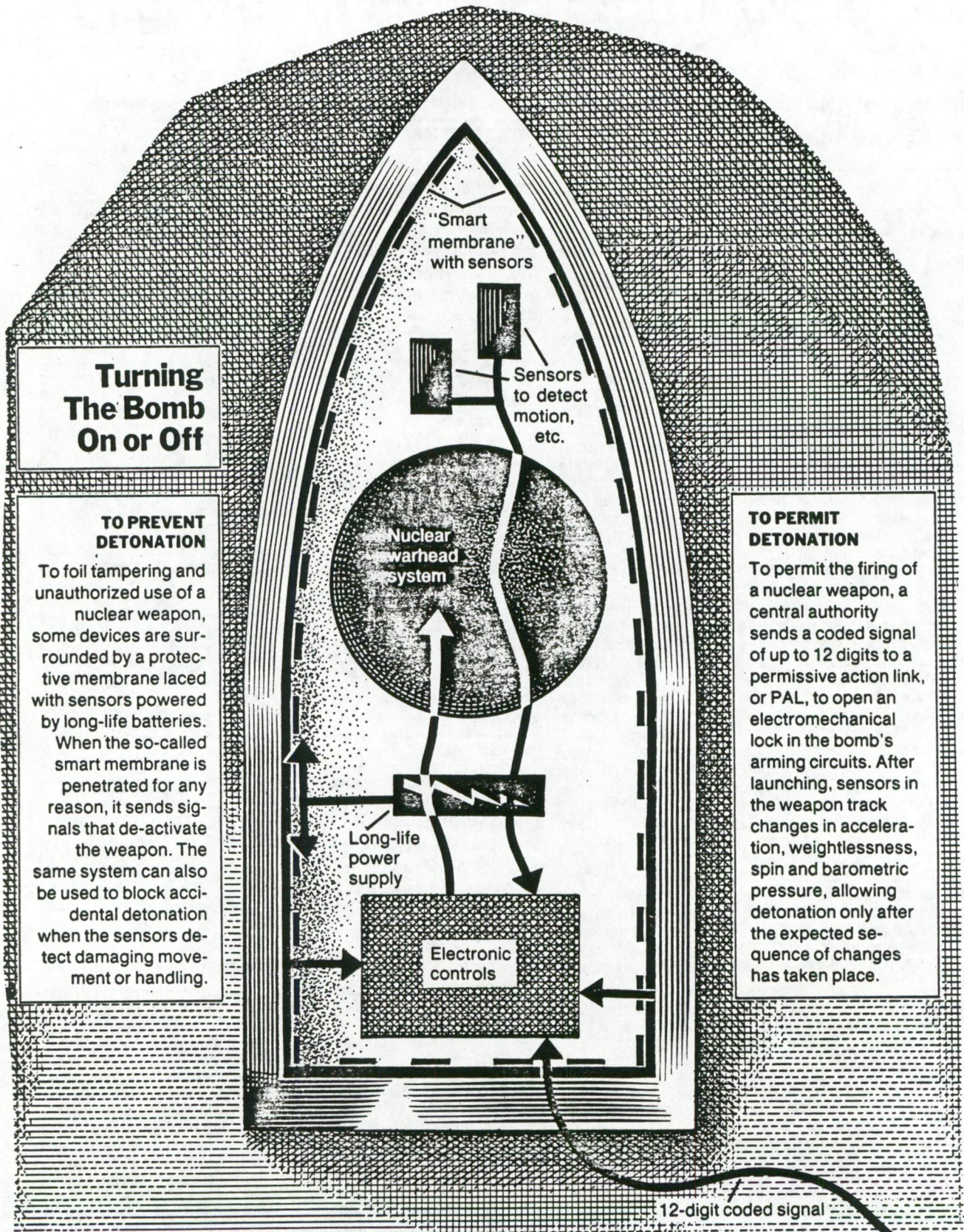
No single climatic feature can be relied on as the proof of greenhouse-induced warming. "You want to look for it in a number of places so you don't get tricked by one," said Dr. Barnett, a leader in the effort to develop a reliable detection strategy.

Possible Greenhouse Fingerprints

Scientists have identified a number of promising candidates to be included in the greenhouse fingerprint. Among the leading ones are these:

Global temperature patterns. In greenhouse warming, scientists believe, the continents would warm more than the oceans. Subarctic latitudes are expected to warm more than tropical latitudes in the Northern Hemisphere, but not in the Southern Hemisphere. The lower part of the atmosphere, or troposphere, would become warmer while the stratosphere would become cooler.

Sea surface temperatures. They are expected to rise fairly uniformly with greenhouse warming, while naturally occurring changes vary more from one part of the globe to another.



Turning The Bomb On or Off

TO PREVENT DETONATION

To foil tampering and unauthorized use of a nuclear weapon, some devices are surrounded by a protective membrane laced with sensors powered by long-life batteries. When the so-called smart membrane is penetrated for any reason, it sends signals that de-activate the weapon. The same system can also be used to block accidental detonation when the sensors detect damaging movement or handling.

TO PERMIT DETONATION

To permit the firing of a nuclear weapon, a central authority sends a coded signal of up to 12 digits to a permissive action link, or PAL, to open an electromechanical lock in the bomb's arming circuits. After launching, sensors in the weapon track changes in acceleration, weightlessness, spin and barometric pressure, allowing detonation only after the expected sequence of changes has taken place.

Source: Donald R. Cotter

Water vapor in the atmosphere. The vapor would not only increase with the warming but, in a classic feedback effect, would also intensify the warming by amplifying the effect of the greenhouse gases. Moisture content would be expected to increase

'You want to look for it in a number of places so you don't get tricked by one.'

more in the tropics than in higher latitudes like the temperate and subarctic zones.

Changes in seasonality. Greenhouse warming is expected to be more evident in winter than in summer, particularly at high latitudes.

From computer simulations of the Earth's climate, scientists believe these indicators of the greenhouse signal are so distinguished from natural, internal fluctuations of the climatic system as to be characteristic of greenhouse warming. One example of the natural fluctuations is the phenomenon of El Niño, in which periodic changes in sea surface temperatures in the tropical Pacific Ocean affect global temperature and rainfall patterns.

Previous Periods of Warming

On a geological time scale, the Earth has undergone periods of substantial natural warming. Between 5,000 and 6,000 years ago, scientists believe, temperatures in various parts of the world were about 2 to 5 degrees warmer than benchmark levels in the late 19th century. By comparison, the average global temperature has increased by about half a degree to one degree in the last century.

There were other warm periods about 125,000 years ago, when parts of the globe were 3.5 to 14 degrees warmer than the benchmark temperatures, and 3.3 million to 4.3 million years ago, when they were 3.5 to 35 degrees warmer, depending on location and season.

These warm periods were presumably caused by natural factors origi-

The temperature is rising, but is 'greenhouse' warming the reason?

nating outside the ocean-atmosphere climate system. These include changes in solar radiation, changes in the Earth's position relative to the Sun, naturally occurring increases in greenhouse gases and changes in relationships between the land and the ocean. These latter changes, brought about by the movement of the Earth's crustal plates, are thought to have altered patterns of ocean circulation that play a critical role in shaping climate.

A modern cause of non-greenhouse climate change may be pollutants, apart from greenhouse gases, that humans are throwing into the atmosphere. Many of these can affect temperature, moisture and atmospheric functioning, complicating efforts to detect greenhouse warming.

'Junk in the Atmosphere'

"We've put a lot of junk in the atmosphere" in addition to greenhouse gases, said Dr. Barnett, "and it seems to be pretty well dispersed.

"What would that do to the climate?" he asked. "I don't think that's been computed, but it could have a large-scale effect."

For example, climatologists say, fine pollution particles emitted by industry cause clouds to form, and these can have warming or cooling effects, depending on the type of clouds and their location. These effects are uneven from one part of the globe to another, further complicating matters.

Another source of distortion, said Dr. James E. Hansen, a climatologist at the Goddard Institute of Space Studies in New York, is the depletion of the Earth's ozone layer because of the release of chlorofluorocarbons into the atmosphere, a change that causes cooling at some levels of the atmosphere in northern regions of the globe. This may affect the expected temperature difference between latitudes and even between land and ocean, for instance, obscuring the greenhouse signal.

"As soon as you start looking at these kinds of details you're in trouble," Dr. Hansen said, adding that detecting greenhouse warming depends on observing all the competing external influences on climate.

Climatologists say the effort to rule out all the greenhouse effect's possible competitors as causes of global warming is slowed and frustrated by a lack of observational data in many key areas and by the state of the art of climatic science.

"Whenever you try to do this quickly, you run up against our ignorance and the quality of the data," said Dr. Michael E. Schlesinger, a climatologist at the University of Illinois at Urbana-Champaign, who has worked closely with Dr. Barnett.

An especially significant indicator of greenhouse warming would be any increase in atmospheric water vapor. It is "the first thing you'd expect," said Dr. Veerabhadran Ramanathan of the University of California at San Diego, who has studied the matter extensively. In greenhouse warming, more water would change into vapor. This vapor is critical to greenhouse warming because it would amplify by five times the relatively small initial warming impulse provided by carbon dioxide and other greenhouse gases.

"You should clearly be seeing that in the observations," said Dr. Ramanathan. "If that's not there, you'd know it's not greenhouse. If it is there, the case would be compelling that it is greenhouse."

But "we don't have the answer to that question," he said, "because we don't have the observational records." Satellite observations provided such data from 1984 to 1989, but the satellite has stopped working. No measurements have been made since then, although the Department of Energy plans to establish a series of ground-based observation stations that could fill the gap. New satellites are also expected to help fill it later in the decade, and Dr. Hansen and others are pressing for an earlier date.

In this and some other areas, scientists say, existing records are too short to discern either trends in natural variability or signs of greenhouse warming. The best and most complete climatic observations are those of surface temperature. Scientists trying to develop a reliable fingerprint are comparing observed temperature patterns in these records with those expected to result from greenhouse-induced warming.

Climatologists at the Max Planck Institute in Hamburg, Germany, and at the University of East Anglia in Britain, for example, have analyzed the globally observed pattern of surface temperatures and are measuring it against model predictions.

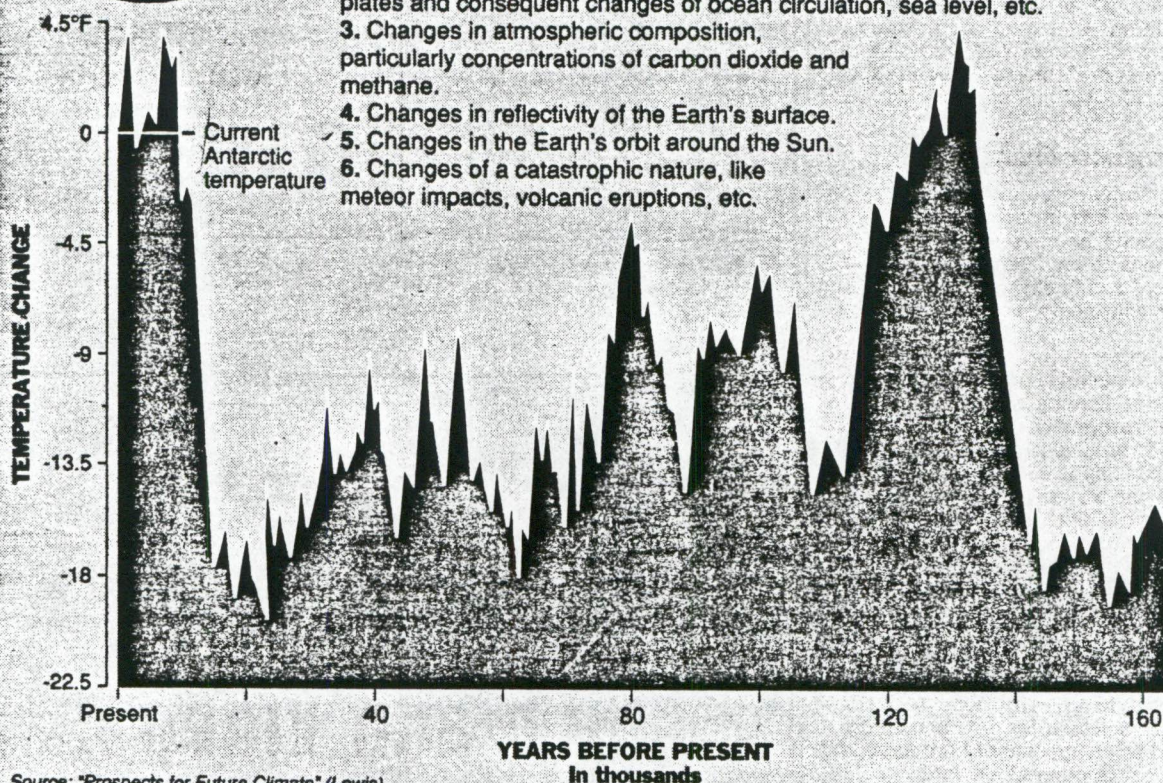
Developing reliable signs of the greenhouse model depends heavily on improving the computer models of the atmosphere that predict greenhouse-induced changes. The models are continually being refined, but are still imperfect representations of the real world.



Scope of Natural Temperature Variations

Temperature changes over the last 160,000 years, based on the deuterium isotopes in an Antarctic ice core, and natural factors believed to have had the largest influences on the long-term evolution of climate:

1. Changes in solar radiation.
2. Changes in land/ocean distribution because of the movement of tectonic plates and consequent changes of ocean circulation, sea level, etc.
3. Changes in atmospheric composition, particularly concentrations of carbon dioxide and methane.
4. Changes in reflectivity of the Earth's surface.
5. Changes in the Earth's orbit around the Sun.
6. Changes of a catastrophic nature, like meteor impacts, volcanic eruptions, etc.



Source: "Prospects for Future Climate" (Lewis)

"Some things, the models don't simulate so well," Dr. Barnett said. "Other things, they seem to simulate quite well." He said scientists would first have to "isolate the best model and the best of the observations" before they were set to do their detecting.

Some climatologists think that refining the models is more important at this point than the accumulation of data. "I don't think more data is going to reduce uncertainties in the next few years," said Dr. Phil Jones, a climatologist at the University of East Anglia. The short-term answer, he said, "is going to be in improvement of the models and better agreement between models."

For the next few years, the public and policy makers will have to rely on all these efforts to tell them what is happening.

"We'd better find out as soon as we can," Dr. Hansen said. If action to reduce emissions of greenhouse gases is delayed, "either the climate changes are going to be larger and the impacts on people are going to be greater, or we will have to make more painful and expensive efforts," he said, adding, "The earlier we know, the easier it is to minimize the impacts or to adapt to them."

A reliable fingerprint could also make it easier not only to detect the human-induced greenhouse effect but also to measure its future magnitude with some assurance. Since the ocean absorbs and holds much of the heat before ultimately releasing it back into the atmosphere, there is a lag of up to several decades between the emission of greenhouse gases into the air and their full effect on climate.

Waiting for Answers

Given all the obstacles, when can answers be expected? Some scientists say in a decade or so, but Dr. Barnett says nobody has really made a good estimate.

"Some of my colleagues say detection is premature because the models aren't good enough," he said. "Others say, 'Detection is a red herring — let's do something about the greenhouse effect right now because the consequences are so bad.'"

"I think we're going to be forced in the next 5 or 10 years to take what we have and make some decision."

Separate Studies Rank '90 As World's Warmest Year

By WILLIAM K. STEVENS

The earth was warmer in 1990 than in any other year since people began measuring the planet's surface temperature, separate groups of climatologists in the United States and Britain said yesterday.

A third group, in the United States, reported record temperatures from one to six miles above the earth's surface. These were recorded from balloons from December 1989 through November 1990.

Some scientists said the new reports, taken together with the series of very warm years in the 1980's, strengthened the possibility that the feared greenhouse effect, a global warming caused by an increase of heat-trapping atmospheric gases, had already begun.

Man or Nature?

These gases, chiefly carbon dioxide, chlorofluorocarbons and methane, are increasing, mostly as a result of human activity. A greenhouse warming could cause drastic changes in climate, agriculture and even sea levels.

Other scientists noted the difficulty of detecting the tiny initial signal of greenhouse warming amid the much greater temperature swings caused by nature.

"I would agree that it is of concern that we've had these hot periods," said Tim Barnett, a climatologist at the Scripps Institution of Oceanography in La Jolla, Calif. "But at this point you can't attribute it to any single cause. Is it the greenhouse gases, or is it natural variability?" It is impossible, he said, to draw any conclusion based on the average global temperatures alone.

The seven warmest years since 1880 all occurred in the last 11 years, according to climatologists at the space agency's Goddard Institute for Space Studies in New York. And six of the seven warmest years since 1850 have all occurred since 1980, according to a

The 10 warmest years since 1880 and average temperatures in Fahrenheit.

1990	59.81
1981, 1988	59.64
1987	59.56
1980, 1983	59.51
1989	59.45
1973	59.31
1977, 1986	59.30

Source: NASA/Goddard Institute for Space Studies

somewhat different set of surface measurements by scientists at the University of East Anglia in England and at the British Meteorological Office. The Goddard team analyzed temperatures recorded on land and on oceanic islands; the British team also included temperatures taken by ships at sea.

"The case for a cause-and-effect relationship" between the recent warming and a human-induced greenhouse effect "is becoming harder to deny," said James E. Hansen of the Goddard Institute. Dr. Hansen made a well-publicized statement in 1988 that the greenhouse effect was probably the cause of the observed rise in global temperatures.

A Skeptic Begins to Waver

His group reported yesterday that 1990, with an average global temperature of 59.8 degrees, was the warmest year globally since the records used by the group began in 1880.

"I wouldn't disagree with that," James K. Angell of the National Oceanic and Atmospheric Administration's Air Resources Laboratory in Sil-

A swing of nature or the unwitting work of humans?

ver Spring, Md., said of Dr. Hansen's comment. Dr. Angell reported the balloon measurements. "I've been a skeptic, but as these warmish years come one upon the other, you begin to waver a little bit."

Nevertheless, he said, "we still may have to wait a decade longer to make sure."

The British groups, headed by Phil Jones at East Anglia and David Parker of the meteorological office, reported 1990 to be the warmest year since comparable records were first kept in 1850.

"Although it is still too early to confirm whether the recent exceptional warmth is related to the greenhouse effect," the British scientists said in a statement, "international scientific opinion strongly supports the reality of this enhanced greenhouse effect, and it is likely that it has played some role in contributing to the recent warmth."

Satellites Measure Warmth

A fourth analysis, of data from satellite measurements of the entire lower atmosphere through the first 11 months of 1990, showed the year could turn out to be the fourth warmest since the satellite measurements began in 1979. The analysis was made by John R. Christy of the University of Alabama and Roy Spencer of the space agency's Marshall Space Flight Center, both in Huntsville.

The Goddard group found that the record average surface temperature for the globe was eight-tenths of a degree Fahrenheit above the 1951-1980 average of 59 degrees. The British group found it seventh-tenths of a degree higher than the 1951-80 average.

The warming was particularly pronounced over the eastern United States, where record temperatures were also set in 1990, and across the entire Eurasian land mass, the Goddard team discovered. The only region with temperatures substantially below normal was Greenland and the neighboring Canadian archipelago. The British group found the warmth of 1990 "particularly evident" over Europe, western Siberia, the Far East and most of the United States and southern Canada.

The Federal Government reported last week that 1990 was the seventh warmest year in the United States since record-keeping began in 1895. In New York City, it was the warmest year recorded since the Government began measuring the temperature in Central Park in 1869.

Dr. Hansen's group calculated that the 1980's were about one degree warmer, globally, than the 1880's, and that 1990 was about 1.25 degrees warmer. By way of comparison, the world's average temperature is about 9 degrees warmer now than it was in the

CONTINUED

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Readings taken with weather balloons launched by Angell and colleagues at NOAA confirmed that 1990 was the warmest year not only at the Earth's surface but in the planet's atmosphere, from about 5,000 to 30,000 feet. Similarly, Angell said, the warming trend of the 1980s was also observed in the atmosphere.

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"If it was a purely scientific thing, I'd say I'm not convinced. I'm skeptical," Spencer said. "But I'm just glad I'm not a policy-maker. There

is so little proof, but the possible consequences are so severe."

Last year also had by far the lowest annual snow cover ever recorded for the Northern Hemisphere, according to analyst David Robinson of Rutgers University.

Robinson said he is not sure whether the decreased snow cover was a result of higher temperatures, or the cover actually contributed to the warming. The less snow cover, the more the Earth's surface heats up. The more snow cover, the more sunlight is reflected back into space.

HEATING THE GLOBAL WARMING DEBATE

In 1988 scientist Jim Hansen testified that the world was getting hotter.

But how hot? And how fast?

BY KAREN WRIGHT

P. 24

LAST MONTH SCIENTISTS reported that 1990 was the warmest year on the meteorological record: the average global temperature, measured over land and sea, exceeded that of any year in the past century or so. Citing this, a group of 16 senators, including Albert Gore Jr., Democrat of Tennessee, wrote a letter to President Bush calling for immediate policy action to counter global warming. The 1990 information, said the senators, "illustrates clearly that global climate change is real."

Does it?

In the five years since the terms "global warming" and "greenhouse effect" became shibboleths of environmental awareness, the weather as a topic of conversation has gone from casual to confounding. The briefest of heat waves is enough to kindle despair over the future of the planet, while a transient cold spell can send greenhouse consciousness into hibernation. Environmentalists conjure images of disaster; industrialists appeal to scientific uncertainty; the media

seize on any hint of controversy with intemperate zeal. And climate experts offer scant relief, insisting as they do that the day-to-day fluctuations ordinary people notice aren't nearly as significant as the long-term trends about which they themselves don't seem to agree.

Anyone who's had traffic with the global-warming issue eventually longs for an oracle or a scapegoat, a figure to trust implicitly or to blame entirely. Both man-

ties have come to rest on the shoulders of one unlikely individual: a mild-mannered scientist in the National Aeronautics and Space Administration named James E. Hansen. Hansen, the director of NASA's Goddard Institute for Space Studies, located in Manhattan, is the plain-spoken climatologist who testified before the Senate Committee on Energy and Natural Resources in the summer of 1988 that the world was warming, probably because of an increase in the atmospheric levels of carbon dioxide and other so-called greenhouse gases, which trap heat the way the glass plates of a greenhouse do.

For those seemingly modest statements, Hansen has been alternately praised, denounced, lionized and lampooned by peers and public alike. Meanwhile, his views on the greenhouse effect

Karen Wright is a contributing correspondent for Science magazine and a former staff writer for Scientific American.

CONTINUED

The New York Times

have come to form the nexus of the scientific debate on when, where and whether global warming will occur in the next century. Some of his conclusions have already become dogma.

In fact, it's not his science that gets Jim Hansen in trouble — it's his style. Hansen has all the moves of a hustler but none of the guile. Backed by a body of exhaustive and universally respected research, he routinely flouts his profession's tacit restrictions on categorical and unauthorized statements while maintaining the pacific innocence of a curious child. It's a combination that baffles his friends, who can't give him their unqualified support, as well as his critics, who can't even manage to dislike him.

This week, representatives from dozens of countries will meet in Washington to begin negotiating an international agreement on global climate change. The conferees will discuss, among other items, the need to control emissions of greenhouse gases. Although Hansen won't be attending, the event itself is part of his legacy; the first Washington-based meeting, last April, was believed by many to have been a conciliatory effort by the White House to quell criticism surrounding its alteration of Congressional testimony given by Hansen in 1989. Both his supporters and his detractors admit that Hansen has done them a service by putting global warming on the political agenda. But Hansen can also be accused of polarizing opinion on an issue that should not really be all that divisive. "You almost have to start your discussions by saying, 'Do you agree or don't you agree with Jim Hansen?'" says James Van Allen, Hansen's former teacher, a professor emeritus in physics and astronomy at the University of Iowa and a seasoned observer of the debate. The answer, it seems, is more a profession of faith than a rational judgment.

KAREN, JIM HANSEN wrote in pencil on lined notebook paper last September. *I'm skeptical about whether a Times magazine article is a good idea. For one thing, I'm not at all an appropriate personality for a profile — I'm a very quiet and shy scientist. I am very inarticulate.*

Also, scribbled Hansen, an article focusing on me will just annoy other researchers — of course, they're already pretty mad.

For such a shy, quiet guy, Jim Hansen has indeed caused a bit of a fuss. A frequent guest during the past decade at Congressional committee hearings on climate change, the "inarticulate" scientist has regularly managed to say something to raise the eyebrows, if not the ire, of his colleagues. His 1988 Congressional testimony drew a barrage of criticism from other climate experts. In 1989 he earned more demerits from his publicity-wary peers when he revealed that his statement of that year had been altered by the Office of Management and Budget. And in 1990 he managed to raise the hackles of a whole new cadre of scientists by proposing a climate-satellite project that other NASA investigators see as a direct challenge to a system they have been planning for years.

The New York Times

"I think you just have to do what you think is right — that's what I learned in 1988. Now I'm really not concerned about the repercussions," says Hansen. Certainly his is not the posture of an anxious man. The 49-year-old Midwesterner is slumped in one of several beat-up leatherback chairs occupying his office at the Goddard Institute. His feet are propped on the only bare spot his desk has to offer. Every surface in the room, including most of the floor, is covered with piles of articles and computer printouts, like the blasted foundation of a paperwork temple.

In his standard office attire — khaki pants, a plaid cotton shirt and a crew-neck sweater — Hansen looks like somebody's dad at a P.T.A. meeting. He speaks with the placid deliberation of an Iowa farmer describing last fall's harvest.

"I think that, after not too long, the better science does rise to the top." Pause. "The scientific process will tell who was right."

Hansen made three claims before Congress in the fateful summer of 1988: First, that he was 99 percent sure the earth was warming. Second, that he could say with a high degree of confidence that the warming was due to an increase in greenhouse gases. And third, that because of global warming, events like droughts would increase noticeably in the 1990's. He hasn't changed his mind about any of those points, except to add floods, storms and fires to the list of events.

Those who disagree with what Hansen says — one climatologist calls them "greenhouse agnostics" — fall into three sects corresponding, more or less, to Hansen's three statements:

- Those who don't believe the temperature record (begun by national meteorological agencies only 140 years ago) is reliable enough to demonstrate a warming trend.

- Those who agree that there has been a warming but aren't sure blame can be assigned solely to increases in the emissions of greenhouse gases. World climate is, after all, the sum total of largely mysterious interactions among clouds, oceans, trees, volcanoes, ice, snow, dust particles, water vapor, aerosols and the sun, as well as greenhouse gases.

- Those who don't think anyone understands climate well enough to predict the meteorological effects of global warming.

Against this legion of critics, Hansen has a corps of admirers as well, climate experts who praise his courage and laud his science. "I don't have any fundamental disagreements with Jim," says Stephen H.

Schneider of the National Center for Atmospheric Research (N.C.A.R.). "He is probably right."

But Schneider, like many others, tiptoes away from endorsing Hansen's statements. Though he is one of the most outspoken advocates of a government policy to address the greenhouse effect, Schneider won't go as far out on the limb as Hansen has in his scientific appraisals.

"It's just that he believes more in the scientific certainty than I do," says Schneider. "I think intuitively he has a higher confidence in the tools."

THE TOOLS TO WHICH Schneider refers are climate models: computer programs descended from the algorithms used to predict the weather, but much more

complicated and much less reliable than those used for weather forecasting on a day-to-day basis. One of the three most advanced models in the United States is at the Goddard Institute; the other two are at N.C.A.R. in Boulder, Colo., and at the National Oceanic and Atmospheric Administration's

Geophysical Fluid Dynamics Laboratory in Princeton, N.J.

All the models are based on two verities of atmospheric science: that gases like carbon dioxide, methane, ozone, nitrous oxide and chlorofluorocarbons (known as CFC's) trap heat in the earth's atmosphere through what is commonly known as the greenhouse effect, and that the atmospheric levels of these gases have risen since the beginning of the Industrial Revolution.

That the greenhouse effect keeps the planet about 30 degrees centigrade, or 54 degrees Fahrenheit, hotter than it would be otherwise is not in dispute. Nor is the amount of the increase in greenhouse gases at issue. There is general agreement that carbon dioxide has increased by about 25 percent in the past century, and methane has doubled; long-term measurements don't exist for the other gases.

Essentially, the increases mean that the earth's atmosphere holds on to 1 percent more of the sun's energy than it did in 1800. It would be fairly easy to calculate the change in average global surface temperature from that figure if the buildup of greenhouse gases were the only factor in climate variability. But there are many, many more.

The ocean, for example, absorbs heat from the atmosphere and seems to act as a buffer against climate change. How fast the heat exchange occurs, however, and how long

the buffer effect will last are anyone's guess. Clouds have a net cooling effect on the earth, but it is not clear whether cloud cover will increase or decrease if the global temperature rises. And even the warming contribution of carbon dioxide is complicated by the fact that the burning of fossil fuels — the main source of carbon dioxide — also releases gases into the atmosphere that form aerosols, which serve to cool the earth.

In science, the traditional approach to such complex phenomena is the empirical method: make a simplifying assumption, generate a prediction and then see if the prediction comes true. If it doesn't, revise the assumption and try again. That's how models for weather forecasting are developed.

"If you find that your forecasting is right eight out of 10 times, you say, 'Look, my simplifying assumption is correct, as demonstrated by the fact that I've succeeded in predicting the weather,'" explains Syukuro Manabe, a veteran climate modeler at the Fluid Dynamics Laboratory. Climate models make predictions on time scales of decades and centuries, however, rendering empiricism impotent.

In the absence of verification, some experts think the models aren't worth the chips they're programmed on.

"I think there's reason to believe that the models are not only bad — that you can't rely on them as forecasting tools — but that when they're used to forecast greenhouse warming, they tend to be systematically too hot," says Andrew R. Solow of the Woods Hole Oceanographic Institu-

tion in Massachusetts. Solow says current models underestimate the ocean's capacity to absorb heat and fail to reproduce either the geographic or temporal patterns of temperature changes in the past century.

"We know the greenhouse effect is real," Solow says. "And we know that the levels of the gases are increasing. And so, other things being equal, you would expect there to be some warming. But other things needn't be equal: other climate processes could act either to suppress or reinforce the warming. And the real question is, how much warming do we expect to get from this, and at what rate? That, I think, is uncertain, highly uncertain."

Hansen doesn't deny the uncertainty. In fact, some days he, too, rues the state of climate modeling. But then he may turn around and bet 75 colleagues at a NASA conference that at least one year from 1990 to 1992 will be warmer than any year in the previous century. Hansen did just that last spring. Only one scientist took him up on his bet, and he lost \$100 when 1990 set the record.

A CASUAL SPECTATOR MIGHT GET THE impression that the implications of the greenhouse effect are disputed as often as the hazards of cholesterol. But disagreement about what has happened to the world's climate over the past century is greater than disagreement over what will happen. Since 1979, when the first comprehensive report on global climate change was compiled for the National Academy of Sciences, consensus statements from the scientific community have predicted a warming of between about 1.5 and 4.5 degrees centigrade (between about 3 and 8 degrees Fahrenheit) in the next 100 years. Climate models haven't challenged that estimate.

The consequences of such warming would range from the uncomfortable to the downright catastrophic. Temperature averages during the last Ice Age, which ended roughly 12,000 years ago, were probably 5 degrees centigrade colder than global averages today and brought dramatic changes in sea level, mass extinction of species and a widespread redistribution of flora and fauna.

Greenhouse scientists place themselves at different points along the warming range. Hansen puts himself at the hot end, predicting a warming of 3 or 4 degrees centigrade. Schneider falls somewhere in the middle. Solow says he could "live with" a forecast of 1.5 to 2.5 degrees. Richard Lindzen, a Massachusetts Institute of Technology meteorologist who has been one of the most dogged critics of Hansen's results, bitterly protests the exercise of predicting climate change, then reluctantly offers an estimate of 1.2 degrees. Truth is, it's hard to find a climatologist these days who *doesn't* believe in global warming.

Last year a comprehensive survey of scientific opinion published through the World Meteorological Organization and the United Nations Environment Program drew the broadest consensus yet on the issue. Hundreds of scientists from around the world participated in the survey. (Hansen limited his participation, deciding that involvement would deprive him of time he would rather spend on research.)

The familiar conclusion of the survey was that average global temperatures would increase by about 3 degrees centigrade by the end of the next century if controls on greenhouse-gas emissions were not instituted. If stringent controls were instituted, the report said, the increase could be cut to 1 degree centigrade. At the same time, the report admitted, "The unequivocal detection of the enhanced greenhouse effect from observations is not likely for a decade or more."

The consensus report offers cold comfort for those who choose not to believe in global warming. But they can find their own sacred texts. A report published in 1989 by a Washington-based think tank called the George C. Marshall Institute, for example, suggested that factors such as variations in solar activity could influence the calculus of global warming. Some greenhouse agnostics have used the report's conclusions to argue that solar activity could mitigate the effects of greenhouse-gas accumulation; most scientists have disregarded it.

OCTOBER 1990: JIM HANSEN, RELUCTANT profile subject, sends me several pounds of background material, including scientific articles, newspaper clippings, letters, Congressional statements and transcripts of speaking engagements, in three separate mailings. His secretary prepares a five-hour videotape of his television appearances.

November 1990: Hansen sends two four-page letters clarifying his thoughts about questions I'd raised in interviews. Several more packages of background material arrive. One contains an older sister's memoirs (unpublished) of their childhood. *I'm not a good interview on personal things*, he writes, and actually seems to believe that's true.

Hansen is the son of a waitress and a tenant farmer from Denison, Iowa (pop. 5,000). He earned money for college with a paper route, played pool in beer halls after school and walked miles of railroad tracks with his dog Skeeter. He claims he almost never cracked a book he didn't have to until he got to the University of Iowa, where he met James Van Allen, then chairman of the physics and astronomy department. Van Allen discovered and gave his name to the belts of radiation that circle the earth; he is something of a legend and, according to Hansen, he ran the kind of program that can change the course of a student's life. Van Allen suggested the topic for Hansen's dissertation and then helped him get a postdoctoral fellowship in 1967 at the Goddard Institute, an offshoot of the Goddard Space Flight Center in Greenbelt, Md.

"I was so excited by the opportunity to study at a NASA laboratory that I drove all the way to New York without stopping to sleep," Hansen says. Two years later the institute offered him a staff position, and he got involved in the weather-prediction research that was a major part of Goddard's charter in the 1970's. In 1981, Hansen succeeded Robert Jastrow as the institute's director.

Hansen is lord of a modest manor. Goddard is housed in a gloomy gray edifice on the northeast

corner of 112th Street and Broadway near Columbia University. The institute sits atop Tom's Restaurant, a greasy spoon of local renown whose fumes often waft up to the floors above. Inside, the hallway is lit like a catacomb. The carpet on the seventh floor is the color of boiled spinach; there's a plant dying in almost every window.

This neglected corner of the NASA empire suits Jim Hansen just fine. "We're close to being a non-civil-service organization, because only 20 people here have hard money for their salaries," he says, including his own \$79,200 annual paycheck. By soliciting additional financing from the Environmental Protection Agency and NASA, Hansen has managed to build the institute's staff to 140.

"We're handicapped, but there are some advantages. The key benefit is independence. We've sometimes expressed strong or unpopular opinions and just ignored the fact that we're civil servants. I recognize the forces that come back and push on us because of those statements. We haven't had a new hire here in four years, and in my gut I know very well that the reason we haven't is that they don't like things I've said." After a moment, he adds, "Though there's no way to prove that," and smiles.

Hansen's initial encounter with the "forces" was in 1981, when he published the first solid evidence that the earth was warming. The Department of Energy reneged on a promise of financial help after Hansen's study made front-page headlines, and he had to lay off five people. "For a while there, I became a 40-hour-a-week scientist."

It didn't last. A year later Hansen managed to wrest some money from the Environmental Protection Agency, and he plunged back into 80-hour workweeks. In testimony before Congress in 1982, 1986 and 1987, he grew ever more confident in his appraisals of the seriousness of greenhouse warming. But few people outside Congress and the scientific community took notice — with the exception of the Office of Management and Budget, which, mindful of the Reagan Administration's penury regarding climate research, tried to tone down the statement he planned to make in 1987. (Hansen was permitted to offer his testimony as a private citizen.)

Then the summer of 1988 struck. Drought stranded barges in the Mississippi and blistering heat tried Congressional tempers in the Capitol. Jim Hansen found himself in front of a Senate committee once again. But this time he had more ammunition: he'd just had a paper accepted by the *Journal of Geophysical Research* that would document the statements he wanted to make.

Within a few weeks of that memorable testimony, a House subcommittee invited Hansen to repeat his performance. "I was told about calls from the White House to NASA expressing great displeasure about my testimony. There were rumors about what might happen to me, with possible implications for the Goddard Institute." Hansen testified anyway, and kept his job in the bargain.

A year later, when O.M.B. tried to alter his testimony a second time — inserting qualifiers about the uncertainty of model predictions and about man's contribution to the greenhouse-gas accumulation — he took his grievances straight to Senator Gore, who played the situation for all it was worth in the media.

"He may have turned it into a circus," Stephen Schneider says of Gore, "but the circus worked. A day later the White House was on the defensive because Hansen was the opening story on the evening news on every network." Before the week was out, the White House announced it would hold a workshop on global warming to prepare for negotiations on an international treaty, a meeting eventually held in April of last year.

LAST OCTOBER HANSEN WAS HOST OF A barbecue in his backyard in Ridgewood, N.J., about 15 miles west of New York City. The festivities began at 11 A.M. with a game of softball. Hansen's team — a spirited if somewhat bedraggled group of Ph.D.'s with thin necks and thick glasses — took on Goddard's computer-support staff, tanned and brawny youths in dazzling blue and white uniforms. Hansen pitched, and in the space of half an hour gave up four home runs, the ball soaring over maple trees and across Pleasant Avenue.

With each homer Hansen, calculating the flight trajectory with a baleful expression, merely tugged at his baseball cap. No cuss words or histrionics here — this is the man who once asked a writer paraphrasing his thoughts to change "damn" to "darned."

Hansen has described himself as "overcompetitive." "Can you believe we actually beat these guys last year?" he asked as he walked off the field.

I couldn't, so I changed the subject. "Nice day for a picnic."

"Yeah," he agreed, pulling off his hat and wiping the sweat from his forehead. "Could be about 10 degrees cooler, though."

Hansen wasn't thinking about carbon dioxide. But I asked the loaded question anyway: could this unseasonably warm fall be a sign of the greenhouse effect in action? Can the man in the street judge for himself whether global warming has arrived?

"You can't stick your head out the window to look for the greenhouse effect unless you're clever enough to compare the climate to what it was a few decades ago," he said. "The problem that people have is not recognizing the magnitude of natural variability, which is large in comparison to the warming." Actual warming, Hansen believes, has been about half a degree centigrade since 1850, a quarter of a degree between 1850 and 1950 and another quarter of a degree since then.

But Hansen says the next 10 years "will tell us quite a lot." He predicts that by the end of the 1990's the world will have warmed up a few tenths of a degree. "The things that we'll see in the 1990's are not necessarily going to seem very threatening. They'll be noticeable, but probably not dramatic."

But, he added significantly, "the same models that project dramatic impacts in 30 or 40 years are predicting noticeable but small effects in the 1990's. I think the public can recognize that statistical change."

Hansen seemed at a loss for an analogy. Then, suitable to the occasion, he came up with the Yankees.

"For example, the public can recognize a significant difference in the chances of Don Mattingly getting a hit as compared to Alvaro Espinoza, even though the percentages represented by their batting averages may not seem so different."

Partly because Hansen is convinced the 1990's will be a pivotal period for climate prediction, he proposed last summer that two small, relatively inexpensive satellites could gather much of the missing data pertaining to global warming by the end of the decade.

Some of Hansen's peers have been less than enthusiastic about his idea — much less. NASA has plans to include some of the same tracking instruments on its mammoth multibillion-dollar Earth Observing System (E.O.S.) project, which is scheduled to be launched in 1998, and some NASA scientists fear that Congress will try to supplant their grand orbiting platform with Hansen's puny satellites. They are also annoyed at the way he went about presenting his ideas. Hansen waited until his proposal was virtually in print (in the National Academy of Sciences magazine) before showing it to his boss at the Goddard Space Flight Center's earth sciences directorate. He says he just forgot, then admits there may have been a method to his amnesia. "If I'd talked

to them beforehand, then I'd have gotten some input, which was the last thing I wanted."

His boss was "sorely distressed," Hansen says. "He felt that I was not supporting the institution's objectives" — meaning E.O.S. "But anyway, it doesn't really matter. Eventually these people come around."

GIVEN THE BUSH ADMINISTRATION'S recent history regarding the issue, Washington seems an unlikely place to convoke this month's global warming conference.

Last fall, climate experts meeting in Geneva issued the most sweeping policy recommendations from the scientific community to date, urging all countries to take immediate steps to reduce greenhouse gases. The report said many industrialized nations could cut carbon dioxide emissions at least 20 percent by the year 2005 with existing technologies and without significantly burdening their economies. Even

before the report, many industrialized nations had instituted plans for stabilizing greenhouse gas levels. All 12 nations of the European Community have set targets for slowing carbon-dioxide emissions generated by cars, homes and factories. Representatives from Western Europe, Japan, Australia and New Zealand stated at the conference that they could impose such restrictions at no extra cost to their economies.

But the United States, which is responsible for more than 20 percent of the world's carbon-dioxide output, has maintained that more needs to be known about global warming before major policy decisions can be made. The Soviet Union and oil producers like Venezuela and Saudi Arabia have sided with it. But the weight of international opinion is bearing down on Washington. Although United States negotiators succeeded in excluding explicit targets for emissions cutbacks from the conference declaration last fall, at this week's conference, some observers say, the Administration might have to capitulate.

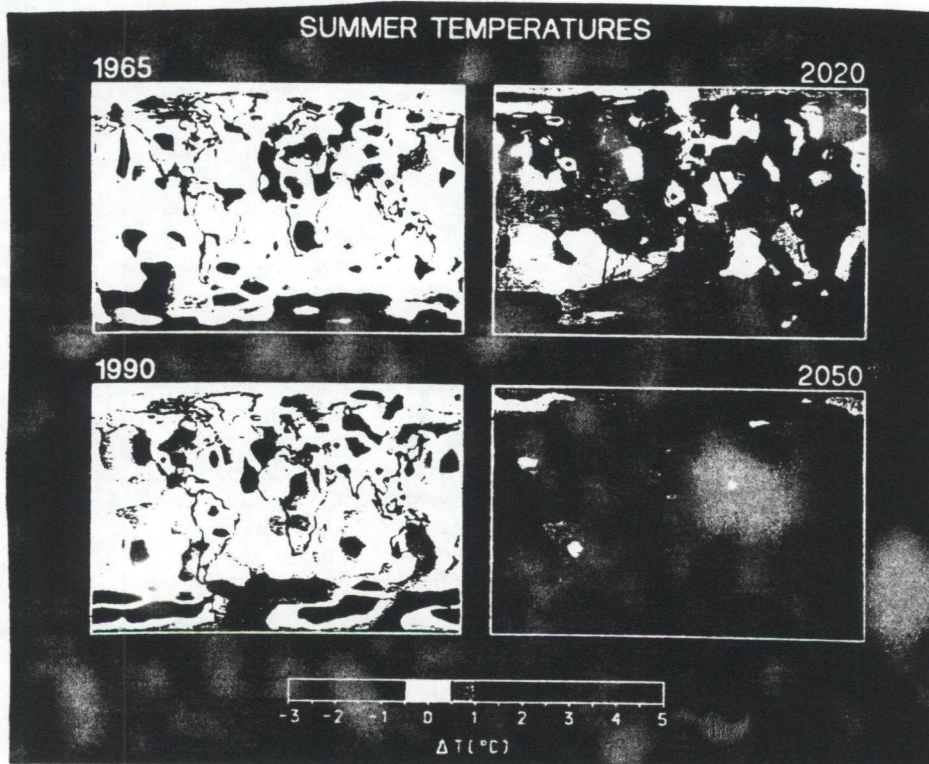
Hansen plans to observe the convention proceedings from the peaceful refuge of his office on the seventh floor at Goddard. "The argument they all make is that if you really care about this, you've gotta help publicize it," he says. "But I think that the best contribution I can make is to the science."

"We're not environmentalists; we're not trying to defend some position that we've taken in the past. We're trying to advance our understanding. We're changing the atmosphere. What's that going to do?"

"Now when the time comes," Hansen continues, "if we have a result that's important, we're not going to be bashful about presenting it."

And Hansen does indulge in a little public relations from time to time. He holds out a letter from a high-school sophomore in Connecticut who had asked him for information on global warming for a term paper. (Did he send her five pounds of background material, too, I wonder?)

"Now she wants advice on college. So I have to think about what to say to her." Hansen lapses into silence again, mulling over recommendations to a 15-year-old girl. In a few days he'll write back to Katie Mottes, stressing the importance of "being what you want to be." *If you do that, you will be more likely to do well and be happy. I have just relearned that myself.* ■



GODDARD INSTITUTE FOR SPACE STUDIES

Hansen's computer-generated models, above, illustrate changes in global temperature relative to the average 1950 to 1980 temperature. If the rate of change remains the same, the world's weather will be dramatically altered by the middle of the next century. Hansen believes, however, that there is a good possibility of reducing the growth rate of greenhouse gases, which would lead to smaller changes than those illustrated.

The Washington Post

Energy Dept. Stations Forces on Rumor Front

By David S. Broder and Haynes Johnson
AIS Washington Post Staff Writers

On the night of Jan. 17, as television monitors showed frantic scenes of the first Scud attacks on Israel and Saudi Arabia, John J. Easton Jr., an assistant secretary of energy, had the "eerie feeling" he was "living out a Tom Clancy novel."

Easton, 48, was working as the senior duty officer in the department's Emergency Operations Center. As the 12-member staff handled the flood of incoming calls from officials worried about the impact on the world's oil supplies, Easton used the secure line to Saudi Arabia and other classified information sources to prevent rumor-fed panic in the financial markets.

The same scramble had taken place when hostilities began—and would happen again when Iraqi President Saddam Hussein unleashed history's biggest oil slick on the Persian Gulf by opening the taps at a captured loading platform. In each case, a department not usually associated with ground combat had an important role to play.

That the Energy Department would have, in effect, its own war room underscores two critical facts that distinguish this war from others America has fought. However the Persian Gulf War is invested officially with moral imperatives—a battle between good and evil, as President Bush has characterized it—this war is driven by economic imperatives, specifically the crucial flow of oil for America and the industrial world.

And after the war is over, Energy will be at the center of another crucial question: Whether the government establishes a national energy policy that will make America less dependent on Middle East oil. Given the long political record of failure to achieve that goal, establishing such a national policy may prove more difficult than prosecuting the war. Already Easton worries that the nation will miss "a golden opportunity" if this war does not result in that.

For now, the emergency operation is playing its own significant part, operating round-the-clock in two cramped, window-

less rooms. Every inch of wall space is lined with maps and charts detailing the latest oil production and price figures and TV monitors bringing the latest news and weather from the gulf.

"Because of my military background," said Energy Secretary James D. Watkins, a retired admiral and former chief of naval operations, "I felt it was critical to have an accurate real-time information flow" to back the decisions officials would have to make and, equally importantly, to "dampen the fires of confusion" and set to rest "the many rumors floating around at a time like this. I told our people, 'Let's don't let world economies go down the tube on the basis of rumor.'"

So far, that has not happened. Watkins' first goal was "to deny the self-fulfilling prophecy that oil would go to \$60 to \$100 a barrel" if war broke out. Instead, the price immediately dropped \$10.56 a barrel and has stayed down.

Watkins credits "80 percent to the success of the military mission the first day," but says, "What we did buttressed that. . . . We could communicate with NYMEX [the New York Mercantile Exchange, where oil futures trade] and others if they got word that some refinery had blown up, as they did once, and we could say, 'It's not a refinery, it's a 260,000-gallon tank that's burning in northern Saudi Arabia.'"

Now that the first crises are past, a sense of quiet routine marks the operations center, which in recent years helped the department respond to lesser crises from Hurricane Hugo in South Carolina to the earthquake that damaged the San Francisco Bay area.

"Anything that happens across the nation or in the world involving energy, we have the information here and we can make the appropriate notification," explains William E. Nay, its manager.

With war, the center's staff grew ten-fold, and a schedule was established to rotate one of six assistant secretaries into the "hot seat" round-the-clock.

Nay recruited a staff of 100 people from Washington and field offices, working in shifts. The center was reconfigured and nearly doubled in size. An elaborate communications system was established, with secure phones providing quick access not only to Saudi Arabia but also to U.S. weapons plants and laboratories under DOE's control—and to "the crisis action center" at the Pentagon.

On the daily "watch desk," employees handle a steady flow of classified data, logging it into computers where it can be retrieved and analyzed.

A month after Kuwait was captured and the center began gearing up, Watkins and his emergency management team started a series of "war game" exercises. The purpose of these "worst-case" scenarios was to ensure that the department was prepared for any wartime eventuality. Watkins termed the first September drill "a dismal failure," assigning it an "F" grade. The next, three weeks later, improved minimally to a "D." The third he gave a "C minus."

After the fourth "game," in November, Watkins felt a need to make a personal trip to Saudi Arabia. He talked with Gen. H. Norman Schwarzkopf, commander of Operation Desert Storm, and met with the Saudi oil minister and the American ambassador. Out of that came the secure phone link, called "Black Gold," between Saudi Arabia and his emergency center. By the fifth and last game, on Dec. 20—"very good, fine tuning . . . an A minus"—Watkins was satisfied. His system was in place, and it worked.

Out of the "games" had come a recommended response to one of Watkins' greatest fears: Saddam's threat to use "oil as a weapon" and cause "an environmental holocaust" in the gulf. The possibility that Saddam would dump oil into the gulf was specifically examined by a team at the department's Sandia lab in Albuquerque, and an emergency solution proposed: to "ignite at the source . . . and stop it" by bombing.

Ranges Of Animals And Plants Head North

Studies in Michigan suggest shift may result from climate change. **C1**

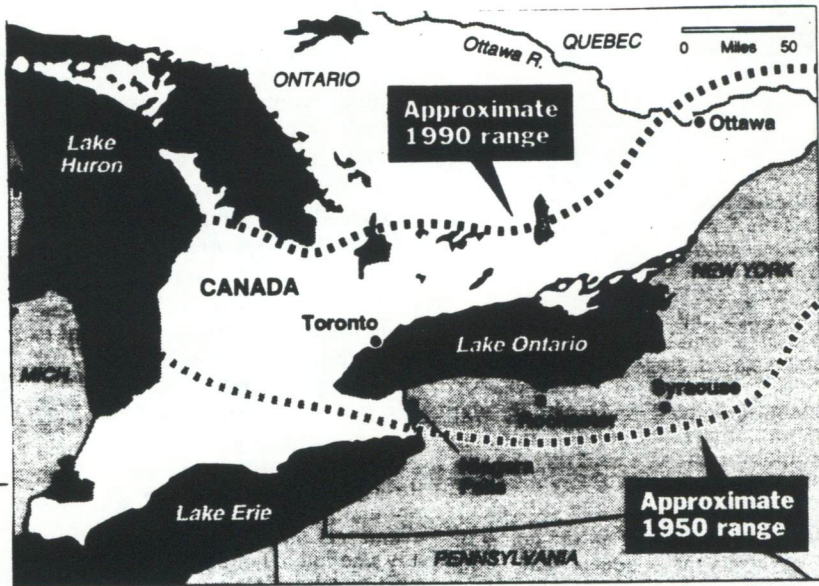
By KEITH SCHNEIDER

THE woodland deer mouse, with its long tail, big ears and powder-white belly, once was so common in the cold forests of northern Michigan that trapping it for study was hardly more difficult than collecting moths and mosquitoes. Sometime in the last 20 to 40 years, though, the deer mouse all but vanished from the woods here, its range retreating north to Michigan's upper peninsula, 30 miles away.

By itself, the deer mouse's disappearance would not have caused much of a stir along the shores of Douglas Lake, where the University of Michigan has maintained a 10,000-acre biological field station for most of the century. But a team of Michigan researchers has documented other striking changes in the geographic distribution of a dozen other plants and animals in this region.

Ferns, fish and mammals common to the southern mixed hardwood forests of the Middle West and East are moving into northern Michigan, some of them at a pace of 10 miles annually. Meanwhile, small mammals, trees and orchid plants of the north that once were plentiful at the southern edge of their range in Michigan are rapidly slipping back into Canada, their major range.

Because the research center has been collecting data for most of this century, the scientists believe the findings reflect long-term climate change, not just recent warm years that might or might not be due to global warming. Although they concede that their work does not prove the case, their study is the first formal scientific research in the United States to determine whether documented changes in species' ranges are being caused by man-made climatic change.



The range of the well-studied *Calypso bulbosa* orchid, a heat-sensitive species, has moved northward.

"It's clear there is enough circumstantial evidence now that many scientists believe the causes of these range changes deserve an immediate and intensive investigation to determine whether it is related to global warming," said Dr. James A. Teeri, director of the Michigan Biological Station, who is coordinating the research team. "The real challenge is to separate possible global warming causes from other changes in land use due to human activities."

Measuring changes in the geographical distribution of plants and animals is often an inexact scientific business. The ranges of organisms are fluid; plants and animals aggressively take ground when conditions are sweet and withdraw in the face of fire, disease, drought and other threats. To link such changes with global warming makes the issue even more murky.

There has clearly been a warming trend in the last decade. What is at issue is the cause; it may be greenhouse gases, but scientists say it is too soon to tell. Scientists in the United States and other nations have hypothesized that the warming trend is a result of industrial and agricultural gases, chiefly carbon dioxide, methane and chlorofluorocarbons, trapping infrared energy from the earth's surface and causing the heating.

Since 1870, the average temperature of the planet has risen 1.6 degrees Fahrenheit or about 1 degree Centigrade, and if a more rapid rate of increase noted over the last two decades continues, the average temperature could climb as much as 8 degrees by the end of the 21st century, some scientists say. British and American scientists said this year that 1990 was the warmest year recorded since people began measuring the planet's surface temperature. Of the 10 warmest years recorded, all have occurred since 1973.

Clues in Natural Processes

It is not yet known whether the warming trend is long term, a result of natural variability or a result of increased emissions of heat-trapping gases. Studies in the last year have sought to answer the question by looking at changes in natural processes.

Scientists have found that the snow mantle covering the Northern Hemisphere is shrinking, that the sea ice near Greenland is thinning and that the Alaskan snow melted about two weeks earlier in the 1980's than it did in the 1940's.

A study by Canadian scientists showed that the average annual temperature in a region of northwestern Ontario climbed more than 3.5 degrees Fahrenheit from the late 1960's to the mid-1980's, causing more droughts and fires and making lakes shallower and more prone to contamination. Earlier this month, scientists from the National Aeronautics and Space Administration and the United States Geological Survey said the ice cap in the Arctic Sea had shrunk 2 percent from 1978 to 1987.

But if projections of a long-term, man-made warming trend are accurate, scientists would expect to observe its results also among plants, animals and ecological systems that are affected by minute shifts in natural conditions, especially in the colder climates of the Northern Hemisphere. This is a difficult endeavor when working with living plants and animals.

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funds were unfrozen, and no notification has been given to the UN.

In initial Council consultations on the resolution, Yemen's Ambassador Abdalla Saleh al-Ashtal charged the proposed draft would in effect make Iraq a trusteeship of the UN. US Ambassador Thomas Pickering replied, according to several diplomats present, that the majority of the American people would have no complaints about that.

Diplomats on the Council say the secretary-general was also concerned about the implications of having him oversee Iraq's oil revenues. He apparently feels that the resolution would in effect turn Iraq into a trusteeship, with him as the proconsul.

The UN charter prohibits any member state from becoming a trusteeship and says relations between members are based on the principle of sovereign equality.

Ancient pines back global warming theory

Study: Trees' growth rings reflect change

By Mike Toner
Staff writer

E1

New signs of a worldwide warming trend have been detected on the slopes of a rain-swept mountain in Tasmania, where ancient pine trees are serving as nature's thermometer.

Researchers reported Friday that the annual growth rings of thousand-year-old trees on the remote Australian island show a pronounced spurt of growth that started in the mid-1960s — reflecting a sustained rise in temperatures unlike anything in the last millennium.

"The growth increase supports claims that a climatic change, perhaps influenced by greenhouse gases, is in progress," U.S. and Australian researchers report in the current issue of the journal *Science*.

Scientists at the Columbia University's Lamont-Doherty Geological Observatory say the trees, a stand of ancient Huon pines on the slopes of Tasmania's 3,500-foot high Mount Read, provide a rare and virtually unbroken record of climate that dates to the time of the Crusades.

Growth rings, alternating bands of light and dark wood that vary in width depending on a tree's annual growth rate, ordinarily reflect both rainfall and temperature. But because the Tasmanian site receives so much rain, variations in ring width primarily reflect changes in temperature — and they show that the period between 1965 and 1988 was the warmest in at least 1,089 years.

The record in the rings

What tree growth rings reveal about past climatic change.

- ▶ Huon pines (western Tasmania): Unusually rapid increase in temperatures since 1965.
- ▶ White spruce (Alaska and Northwest Territories of Canada): Uneven, but gradual warming since the late 1800s.
- ▶ Larch (Siberia): Trend toward increasing temperatures, most pronounced since mid-1900s.

Similar but less extensive tree ring studies in Alaska, Canada and Siberia also show a trend toward warmer temperature and increased growth rates.

"With some minor blips, there has been a general trend toward warmer temperatures since the late 1800s," says Dr. Gordon C. Jacoby, senior researcher at the Lamont-Doherty observatory.

Recent studies of polar ice show that the surface area of the Arctic sea covered by ice has decreased since the late 1970s, and an analysis of satellite photographs this year also suggests that Antarctica's Wordie Ice Shelf has been slowly breaking up over the past few decades.

Official temperature measurements show an uneven worldwide warming trend over the last quarter of a century. The 1980s, however, was the warmest decade on record and 1990 was the warmest year in a century of record-keeping.

Because temperature records have only been kept since the late 1880s, however, scientists can't be sure that the current warming is unprecedented until

they can see how the climate has fluctuated over a period of centuries.

So far, the Tasmanian tree rings provide one of the few reliable records of climatic conditions in the Southern Hemisphere.

Researchers can, for instance, identify the increase in growth that reflects the so-called Medieval Warm Epoch, a worldwide warming around A.D. 1100 that coincided with the establishment of Viking settlements on the previously inhospitable coasts of Greenland, Iceland and Newfoundland.

Dr. Edward Cook, who headed the U.S.-Australian research team, says it may be possible to extend the tree ring record even further back in time.

Because Huon pines contain a natural substance that makes them unusually resistant to decay, the Tasmanian forest is littered with hundreds of well-preserved trunks — some of them more than 12,000 years old.

By cross-dating the growth rings of standing trees with the ancient logs, Dr. Cook eventually hopes to develop a tree-ring climatic chronology that reaches all the way back to the time of the last ice age.

Electric bills may increase by 3.5%

Georgia Power seeks compromise rate hike

By Ben Smith III
Staff writer

CI

Residential customers will see their monthly electric bills rise an average of \$2.40 if the state Public Service Commission (PSC) agrees to a compromise struck between its staff and Georgia Power Co.

If approved, the agreement probably would avert a court appeal by Georgia Power, and would slash Georgia Power's \$384 million rate hike request by more than two-thirds, to \$117 million.

Georgia Power's original request would have raised electric bills by an average of \$8 a month.

The reduced rate hike was agreed upon by Georgia Power, the PSC staff, and eight of 12 organizations that have testified in the current rate case. It would increase residential bills by 3.5 percent.

"We're not thrilled with the settlement, but we think the process was a good one," said David Altman, a Georgia Power spokesman. "We're aware of the current economy, and frankly that helped drive our decision."

To figure how much the proposed hike could affect your Georgia Power bill, multiply a typical monthly bill by .035. An apartment dweller paying \$40 a month for electricity would watch his bill rise about \$1.40.

The average residential Georgia Power customer currently pays \$71.07 a month for electricity.

PSC Chairman Bob Durden, who recently urged a settlement in the case, said he was pleased.

"However, I will reserve final judgment on the merits until an open hearing has been held before the commission, in which all parties of record can be heard from," he said.

That hearing is expected to be held Monday. The PSC is scheduled to decide the case Sept. 30.

Danes Link Sunspot Intensity to Global Temperature Rise

The theory, if true, would mean less of a role for carbon dioxide.

By WILLIAM K. STEVENS

ARE changes in the intensity of the Sun's radiation partly responsible for the rise in global temperature that has been observed over the last century and especially over the last few years? If so, it would mean that heat-trapping atmospheric gases like carbon dioxide played a smaller role in the warming than some scientists have believed likely.

The possibility has been raised anew by Danish geophysicists. They report in the current issue of the journal *Science* that they have established a close statistical correlation between variations in the length of the sunspot cycle — which they say are an indicator of changes in the intensity of solar radiation — and fluctuations in the world's surface temperature over the last 130 years.

The analysis was made by Dr. Eigil Friis-Christensen and Dr. Knud Las-

sen of the Danish Meteorological Institute in Copenhagen.

Bush's Cautious Approach

Their finding is one of a number of new pieces of information being considered by the Intergovernmental Panel on Climate Change, an international group of scientists convened by the United Nations to make a continuing assessment of the global warming problem as new evidence develops.

In international talks on a treaty to deal with the threat of global warming, the Bush Administration has taken a cautious approach on the question of whether to reduce carbon dioxide emissions. It argues that significant reductions would be economically damaging and that not enough is known about the magnitude of the threat. Earlier suggestions that changes in solar radiation might affect the climate as much or more than the heat-trapping gases have played to the Administration's hand.

Some scientists say that if the findings of the Danish scientists are borne out by further investigation, carbon dioxide's suspected role in the warming of the last century would

have to be downgraded. But they emphasize that even then, no conclusions could be drawn as to how the climate would be affected by changes in solar radiation over the next century, since the length and intensity of solar cycles are unpredictable. Meanwhile, atmospheric carbon dioxide is expected to increase steadily as a result of the burning of fossil fuels.

To cancel out the warming that many scientists expect to come from carbon dioxide would require a decrease of 2 percent in the intensity of solar radiation, "and I don't know of anyone who believes there is that large a variability" in solar activity over a century's time scale, said Dr. James E. Hansen of the Goddard Institute for Space Studies in New York. Dr. Hansen is a foremost proponent of the view that global warming caused by humans is taking place.

He and others, including the authors of the new study, point out that the new finding is based on a statistical correlation and that no physical mechanism for the supposed variations in solar radiation has been demonstrated.

A Remarkably Close Fit

Dr. Friis-Christensen and Dr. Lassen analyzed the lengths of sunspot cycles, which vary from 9 to 13 years with an average of 11 years. Shorter cycles, they said, are associated statistically with more intense solar activity. The variations in cycle length, the scientists found, almost precisely match the fluctuations in Northern Hemisphere temperatures from the mid-1850's to the mid-1980's.

The years immediately before 1985, when temperatures were rising, coincided neatly with a period of shorter solar cycles lasting about nine and a half years. By contrast, the years from 1945 to 1970, when the climate cooled, coincided with a period of longer cycles.

While the correlation established by Dr. Friis-Christensen and Dr. Lassen falls short of definite proof, a number of scientists nevertheless called it remarkable in its close fit between the solar and temperature trends. The findings were termed "a major advance" by Dr. Robert Jastrow, a professor of earth sciences at Dartmouth College who is also the president of the George C. Marshall Institute in Washington.

In 1989, the institute issued a report, cited favorably by Bush Administration officials, which said that the last century's warming could have been caused partly by solar variability.

It also said that natural cooling factors could partly or largely offset any temperature increase caused by carbon dioxide in the next century.

A 'Gut Feeling'

Dr. Hansen said that while the Danish researchers' statistical correlation may or may not hold up, "my gut feeling, nevertheless, is that they're at least partly right." If the findings turn out to be true, he said, the varia-

tions described by the Danes "could substantially moderate or enhance" climate changes brought about by heat-trapping gases.

If the findings are ultimately borne out by physical evidence, they would advance the effort to separate from a welter of natural variations whatever amount of warming humans have contributed to a rise of about 1 degree Fahrenheit in the average surface temperature of the globe over the last century. The Danish scientists said that human-induced warming could have taken place but might have been counteracted by air-polluting sulfates produced by industrial activity. These are believed to exert a cooling effect on climate.

It is also possible, Dr. Friis-Christensen said, that some of the observed warming might be attributable to human factors and some of it to increased solar radiation.

GOING TO THE POLLS

Voters go to the polls today in an off-year cycle of state and local elections. While political pundits look for trends, voters' concerns will be closer to home. Some examples:

Incinerator pits jobs vs. environment

By Linda Kanamine
USA TODAY

WOODLAND, N.C. — An unusual new crop has popped up in this normally close-knit Southern town, signaling a bitter harvest at the polls today.

From nearly every other yard spring campaign signs: dotting manicured lawns, encircling trees. Their multitude, as much as their messages, speak volumes of the conflict polarizing neighbors.

A single issue, the proposed site of a hazardous waste incinerator, has jolted this un-political town founded by Quakers 107 years ago into its first modern campaign maelstrom.

"This has been awful. It's caused rifts in families, brothers against sisters, relatives, friends and neighbors," says opponent Willa Majette.

The controversy started when incumbent Mayor John Stanley and four council members invited incinerator company ThermalKEM Inc. to build a \$70 million facility in



AP

STANLEY: Mayor favors incinerator

Woodland — without a referendum.

In a town of 850, the incumbent officeholders face a slate of anti-incinerator challengers in today's election.

"It's like a Rip Van Winkle thing. People have been here, but haven't really paid attention. All of a sudden, they wake up," says proponent Pat Liverman.

There's plenty to watch: Stanley, who's also the only town doctor, faces serious opposition for the first time in 27 years.

"If we win, democracy will thrive here in a small town," says mayoral candidate William Jones, who painted a 10-foot "NO" on his tin roof.



By Brad Isbell, AP

CANDIDATES: Thomosena Boone, left, and Jean Justice urge Woodland, N.C., voters to say NO.

So hot is a jobs vs. environment battle that a 90% turnout is predicted — some of that by the town's black residents, who generally oppose the incinerator and see the issue as an opportunity to gain representation on the town board.

"Somebody needs to speak for the black community," says anti-incinerator candidate Thomosena Boone, a sausage company manager and 41-year resident.

Also drawing attention to Woodland's virulent campaign have been the juicy trademarks of local politics: hot dog roasts and pig-picking rallies, accusations of lying, personal attacks, secret meetings and sign wars.

When opposition candidate Jean Justice saw one man taking down her campaign flier, "I chased him around town," she says.

Despite the onslaught against his slate, Stanley is steadfast in support for the incinerator project, especially its 300 jobs. "I'm satisfied it was a safe operation. I'd do the very same thing again. We're desperate."

ENVIRONMENT

Bring Back the Ozone Layer!

But wait: there's evidence that patching the hole will make the greenhouse effect even worse

No wonder politicians curse the environment. After intense horse-trading, arm twisting and agonizing, 93 industrialized nations agreed in 1990 to phase out by the year 2000 chemicals that destroy the Earth's protective ozone layer. The developing world agreed to do the same by 2010. But if they thought this move would save the planet's shield against ultraviolet radiation, they were in for a nasty shock. Last week scientists convened by the United Nations Environment Program unveiled satellite data showing summertime ozone loss of 3 percent in the 1980s. That was triple the loss in the 1970s. Worse, it came during the season when sun worshipers broil at the beach and crops (some of which are damaged by ultraviolet radiation) approach harvest. "The ozone layer is peeling away," said physicist Michael Oppenheimer of the Environmental Defense Fund. "And we have no idea how bad it can get."

But scientists have been seeing hints all year. In April the U.S. Environmental Protection Agency announced that the ozone layer is now 5 percent thinner over the Northern Hemisphere in winter and early spring than it was a decade before. That portends more cases of UV-induced cataracts and skin cancer—an extra 12 million cancer cases among Americans over the next 50 years. Already, skin-cancer rates have doubled since 1980. Even more dispiriting, the ozone is slipping away despite the best-intentioned steps to save it. By next year, for instance, the United States will halve its production of chlorofluorocarbons (CFCs), the chemicals primarily responsible for ozone loss, from 1986 levels. By 1997, Du Pont, the world's largest CFC maker, will stop producing these refrigerants and foam blowers, the company announced last week; several major German firms will beat that by two years. And EPA Administrator William Reilly told NEWSWEEK that his agency persuaded China, which had been planning to build 300 million CFC-cooled refrigerators, to use substitute coolants instead. All this will help, but not as much as once hoped. Robert Watson of NASA calculates that the ozone layer will still thin at least another 3 percent in the 1990s. And even if CFCs were banned tomorrow, so many tons of the gases are on the way to the stratosphere that it would take until the middle of the next century for the ozone layer to recover.

Can anything be done? Reilly is calling for "a reconsideration of all efforts underway to respond to" ozone depletion. That means banning CFCs before the millennium, as the 93 nations will consider when they meet in Copenhagen next August. It means, too, tackling other ozone eaters, such as halons. These gases can extinguish fires in a split second. Halon systems were standard equipment in tanks on both sides during the gulf war. They are also ubiquitous around expensive computer installations, a use for which there are no good

planet. So if nations manage to patch the ozone, the world may well heat up, exacerbating the greenhouse effect that threatens to cause sea levels to rise, ferocious storms, droughts and heat waves. In fact, if not for ozone loss, the greenhouse effect might have been more pronounced by now. That finding may settle an ongoing, and frequently nasty, greenhouse debate. Given how much carbon dioxide and other heat-trapping gases have been belched out of power plants and cars in the last 100 years, the Earth should be warmer than it is; since it's not, argue skeptics, the greenhouse theory must be wrong. The ozone effect may explain why the Earth is only slightly warmer than the historical norm despite the buildup of greenhouse gases.

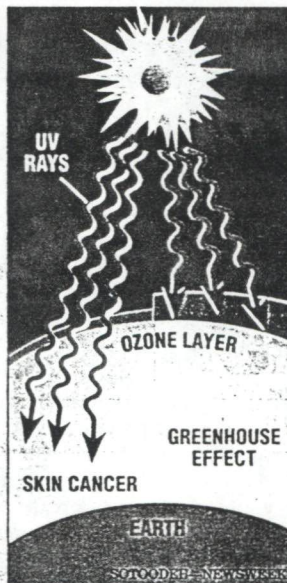
The United States is counting on stemming the greenhouse effect by eliminating CFCs. But if doing so will simultaneously fatten the ozone layer, and thus cause warming, we need other solutions. UNEP's Mostafa Tolba said last week that the tar-

An Atmospheric Catch-22

There are two crises in the skies: the thinning ozone layer and the steady accumulation of greenhouse gases. It now appears that they're related.

More CFCs

- 1 CFCs, chemicals used as coolants and fire extinguishers, destroy ozone in the stratosphere.
- 2 A thinner ozone layer absorbs less UV radiation than a thicker layer. The less UV absorbed, the cooler the stratosphere.
- 3 But the increased UV from a thinner ozone layer is harmful. Result: more skin cancer and, possibly, damage to crops and marine life.



Less CFCs

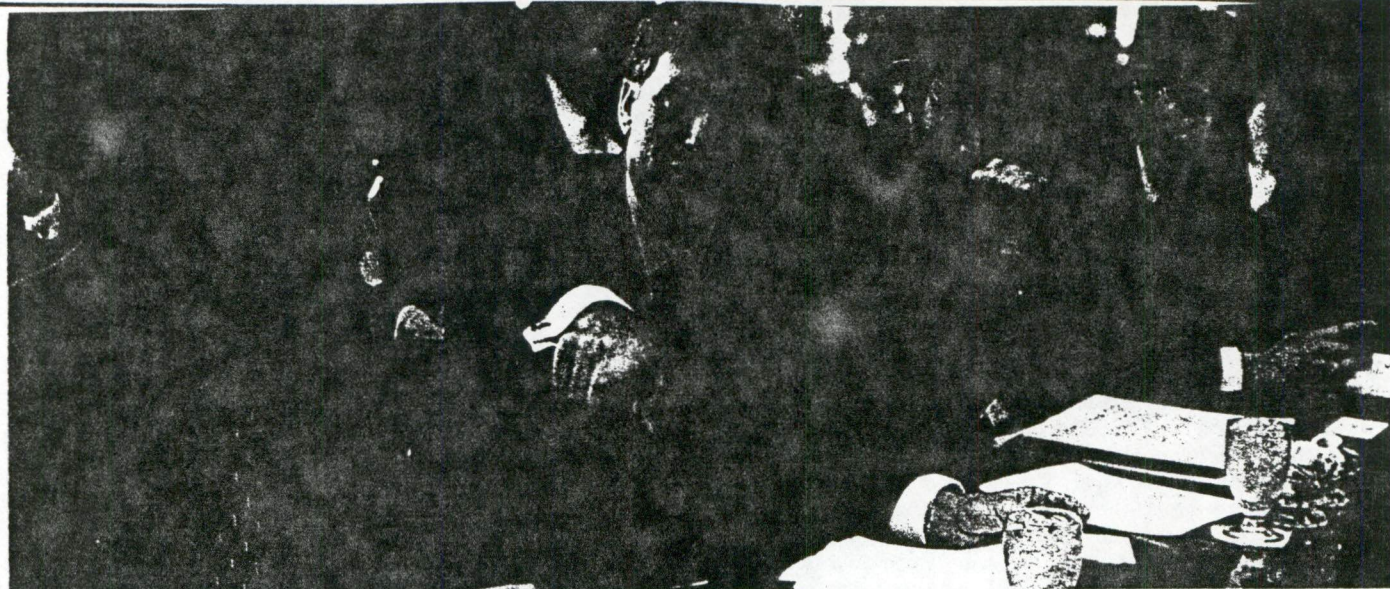
- 1 If CFCs are curtailed, the ozone layer will eventually repair itself. Result: more UV absorbed in the stratosphere.
- 2 The less UV reaching the planet's surface, the fewer cases of skin cancer and cataracts.
- 3 But a thicker ozone layer, absorbing more UV, will be warmer. It will radiate more heat toward Earth, worsening the greenhouse effect.

substitutes yet. Another voracious ozone eater is methyl bromide, a crop fumigant. Controlling its use, says Susan Solomon of the National Oceanic and Atmospheric Administration, would have a "rapid and large influence on the ozone layer."

But there may be a downside to fixing the ozone problem. New data suggest that, even though CFCs warm the planet, ozone depletion cools it. That's because when ozone absorbs UV rays the stratosphere warms (diagram). Less ozone, therefore, means a cooler stratosphere and a cooler

get must be carbon dioxide (CO₂), the chief heat-trapping gas. But the United States argues that controls on CO₂—switching to nonfossil fuels, requiring higher-mileage cars and energy-efficient factories, for instance—will prove too costly. The Bush White House has expressed little interest in CO₂ limits. Humans have turned the atmosphere into a giant chemistry experiment, and we have precious little idea how to control it.

SHARON BEGLEY with
MARY HAGER in Washington



STEVEN PUNCELL—THE WHITE HOUSE

Lacking a high-profile role, the Vice President jumped in with both feet to make the council a powerful body

TIME, NOVEMBER 4, 1991 25

THE ADMINISTRATION

Need Friends in High Places?

For industries trying to skirt the law, Dan Quayle's Council on Competitiveness is a good place to start

By MICHAEL DUFFY WASHINGTON

William Reilly thought he had a deal. The besieged chief of the Environmental Protection Agency was certain Dan Quayle had agreed that any piece of land that was flooded or saturated with water for 15 consecutive days a year would constitute a "wetland" and deserved protection from private development. The next day Reilly received a call from Allan Hubbard, who heads Quayle's Council on Competitiveness, telling him the deal was off. Within days the council hatched a new plan, narrowing the definition of "wetness" by six extra days, satisfying a powerful coalition of farmers and builders and reducing America's wetlands by as much as 30 million acres.

Reilly was privately steamed. If George Bush persuaded Congress last year to pass most of his kinder, gentler legislation untouched, Quayle's Council on Competitiveness is spending much of this year making sure that the new environmental and health laws are as beneficial to business as possible. California Democrat Henry Waxman calls the council a "shadow government." Senator Albert Gore believes that the mysterious body allows Bush to pose as an environmentalist long enough "to justify a television commercial. Then, behind the scenes, the [council] guts the law."

Bush created the panel in 1989 but gave it new powers a year later, when he began hearing complaints from friends that his government was reregulating industries that the Reagan Administration had sought to deregulate. Not long afterward, the President appeared before aides one

morning waving a newspaper clipping about reregulation and asking, "What's going on here?" Bush, who headed a task force on regulatory relief as Vice President, asked Quayle to review new regulations to make sure that costs would not outweigh benefits. Lacking a high-profile White House role at the time, Quayle jumped in with both feet.

This is no renegade operation: Bush, chief of staff John Sununu and Budget Director Richard Darman are fully apprised of the panel's activities. When such agencies as the EPA and the White House differ over how aggressively to implement a law, the council moves in to referee. Staffed by fewer than a dozen officials, who are, even by Bush White House standards, unusually conservative, the council regularly sides with business against the environment. Even Administration officials marvel at how powerful the body has become. "Because Quayle has Bush's total confidence," said a former Administration official, "nobody can touch those guys."

The council's favorite target is the 1990 Clean Air Act, which the White House backed but now fears will cost more than \$26 billion to implement. Last summer the council asked the EPA to make more than 100 changes in proposed regulations for carrying out the act, changes that top EPA officials say undercut the law. The most controversial proposed change would allow polluters to unilaterally increase their emissions if states ignore a waiver request for more than seven days. "You could drive a big truck through some of those holes," said a top EPA official.

The council has also opposed an EPA

plan to require liners and leachate collection systems at all new solid-waste landfills. For nearly a year, the council argued that the plan was too costly, though other officials noted that in the past five years no city has permitted the construction of a new landfill without such equipment. The nation is short on landfills, and the rules for creating new sites are already three years behind schedule.

Hubbard, a gregarious Indiana entrepreneur who ran Pierre du Pont's 1988 presidential bid, points out that those who object to the council's rulings are free to mount challenges in the courts. Hubbard says the council's goal is to improve the nation's competitiveness, not to shelter industry from regulation. "The higher the cost of the regulation, the higher the cost of the product to the consumer," he explains. "Our whole effort is to protect the consumer and the American worker."

There's a little more to it than that. The council is potentially a political gold mine for Quayle, who often refers businesspeople with complaints about government meddling to his eager staff of deregulators. The council spearheaded Quayle's attack on lawyers and excess litigation last August, and is preparing to move beyond reviewing new regulations to tackling rules already in place. While Quayle's detractors dismiss the Vice President as silly and feckless, his shrewd handling of the council's affairs is just another sign that he is taking full advantage of his office.

For Bush, who in the midst of a sluggish recovery can neither pass out tax cuts nor launch spending programs to promote economic growth, the council is "the only game in town," an official said. "The one thing that can cause George Bush problems in 1992 is the recession." The council also exemplifies Bush's have-half approach to political problems. In 1992 he can run as an environmentalist while telling industrialists he's on their side too.

—With reporting by Dick Thompson/Washington

**The United States
Man and the
Biosphere
Program**



The United States Man and the Biosphere Program (U.S. MAB) fosters harmonious relationships between humans and the biosphere through an international program of policy-relevant research which integrates the social, physical and biological sciences to address actual problems. U.S. MAB is supported by the United States Department of Agriculture-Forest Service, the United States Department of Energy, the United States Department of the Interior-National Park Service, the United States Department of State, the Agency for International Development, the Environmental Protection Agency, the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, the National Science Foundation, the Peace Corps, and the Smithsonian Institution.

Inquiries concerning the U.S. MAB Program should be addressed to the U.S. MAB Secretariat, OES/EGC/MAB, United States Department of State, Washington, D.C. 20522-0508.

DEPARTMENT OF STATE PUBLICATION 9798
Bureau of Oceans and International Environmental
Science and Technology

BUSH LIBRARY PHOTOCOPY

Released July 1990

The varied yet characteristic uses of the landscapes make them particularly suitable for interdisciplinary studies to support regional planning for conservation and rural development.

The buffer zone, and more often the transition area, include areas where manipulative management can be practiced. Experimental Research Areas are used to discover ways to manage vegetation, wildlife, croplands, forests and other natural resources to enhance production while conserving natural processes.

Modified or degraded landscapes are often used as rehabilitation areas to promote the development and demonstration of methods to restore natural conditions or return these areas to sustainable development.

Where possible, biosphere reserves also include landscapes resulting from traditional patterns of land use. Such areas provide opportunities to document traditional knowledge and explore new ways to apply it.



A stylized ankh, the ancient Egyptian sign for life, has been incorporated into the symbol of UNESCO's Program on Man and the Biosphere (MAB.)



THE UNITED STATES MAN AND THE BIOSPHERE PROGRAM

An Overview

The blue-marble picture of Earth from 23,000 miles in space was the first full-length portrait of the Earth that mankind had seen. Its effect was profound. From that distance, it was apparent that the Earth is whole, and that the only fragmentation is in perception—created and perhaps existing in the human mind.

Ever since that picture-postcard arrived from outer space, human beings have been trying to patch their fragmented perception of the environment into something that resembles the whole.

The Man and the Biosphere Program (MAB) is one of the most promising efforts in that direction. It attempts to bind fragmented disciplines into a tool for understanding humans and their relationship to their environment, as well as in coordinating the efforts of many nations toward this understanding.

MAB International Program

The objective of the Man and the Biosphere Program (MAB) is to develop a scientific basis linking the natural and social sciences for the rational use and conservation of the biosphere—that portion of the Earth which contains living organisms—and for the improvement of the relationship between humans and their environment.

MAB was established at the 1970 General Conference of the United Nations Educational, Scientific and Cultural Organization (UNESCO) when initial plans were approved and the governing body, the International Coordinating Council (ICC) for MAB, was chartered.

In many ways, MAB builds on the former International Biological Program (IBP), but differs from IBP in that MAB is intergovernmental in structure and oriented toward solving management problems arising from the interactions between human activities and natural systems. MAB is an integrated, interdisciplinary, problem-focused research approach. MAB seeks to provide a bridge between fundamental science and technological applications.

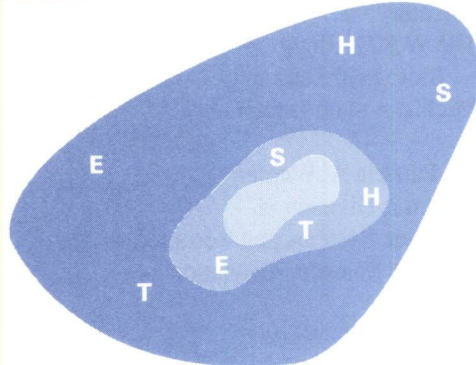
MAB provided the first formal mechanism for bringing together and coordinating diffuse national and international research, conservation and training activities. In the United States, for example, 46 areas have been designated to be part of an international network of more than 285 biosphere reserves. Biosphere reserves are unique multipurpose areas dedicated to both conservation of characteristic ecosystems and

A core area consists of examples of minimally disturbed ecosystems characteristic of one of the Earth's terrestrial or coastal/marine regions. It provides a suitable habitat for numerous plant and animal species, including higher order predators. The core area may contain centers of endemism or high biological diversity. Core areas often conserve the wild progenitors of economic species, such as valuable timber trees, or serve as important genetic reservoirs for observing particular species, features or processes. A core area has secure domestic legal protection and only activities that do not adversely affect natural processes and wildlife are allowed. For this reason, strictly protected nature reserves and wilderness portions of national parks often serve as core areas of biosphere reserves.

In the buffer zone (sometimes referred to as the zone of managed use), uses of resources and activities in the area are managed in a way that helps to protect the core area. The outer boundaries of the buffer zone often coincide with those of a national park, wildlife refuge or multiple-use area.

The outermost part of a biosphere reserve is the transition area. This is usually an unlimited, dynamic zone of cooperation in which conservation knowledge and management skills are applied. The area may contain settlements, croplands, managed forests, areas for intensive recreation or other economic uses characteristic of the region.

MODEL BIOSPHERE RESERVE



- | | | | |
|---|------------------------|----------|-----------------------------------|
|  | Core Area | E | Experimental Research Area |
|  | Buffer Zone | H | Rehabilitation Area |
|  | Transition Area | S | Settlement |
| | | T | Traditional Use Area |

Model Biosphere Reserve

A biosphere reserve is a unique category of protected area dedicated to solving problems associated with the effects of human impacts, over time, upon natural ecosystems.

A model biosphere reserve consists of a core area, a buffer zone which adjoins or surrounds the core area and a transition area.

species, as well as managing land, water and resources for sustainable development to meet human needs.

Over 110 nations currently participate in the MAB program. In each country, a MAB national committee defines and organizes specific national activities to be under the aegis of MAB. The United States MAB Program collaborates with the MAB Programs of other nations both on a bilateral basis and through the international MAB secretariat at UNESCO.



U.S. MAB Program

In 1974, the U.S. Department of State established a U.S. National Committee for the MAB Program composed of representatives from supporting federal agencies and state and private institutions, which guides the development of national research, education and training activities. Under its direction, United States Man and the Biosphere Program (U.S. MAB) projects are administered by groups, called directorates, of selected experts whose chairs also serve on the U.S. National Committee.

The mission of U.S. MAB was defined in January 1989:

“to foster harmonious relationships between humans and the biosphere through an international program of policy-relevant research which integrates social, physical and biological sciences to address actual problems. These activities, broadly interpreted, include catalytic conferences and meetings, education and training, and the establishment and use of biosphere reserves as research and monitoring sites.”

The U.S. National Committee for the Man and the Biosphere Program is chaired by Thomas E. Lovejoy, Assistant Secretary for External Affairs, of the Smithsonian Institution. Current institutional members of the National Committee represent supporting federal agencies. They are:

Department of Agriculture-
Forest Service;
Department of Energy;
Department of the Interior-
National Park Service;
Department of State;
Agency for International
Development;
Environmental Protection
Agency;
National Aeronautics and
Space Administration;
National Oceanic and
Atmospheric Administration;
National Science Foundation;
Peace Corps; and
The Smithsonian Institution.

Dr. Patrick J. Webber
Chair, Directorate on
High Latitude Ecosystems

Director
The W.K. Kellogg
Biological Station
Michigan State University

Dr. Patricia A. Werner
Director, Division of
Biotic Systems and Resources
National Science Foundation

Dr. Gilbert F. White
Institute of Behavioral Science
University of Colorado

Dr. Robert G. Woodmansee
Director
Natural Resource Ecology Laboratory
Colorado State University

Note: For further information on U.S. MAB activities or if you would like to receive the *U.S. MAB Bulletin*, published quarterly, please contact:

The U.S. MAB Secretariat
OES/EGC/MAB
Department of State
Washington, D.C. 20522-0508
U.S.A.
Tel. (202) 632-2816 or
632-2786.

For specific information on the international MAB Program, please write to:

The MAB Secretariat
Division of Ecological Sciences
UNESCO
7, place de Fontenoy
75700 Paris, France.

Dr. Roberta B. Miller
Chair, Directorate on
Human Dominated Systems
Director
Division of Social and Economic Science
National Science Foundation

Dr. Robert J. Naiman
Chair, Directorate on
Temperate Ecosystems
Director
Center for Streamside Studies in
Forestry, Fisheries and Wildlife
University of Washington

Dr. Paul G. Risser
Vice President for Research
University of New Mexico

Dr. Eldon W. Ross
Associate Deputy Chief for Research
Forest Service
Department of Agriculture

Dr. Roger E. Soles
Executive Director
U.S. MAB Secretariat
Department of State

Dr. Shelby G. Tilford
Director, Earth Science and
Applications Division
National Aeronautics and Space
Administration

Dr. Jack Vanderryn
Agency Director for Energy
and Natural Resources
Agency for International Development

Additional members of the Committee are from U.S. universities and private sector organizations. The Chairman of the Committee is appointed by the Department of State. The U.S. MAB Secretariat operates within the Office of Global Change of the Bureau of Oceans and International Environmental and Scientific Affairs of the Department of State.

The Way U.S. MAB Works

During 1989, the U.S. National Committee for the Man and the Biosphere Program directed that the Program reflect current understandings of global and scientific interrelationships. Five program directorates were organized to provide increased opportunities for cross disciplinary collaboration among biological/natural and social scientists. These U.S. MAB Program directorates are:

High Latitude Ecosystems;
Human Dominated Systems;
Marine and Coastal Ecosystems;
Temperate Ecosystems; and
Tropical Ecosystems.

The U.S. National Committee also established an inter-directorial Coordinating Committee on Biosphere Reserves.

The U.S. National Committee directed that the membership of the program directorates reflect a balance of experts between social and biological/physical scientists, as well as between federal and private sector scientists and individuals who are appointed for a 3-year term. The representative of a supporting government agency on a directorate ensures that a link is

forged between the products of the directorate's activities and their consideration by the agency's policy and program decision makers. At present, some 25 universities are represented among the scientists and managers who are serving on the various directorates.

Each directorate has a mission statement to reflect its basic framework and goals for research, training and project implementation. The directorate initiates proposals for activities, or requests that other interested parties do so, and the directorate takes over the role of coordination and review.

U.S. MAB pursues its objective through competitively funded, peer-reviewed projects of both its program directorates and awards to U.S. individuals or interdisciplinary teams of scientists received in response to an annual Request for Proposals (RFP). The RFP is printed each summer in the *Federal Register* and in the *U.S. MAB Bulletin* and is reprinted in various scientific and research journals.

The program missions of the new directorates are as follows:

Directorate on High Latitude Ecosystems

Special emphasis has been placed on the high latitude regions of the Earth as potentially responding earliest to the possibility of global warming, responding more rapidly than tropical or temperate regions, and being subject to the greatest magnitude of warming. They include the zones of continuous and discontinuous

Dr. Arthur W. Cooper
Head, Department of Forestry
College of Forest Resources
North Carolina State University

Mr. Paul Coverdell
Director
The Peace Corps

Dr. Sylvia Earle
Chief Scientist
National Oceanographic and
Atmospheric Administration
Department of Commerce

Dr. F. Eugene Hester
Associate Director for Natural Resources
National Park Service
Department of the Interior

Dr. Michael A. Little
Professor, Department of Anthropology
State University of New York, Binghamton

Dr. Ariel Lugo
Chair, Directorate on
Tropical Ecosystems
Project Leader
Institute of Tropical Forestry
Southern Forest Experiment Station
Forest Service
Department of Agriculture

Dr. Helen C. McCammon
Director, Ecological Research
Department of Energy

Mr. Samuel McKee
Former Chairman,
U.S. MAB National Committee
Office of International and Territorial Affairs
Department of Education

**U.S. NATIONAL COMMITTEE
FOR THE MAN AND THE
BIOSPHERE PROGRAM**

Dr. Thomas E. Lovejoy
Chairman, U.S. MAB
Assistant Secretary for External
Affairs
The Smithsonian Institution

Mr. E. U. Curtis Bohlen
Assistant Secretary
Bureau of Oceans and International
Environmental and Scientific Affairs
Department of State

Mr. Erich W. Bretthauer
Assistant Administrator for
Research and Development
Environmental Protection Agency

Dr. James M. Broadus
Chair, Directorate on Marine
and Coastal Ecosystems
Director
Marine Policy Center
Woods Hole Oceanographic Institute

Dr. Stephen B. Brush
Administrator
International Agricultural Development
Graduate Group
University of California, Davis

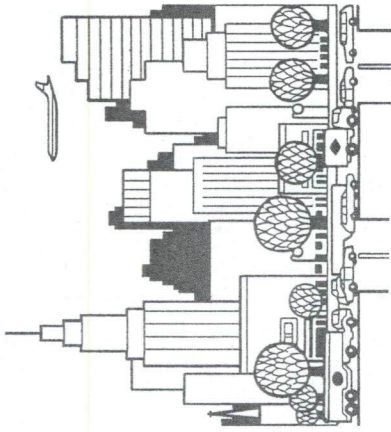
Dr. David Challinor
Science Advisor to the Secretary
The Smithsonian Institution

permafrost and some of the most undeveloped land areas of the northern hemisphere. These regions support indigenous human populations, which, until very recently, have been practicing a relatively stable subsistence lifestyle.

Now these regions are undergoing rapidly accelerating social change, including increasing pressure for resource extraction, growing resident populations as a result of population migration from lower latitudes, and, concurrently, increased scrutiny of resource use and decisions concerning their management.

Among the areas of interest to the Directorate on High Latitude Ecosystems for concentrated project activities and proposed research are:

- Sustainable resource management and cultural development;
- Monitoring for global climate change, potential implications for biological productivity, engineering works and transportation systems, and resident human populations;
- Maintaining aquatic areas and wetlands;
- Maintaining and protecting biological diversity; and
- Cooperation in research and policy development to recover any systems that are lost or are in the process of being damaged.



- Tropical forest restoration;
- Producing management plans that outline the steps for restoring tropical landscapes, or wetlands;
- Improving communication between social and natural scientists or managers who are working on the conservation of tropical ecosystems; and
- Generating data bases which contain available solutions to the problems of natural resource management in the tropics.

Directorate on Human Dominated Systems

There are many circumstances in which human activity has so profoundly altered the underlying ecosystems that a very different environment is created. Present day population growth levels have caused such ecosystem alteration more rapidly and over wider areas than ever before, resulting in urbanization and intensification of agriculture that present tremendous problems for human health and continued food production. Other processes, such as mining and resource extraction, and tourist developments also create altered and distinct ecologies dominated by humans. Many of these areas suffer from severe problems such as air pollution in cities, soil degradation and tropical deforestation in relation to agriculture, and the loss of beaches and coastal areas due to the expansion of various

U.S. MAB Coordinating Committee for Biosphere Reserves

Each directorate chair designates one member to serve on the U.S. MAB Coordinating Committee for Biosphere Reserves along with representatives from each of the supporting federal agencies and several from the private sector. This committee aims to strengthen the biosphere reserve program within U.S. MAB by encouraging pilot projects that demonstrate the biosphere reserve concept in practice; networking among biosphere reserve managers; and developing management programs that conserve characteristic ecosystems and species, as well as managing land, water and resources for sustainable development to meet human needs.



Directorate on Tropical Ecosystems

Dramatic changes in land-use have had enormous effects on maintenance and quality of life of people in the tropical latitudes. The magnitude of the change is affecting the biological diversity of the planet, causing losses of precious genetic material, changing the chemistry and composition of the oceans and the atmosphere, seriously depleting the fertility of soils and nature's ability to replenish that fertility, changing the climate of the Earth and greatly influencing the biogeochemical cycles of the planet.

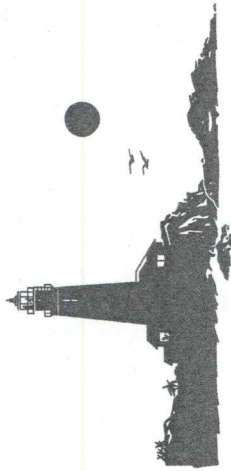
Therefore, governments, researchers, resource managers, local communities and resource users in the tropics are concerned with how we can stem the tide of negative global change and protect the biological diversity, while also providing conditions supportive of the growth and development of social systems needed to maintain a healthy human population.

Among the areas of interest to the Directorate on Tropical Ecosystems for concentrated project activities and proposed research are:

kinds of development. As a result, the capacity of natural systems and the viability of various types of human interventions need to be better understood.

Among the areas of interest to the Directorate on Human Dominated Systems for concentrated project activities and proposed research are:

- Quantifying the intensity of an activity that can be supported without causing the collapse of life support systems essential to the activity;
- Assessing the role of population size and distribution on various environmental changes;
- Analyzing anthropogenic causes of the "greenhouse effect" and costs to control;
- Identifying immediate health effects and indirect effects of groundwater pollution, chemical run-off, atmospheric pollution or climate change;
- Identifying methods for improving the integration of ecosystem considerations in human decision making processes as they relate to resource and ecosystem management; and
- Identifying and analyzing methods for maintaining or restoring important life support systems.



Among the areas of interest to the Directorate on Temperate Ecosystems for concentrated project activities and proposed research are:

- Human modification of ecosystem structure and function, with implications for ecosystem productivity, sustainability and resilience;
- Adaptation of human populations to economically marginal or increasingly hazardous environments;
- Development and application of environmental management practices that provide for both commodity production and preservation of biological diversity; and
- Adoption of soil conservation practices in arid and semi-arid temperate ecosystems with declining productivity.

Directorate on Marine and Coastal Ecosystems

The oceans regulate the Earth's ecological balance and moderate both global climate conditions and local weather patterns. Far ranging ocean currents can transport pollutants from one area to another, and environmental damage in one place can impair natural habitats at distant locations.

Growing problems of marine pollution, habitat degradation and biological impoverishment are found in a number of the Earth's poorly mixed coastal waters, especially those associated with population centers, industrial activity and river inputs. An association of these problems with population growth, economic growth and development is readily apparent, but it need not be inescapable. Investments in environmental quality for marine and coastal ecosystems, leading to improved human welfare, can contribute to economic growth just as can expanded infrastructure. The Directorate will manage and will encourage project activities and research on the biogeography of marine and coastal ecosystems and their influences upon and interdependencies with human activities and well-being.



Directorate on Temperate Ecosystems

The temperate zone is occupied by the most industrialized nations on Earth and contains about two-thirds of the population. Consequently, human activities have had substantial impacts on natural ecosystems and on ecological processes. The per capita rates of resource consumption and pollution are far higher than in other latitudinal zones, and modifications to natural ecosystems are extensive.

The temperate zone encompasses a wide variety of ecological systems ranging from forests in wetter regions to grasslands and deserts in dryer regions and in aquatic ecosystems such as lakes, rivers and freshwater wetlands.

Among the areas of interest to the Directorate on Marine and Coastal Ecosystems for concentrated project activities and proposed research are:

- Assessment of sources, impacts and control of marine pollution, including, but not limited to nutrient loading and eutrophication, siltation and relationships to freshwater resources;
- Analysis of sea level rise, coastal erosion and other land-margin disturbances;
- Assessment of habitat loss or alteration, including implications for biological diversity;
- Identification and estimation of means for and benefits of preservation of traditional marine and coastal uses;
- Clarification of relationships between natural fluctuations and human perturbations, as with red tides and harmful algal blooms;
- Innovative investigation of fisheries and other living resource management issues, especially related to the above.

