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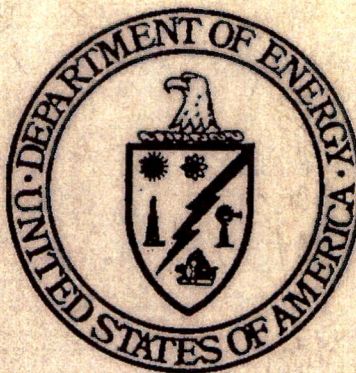
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Global warming

OFFICE OF THE SECRETARY

FACSIMILE TRANSMITTAL SHEET

DATE September 21, 1992TO Richard PorterFAX NUMBER 456-6216OFFICE NUMBER 456-6640COMMENTS FYI.FROM Linda G. StuntzFAX NUMBER 586-0148OFFICE NUMBER 586-5500NUMBER OF PAGES INCLUDING COVER 2

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Department of Energy
Washington, DC 20585

TO: Global Warming
LGS

September 18, 1992

We should not get
into protocol development
at this time.

MEMORANDUM FOR HOWARD GRUENSPECHT

FROM: Ed Watts (EP-63) *EW*
SUBJECT: Gore Testimony on Rio Follow-up

At a hearing today before the Senate Foreign Relations Committee, Sen. Gore called for the following actions in response to the signing of the Framework Convention on Climate Change:

- o Initiation of an open public process to develop the U.S. action plan promised for January 1993.
- o A meeting of the Parties in January 1993 to review the progress made in implementing the Convention.
- o Development of a protocol to assure "meaningful reductions".
- o Affirmation in November that the IPCC will continue as an independent scientific body.

Sen. Gore also mentioned that he and Sen. Biden would be introducing legislation to encourage U.S. exports of environment-related technology and that he would be making a proposal to re-orient the work of the national labs more toward the development of environmental technology.

↳ This is potentially a problem. Given that we are already at the end of Sept, this doesn't seem possible. In any event, the January 1993 (really December 1992) action plan is not a major milestone. Perhaps we can use the NES public process as a way to ~~satisfy~~ involve the public.

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WARMING THEORIES NEED WARNING LABEL

By S. FRED SINGER

The debate over global warming has been more hype than solid fact.

The conventional wisdom these days seems to be as follows: increasing carbon dioxide from burning fossil fuel is enhancing the natural atmospheric greenhouse effect. By the next century, the resulting global warming will present a clear and present danger to humankind. We need to find radical solutions as quickly as possible to avert catastrophes—including violent weather, parched farmlands, rising sea levels, flooded continents, complete ecological collapse, and millions of environmental refugees. I suppose that many readers of the *Bulletin* would agree.

Furthermore, some of the more ardent proponents of global warming theories seem to believe that it is somehow inappropriate, if not downright immoral, for any scientist to emphasize the theories' uncertainties. Their argument seems to be that it is better for national governments to do something, however costly (even if it turns out that warming theories are wrong), rather than risk waiting for more certain and persuasive data.

It is not surprising that such views are widely held. After all, the public has been exposed to a steady diet of hyped news stories and TV specials and propagandized by environmental pressure groups. However, these views are not shared by all specialists in atmospheric physics or climatology—scientists who actually study these problems. There is no scientific consensus in support of a greenhouse warming threat.

A growing number of experts have become

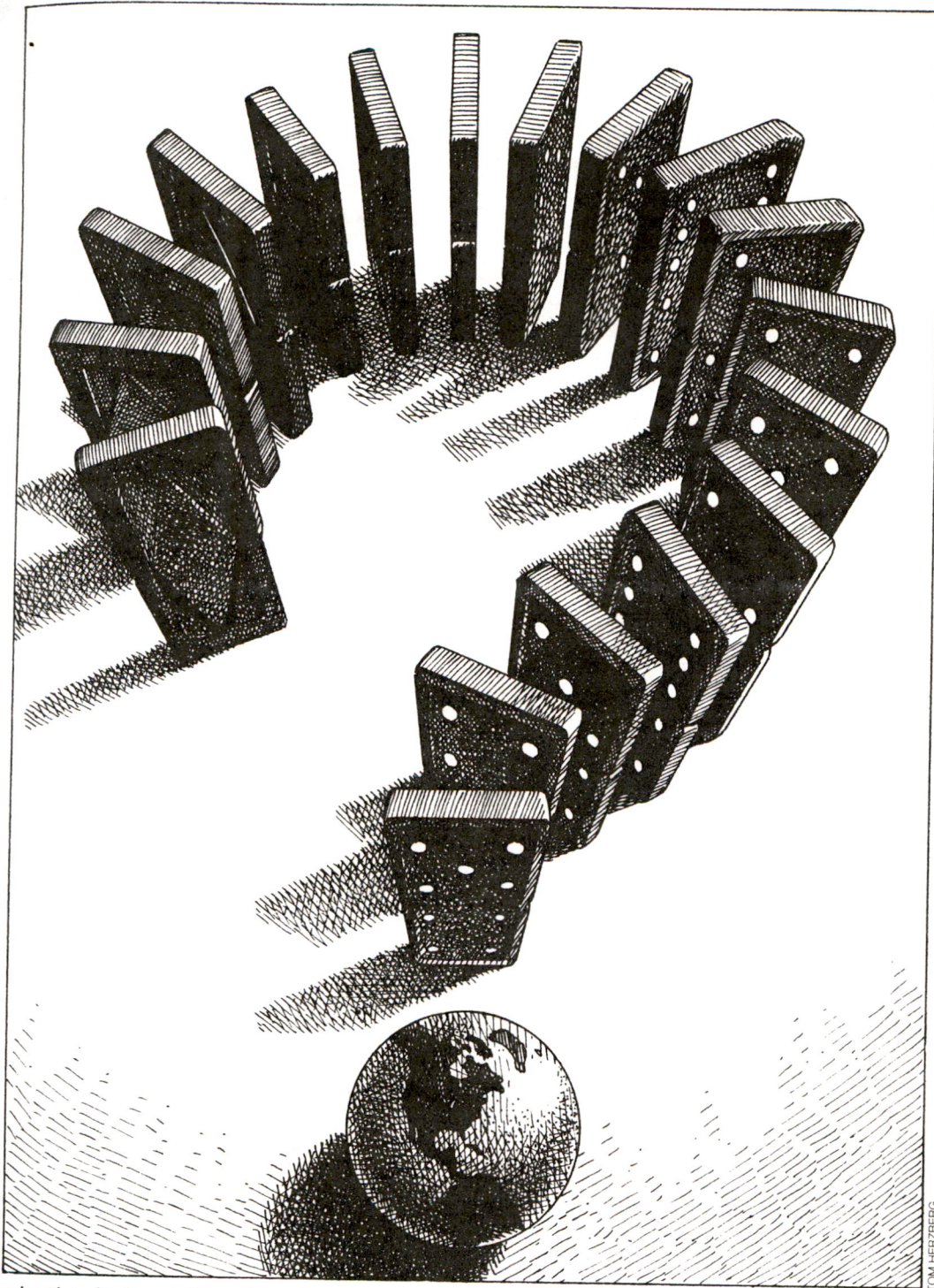
concerned that opinion-making and "publication by press release" are being used to influence environmental policy. With momentum building toward the "Earth Summit"—the U.N. Conference on Environment and Development (UNCED) in Rio de Janeiro this month—the issue of climate warming has taken center stage. Many scientists have spoken out. Philip Abelson, in a lead editorial in the March 30, 1990, *Science*, observed that "if [global warming] is analyzed applying the customary standards of scientific inquiry, one must conclude that there has been more hype than solid fact."

Robert M. White, president of the National Academy of Engineering and a distinguished meteorologist, wrote in the July 1990 *Scientific American*, "Given this 'cry wolf' history, it is not surprising that many meteorologists harbor deep reservations about taking costly actions on the basis of predictions of a climate warming." And in late December, John Houghton, chief editor of the U.N.-sponsored Intergovernmental Panel on Climate Change (IPCC) Report, which forms the basis for the global warming portion of the UNCED Earth Summit, announced a much reduced prediction of future climate warming based on new studies. As reported in the December 29, 1991 *Sunday Times* of London, Houghton, who also directs the British Meteorological Office, castigated environmental activists for scaremongering.

About global warming

During the summer of 1991, researchers at the Science & Environmental Policy Project (SEPP), an independent, foundation-funded research group, sent survey forms to more than 120 U.S. atmospheric scientists. Most of these

S. Fred Singer is director of the Washington-based Science and Environmental Policy Project (SEPP) and professor of environmental sciences (on leave) at the University of Virginia in Charlottesville.



scientists had contributed to or reviewed the IPCC report, which has been widely described by UNCED supporters as presenting a "scientific consensus" about the reality and danger of enhanced greenhouse warming. Colleagues who worked on the report had complained that its "Policymakers Summary" did not accurately represent the conclusions in the report itself. And journalists and bureaucrats presumably read only the summary, not the rather technical 400-page report.

The survey results were remarkable. Of over 50 scientists who responded, 23 agreed that the

summary did not represent the report fairly and could be misleading to non-scientists. An overwhelming majority of respondents agreed that there was no clear evidence in the climate record of the last 100 years for enhanced greenhouse warming due to human activities. Nearly all respondents expressed skepticism about the adequacy of the global climate models (GCMs) used to predict future climate warming.

Other independent surveys support these findings. For example, a November 1991 Gallup poll of 400 members of the American Meteorological Society and the American Geophysical

Current models to not jibe with the climate history of the last 100 years.

Union (actively involved in global climate research) responded to the question: Do you think that global average temperatures have increased during the past 100 years and, if so, is the warming within the range of natural, non-human-induced fluctuation? The poll found that only 19 percent believed that human-induced global warming has occurred.

Greenpeace International also surveyed scientists who worked on the IPCC report. Asked whether business-as-usual-policies might instigate a runaway greenhouse effect at some (unspecified) future time, only 13 percent of the 113 respondents thought it "probable" and 32 percent "possible." But 47 percent said "probably not"—far from a consensus. Jeremy Leggett, Director of Sciences in Greenpeace International's Atmosphere and Energy Campaign, described this same survey as revealing "an as-yet poorly expressed fear among a growing number of climate scientists that global warming could lead not just to severe problems but complete ecological collapse."

These surveys all guaranteed respondents' anonymity, although some did sign their names. But this February, SEPP went a step further and contacted some 300 atmospheric physicists and meteorologists (most of them serving on technical committees of the American Meteorological Society) and asked them to publicly endorse a strongly-worded statement (see the facing page) expressing concern that policy initiatives being developed for the Earth Summit were being driven by "highly uncertain scientific theories." One of those who replied objected, four wanted changes, but more than 50 put their names to the statement.

These surveys all confirm that most climate scientists believe that some global warming may be occurring, but that catastrophic predictions are unsupported by the scientific evidence, and that predictions of disaster are based on yet-to-be validated climate models.

But what do the surveys mean in terms of greenhouse warming? Science is not democratic; truth is not arrived at by vote. The surveys tell us that there are still unanswered questions that need to be settled by additional research before drastic and far-reaching policies are undertaken. And there is time for this research.

Model shortcomings

How can we tell if human activities are having a significant effect on the global environment, either good or bad? There are really only two methods available: one is theory—calculating the expected effects, based on some model of the earth's atmosphere and associated environments (oceans, biosphere, cryosphere or even lithosphere). The other is empirical—it requires an examination of data based on actual obser-

vations of the atmosphere or some other environmental parameter, like sea level or ice cover.

If theory and observations agree, then we can be confident that the theory is valid and that its predictions are likely to be correct. If the two methods do not agree, then the observations could be faulty, or the theory incomplete, or both. This is the conclusion that logic demands when we are told that an event is "worse than expected." After all, expectations about the future can only be based on theory. When observations and theory disagree, the theory cannot be used to forecast future events.

Any theory that attempts to explain the effects of human interventions and predict future changes must inevitably be based on a model—a much simplified mathematical description—of the atmosphere or other relevant environment. There is no alternative. "Models are better than hand-waving," says Stephen Schneider of the National Center for Atmospheric Research, and an ardent proponent of global-warming theories. But how much better? A good model will incorporate those features of the atmosphere that are important, but leave out those that are not. The model builder has to decide what is important and what is unimportant—and thereby hangs the tale.

Ideally, one would like to calculate the characteristics of the atmosphere at every point in space with the finest possible resolution. But computational limits prohibit this. Current computers provide fairly coarse resolution. Sampling points on the globe are typically 300 to 500 kilometers apart, still not close enough to discern cloud systems, or even such surface features as the Florida peninsula. Vertical sampling of the atmosphere occurs only at a few levels, typically a dozen, ranging from the earth's surface to the stratosphere.

As computing power increases, finer topographic detail will be incorporated and climate models will move closer to reality. A similar argument applies to time steps: sampling at hourly intervals will give greater precision than daily intervals.

Another difficult problem involves how much atmospheric physics to put into the model—how to incorporate clouds, small-scale convection in the atmosphere, transport of water vapor, effects of aerosols from air pollution, and how to incorporate and couple ocean circulation with that of the atmosphere.

Specialists argue endlessly about these important questions. It is clear that current models do not jibe with the climate history of the past 100 years. The challenge is to improve the models so that they represent the atmosphere/ocean circulation system more closely. Most models must be "tuned" to give the right mean temperature and seasonal temperature variations, but they often fall short of accurately repro-

ducing many other atmospheric parameters.

A major component of the debate focuses on the question of water vapor and "feedback." It is generally agreed that most of the naturally occurring greenhouse effect is due to water vapor, rather than to carbon dioxide, methane, and other greenhouse gases. Some estimates ascribe 98 percent of the greenhouse effect to atmospheric water in its various forms.

Exactly what happens to water vapor—which is not under human control—as carbon dioxide increases? Current climate models demonstrate positive feedback—that is, water vapor reinforces and amplifies the effect of increasing carbon dioxide. (Air with higher temperature "holds" water vapor better than cool air.) But leading atmospheric scientists, such as Hugh Ellsaesser of Lawrence Livermore National Laboratory and MIT researcher Richard Lindzen, have argued to the contrary, that the feedback is smaller and could even be negative—it could oppose and diminish the greenhouse effects of increased carbon dioxide.

An example of such negative feedback might occur if increased ocean temperatures lead to increased evaporation and increased cloud cover. Although clouds induce cooling by reflecting sunlight back into space, they can also increase warming by keeping heat in. On balance, however, and as shown by actual observation, low clouds promote cooling. In contrast, a clear example of a positive feedback is ice cover. As it shrinks from warming, less sunlight is reflected back out to space and more is absorbed to warm the earth further.

Global observations

In the presence of both positive and negative feedbacks of immense complexity, how can a non-specialist judge the adequacy of global climate models? One method is to examine their gross characteristics—consistency and validation. Consistency refers to the extent to which different modelers agree, and differences are rather large in greenhouse warming models. Warming predictions range from negligible or small (compared to naturally occurring year-to-year variations), all the way to catastrophic—from 1.5 to 5.0 degrees centigrade in response to a doubling of carbon dioxide in the atmosphere. Even more pronounced are the differences between predictions of regional temperature changes and precipitation patterns.

Consistency also refers to consistency over time. An analogy from the related field of ozone-depletion research is illustrative. In 1972, theories predicted decreases in stratospheric ozone of up to 70 percent as a result of the planned use of high-flying supersonic aircraft, which would produce nitrogen oxides. As

Dissent on warming

In late 1991, the Science & Environmental Policy Project (SEPP) circulated this statement to some 300 atmospheric scientists in the United States. Thus far, more than 50 scientists at a wide range of institutions (including MIT, Yale, Woods Hole, and the University of Virginia) have signed it.

As independent scientists researching atmospheric and climate problems, we are concerned by the agenda for UNCED, the U.N. Conference on Environment and Development, being developed by environmental activist groups and certain political leaders. This so-called Earth Summit is scheduled to convene in Brazil in June 1992 and aims to impose a system of global environmental regulations, including onerous taxes on energy fuels, on the population of the United States and other industrialized nations.

Such policy initiatives derive from highly uncertain scientific theories. They are based on the unsupported assumption that catastrophic global warming follows from the burning of fossil fuels and requires immediate action. We do not agree.

A survey of U.S. atmospheric scientists, conducted in the summer of 1991, confirms that there is no consensus about the cause of the slight warming observed during the past century. A recently published research paper even suggests that sunspot variability, rather than a rise in greenhouse gases, is responsible for the global temperature increases and decreases recorded since about 1880.

Furthermore, the majority of scientific participants in the survey agreed that the theoretical climate models used to predict a future warming cannot be relied upon and are not validated by the existing climate record. Yet all predictions are based on such theoretical models.

Finally, agriculturalists generally agree that any increase in carbon dioxide levels from fossil fuel burning has beneficial effects on most crops and on world food supply.

We are disturbed that activists, anxious to stop energy and economic growth, are pushing ahead with drastic policies without taking notice of recent changes in the underlying science. We fear that the rush to impose global regulations will have catastrophic impacts on the world economy, on jobs, standards of living, and health care, with the most severe consequences falling upon developing countries and the poor.

theorists incorporated more data, these predictions gradually diminished. By around 1977, theorists suggested an increase in ozone. But after 1978, theorists predicted a modest ozone decrease. Current theory, however, holds that nitrogen oxides would protect ozone by counteracting the ozone-destroying properties of chlorofluorocarbons.

The concept of enhanced greenhouse warming has been undergoing similar changes. Although modelers' predictions have never changed from positive to negative, the magnitude of the predicted change began to drop as greenhouse warming models incorporated ocean circulation, the effects of sulfate pollution, and a better understanding of cloud formation. Most startling has been the downgrading of the greenhouse effect on sea level rise. Only a few years ago, some modelers forecast a 30-foot rise in sea

levels; current IPCC estimates range from a three- to 11-inch rise, far short of catastrophe.

Levels of carbon dioxide have increased by 25 percent over the past 100 years; and all green-

Ambiguous conclusion

The 1990 report of the Intergovernmental Panel on Climate Change (IPCC) notes that enhanced human-induced global warming has not yet been reliably detected:

Because of the strong theoretical basis for enhanced greenhouse warming, there is considerable concern about the potential climatic effects that may result from increasing greenhouse gas concentrations. However, because of the many significant uncertainties and inadequacies in the observational climate record, in our knowledge of the causes of natural climatic variability and in current computer models, scientists working in this field cannot at this point in time make the definitive statement: "Yes, we have now seen an enhanced greenhouse effect."

It is accepted that global-mean temperatures have increased over the past 100 years, and are now warmer than at any time in the period of instrumental record. This global warming is consistent with the results of simple model predictions of greenhouse-gas-induced climate change. However, a number of other factors could have contributed to this warming and it is impossible to prove a cause and effect relationship. Furthermore, when other details of the instrumental climate record are compared with model predictions, while there are some areas of agreement, there are many areas of disagreement.

The main reasons for this are:

1. The inherent variability of the climate system appears to be sufficient to obscure any enhanced greenhouse signal to date. Poor quantitative understanding of low-frequency climate variability (particularly on the 10-100 year time scale) leaves open the possibility that the observed warming is largely unrelated to the enhanced greenhouse effect.

2. The lack of reliability of models at the regional spatial scale means that the expected signal is not yet well defined. This precludes any firm conclusions being drawn from multivariate detection studies.

3. The ideal model experiments required to define the signal have not yet been performed. What is required are time-dependent simulations using realistic time-dependent forcing carried out with fully coupled ocean-atmosphere GCMs [global climate models].

4. Uncertainties in, and the shortness of available instrumental data records mean that the low-frequency characteristics of natural variability are virtually unknown for many climate elements.

Thus, it is not possible at this time to attribute all, or even a large part, of the observed global-mean warming to the enhanced greenhouse effect on the basis of the observational data currently available. Equally, however, we have no observational evidence that conflicts with the model-based estimates of climate sensitivity. Thus, because of model and other uncertainties we cannot preclude the possibility that the enhanced greenhouse effect *has* contributed substantially to past warming, nor even that the greenhouse-gas-induced warming has been greater than that observed, but is partly offset by natural variability and/or other anthropogenic effects.

J. T. Houghton, G. J. Jenkins, and J. J. Ephraums, eds. *Climate Change, The IPCC Scientific Assessment*. Cambridge: Cambridge University Press, 1990, p. 254.

house gases taken together have increased carbon-dioxide-equivalent levels by about 50 percent. In other words, we have already gone halfway towards the greenhouse gas doubling which is often taken as the benchmark for model predictions. One would have expected a warming of at least 0.75 degrees centigrade by now, and more likely a rise of 1.5 degrees centigrade, according to the predictions of many models.

The reality is quite different. Since 1880, temperature has increased only 0.5 degrees centigrade, and that primarily before 1940—that is, before appreciable greenhouse gases were added to the atmosphere. The global climate record during the last 50 years shows no appreciable temperature increase at all. In the United States, the warmest years were in the 1930s, not in the 1980s, based on the analyses of the U.S. Climate Center in Asheville, North Carolina, which uses the U.S. observational network and also corrects for the "urban heat island" effect.

Many climatologists identify the pre-1940 warming with a recovery from an anomalous cooling of the preceding centuries, known as the "Little Ice Age." Certainly, the observed global cooling that inspired a fear of a coming ice age in the 1970s is not in accord with greenhouse models. Adding to the problem, a November 1, 1991 *Science* article by Danish meteorologists, E. Friis-Christensen and K. Lassen, shows that average temperature and solar activity are closely correlated, as measured by the length of the sunspot cycle. If this is correct, then little or no warming can be ascribed to the greenhouse effect.

The most appropriate data for validating current climate models is the global temperature record from satellite microwave observations, which began in 1979. This is the only truly global and continuous set of data available, with heat islands and other surface distortions of temperatures eliminated. Contrary to an expected 0.3 degree centigrade rise per decade, based on current theory, the satellite record shows no significant temperature trend.

Trend or fluctuation?

Temperature observations generally show large fluctuations from unknown causes. Some of the fluctuations may be due to natural influences, such as volcanic activity. Other fluctuations are a consequence of the chaotic behavior of the system itself, involving feedbacks, both positive and negative, on many different time scales. These fluctuations make it difficult (if not impossible) to identify small long-term trends caused by human activities. Interannual and longer-term fluctuations of global temperature exceed those predicted by many greenhouse model calculations.

Disentangling natural changes from a greenhouse effect enhanced by human activities will

require detailed examination and more refined indicators than simply average global temperature. The climatological record may contain specific "fingerprints" that are unique to specific mechanisms of change. But, as pointed out by Hugh Ellsaesser, neither the observed latitude, altitude, or hemispheric variations of global warming in the past century are in agreement with greenhouse theory.

(Even the 1990 IPCC report on climate change waffles on that issue. The report says that the data are too ambiguous to fully support greenhouse theory. Nevertheless, the data are not inconsistent with the greenhouse effect. See "Ambiguous Conclusion," facing page.)

One result of detailed climate studies was the discovery that U.S. temperature records reflect a warming trend mainly for night-time temperatures; that is, there is a decrease in the day-to-night temperature range. Data on the same effects in the former Soviet Union and China have now been published. If greenhouse gas increases were the cause of this increase in night temperatures—and we don't know that—then the obvious benefits to agriculture would make this climate change a plus rather than a minus. This argument is strengthened by the expectation that the present interglacial (warm) period, which started around 11,000 years ago, must soon come to an end. With a renewed ice age "on the horizon," the possibility of greenhouse warming takes on a relatively beneficial interpretation.

What to do

We can sum up present understanding of the enhanced greenhouse effect as follows: experts generally agree that the expected doubling of greenhouse gases in the next century will not cause a severe or catastrophic warming. Many scientists and most agricultural experts would argue that a longer growing season and enhanced carbon dioxide levels are, on the whole, beneficial to crops, which require both warmth and carbon dioxide to flourish. It is also agreed that it will take years, maybe a decade or more, before satellite data can establish a definite climate trend and before theoretical understanding of the atmosphere is comprehensive enough to allow accurate predictions.

This uncertainty raises an important but controversial question. How long should governments wait before taking drastic policy actions—if we cannot now identify a long-term climate trend? And if a trend is eventually identified, how can we be sure of its cause—or whether the cause is man-made? Answers to these questions are crucial if the proposed policy actions have a negative impact on other human values—economic welfare, health, and life expectancy. Environmental pressure groups often say that "we cannot afford to play Russian

roulette with the planet's future." But this is an appeal to emotion, instead of the careful analysis that is called for.

Delaying action is not an invitation to disaster, as often claimed. Calculations by atmospheric scientist Michael Schlesinger of the University of Illinois, a climate modeler, clearly demonstrate that postponing controls on carbon dioxide for even a decade would have no noticeable impact on the next century's temperature trends. Moreover, even the most drastic limits on carbon dioxide emissions by industrialized countries would delay the doubling of greenhouse gases in the next century by only a few years.

A contributing factor to global warming is thought to be population growth and economic development in Third World nations, which will soon determine the growth rate of greenhouse gases. Carbon dioxide will increase because of fuel burning and forest clearing, and methane emitted from rice paddies and cattle raising will increase. It is well recognized, but seldom said, that controlling these activities and thus condemning billions to continued poverty, starvation and misery—or to draconian restrictions on population growth—would rightly be regarded as immoral and as a form of "eco-imperialism."

If greenhouse warming should become a problem, two reports from the U.S. National Academy of Sciences during the past year have suggested that mitigation of the effects of climate change, or adjustment to the change, is quite possible, and not prohibitively costly. A wide range of technological options can be pursued. These include planting trees on a large scale to replace logged or burned forests, and fertilizing the ocean with trace nutrients for plankton growth to sequester and thus reduce atmospheric carbon dioxide. Using satellites to screen out some incoming solar radiation also has been suggested. Such schemes may sound farfetched, but at one time so did many other futuristic projects that have since been realized.

Drastic, precipitous, and especially unilateral steps to roll back carbon dioxide emissions simply to delay an unlikely greenhouse warming will imperil living standards—and even political freedoms—in the industrial world. Yale economist William Nordhaus, who has been trying to deal quantitatively with the economics of this issue, has pointed out that "those who argue for strong measures to slow greenhouse warming have reached their conclusion without any discernible analysis of the costs and benefits."

At this stage, there are major uncertainties about greenhouse theory, about the effects of a possible warming, and about the economic and political impacts of hasty, ill-considered policies. Does it make sense to waste \$100 billion a year on what is still a phantom threat when there are so many pressing—and real—problems in need of resources. ■

**Drastic steps
to roll back
carbon dioxide
emissions will
imperil living
standards.**

Global
& Warming
Gore

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cc: Khirtal 8/9/18

THE SCIENCE AND ENVIRONMENTAL POLICY PROJECT

S. Fred Singer, Ph.D., Director

→ R. Parker
September 15, 1992

"Letters to the Editor"
The Washington Post
1150 15th Street, NW
Washington, D.C. 20071

Dear Sir:

I can well imagine Senator Gore's embarrassment after learning from George Will's column ("Al Gore's Green Guilt," op-ed, Sept. 3) that his mentor, the recently deceased geophysicist Roger Revelle, did not share Gore's alarmist views about the greenhouse "threat." Will quotes Revelle: "The scientific base for greenhouse warming is too uncertain to justify drastic action at this time."

As a coauthor of the 1991 Cosmos article, with Prof. Revelle and energy expert Dr. Chauncey Starr, I find Carolyn Revelle Hufbauer's reply to Will ("Global Warming: What My Father Really Said," Sept. 13) somewhat puzzling. Our article (on page 32) says all of the things that she has listed--as indeed it should. We supported prudent and relatively low-cost policies that make sense even if the greenhouse effect does not exist:

- o Conserve energy by using economic incentives, such as peak pricing for electric power and an increase in the tax on gasoline to make it a true highway-user fee.

- o Improve efficiency in energy use, by providing consumers with full information on life-cycle costs, by encouraging the turnover and replacement of older, less efficient and often more polluting equipment, by stimulating the development of more efficient systems for electric power production and road transportation.

- o Use non-fossil fuel energy wherever this makes economic sense--nuclear power, as well as solar and other forms of renewable energy.

We did not support any more drastic policies, however. Hufbauer properly identifies "drastic" with "trillions of dollars." Based on published authoritative estimates, the imposition of carbon taxes to attempt a stabilization of atmospheric carbon dioxide--and similar schemes to restrict energy use advocated by Senator Gore in his book Earth in the Balance--would impose cumulative costs of this order.

Revelle had a balanced view of the consequences of increased carbon dioxide, whose measurements he pioneered. In an article published in The Resourceful Earth in 1984, he indicated (on page 198) that average temperatures near the Earth's surface might rise between 2 and 3 degrees with a doubling of atmospheric CO₂ (after another century), but expressed no particular alarm. He was also intrigued by the beneficial consequences of increased CO₂ as a "fertilizer" for crop plants, such as rice, wheat, millet, and potatoes. He even speculated that part of the improvement in agricultural yields during the past decades has resulted from the increase in atmospheric CO₂ since the end of the 19th century.

Sincerely yours,

A handwritten signature in dark ink, appearing to read "S. Fred Singer". The signature is fluid and cursive, with a long horizontal stroke extending to the right.

S. Fred Singer
Director
The Science & Environmental Policy Project

Yarborough's argument, since, after 25 years of bilingual education, the high-school dropout rate among Hispanics has reached almost 50 per cent.

We remain skeptical of the entire notion of bilingual education. As the Mexican-American writer Richard Rodriguez has written, it is an education that often leaves the child illiterate in two languages. At the very least, whoever is President in 1993 should refuse to sign the reauthorized Bilingual Education Act unless Congress inserts in it programs to help children move into the English-speaking mainstream. Bilingual education in any form should be limited to two years. And the test of success, required for continued funding, should be a high percentage of children attaining real proficiency in English. Learning a foreign language is a difficult task; immigrant children should not be lulled into thinking otherwise; nor should we.

NOTES & ASIDES

■ Dear Mr. Buckley:

Regarding the environmentalists' concern over CO₂, here are some facts nobody argues with:

1. Atmospheric pressure is about 15 psi (pounds/in.²).
2. Earth's radius is about 4,000 mi.
3. CO₂ constituted about 0.04 per cent of the atmosphere in 1950.

Here is another fact that I have seen. It is politically correct and therefore no one questions it; it's probably scientifically correct as well:

4. CO₂ now constitutes more like 0.06 per cent of the atmosphere.

From #2 we calculate that Earth's surface area is 0.8 billion billion sq. in. And from #1 that the atmosphere weighs 11.9 billion billion lbs. This is 6 million billion tons. Now take fact #3; 0.04 per cent is 2,400 billion tons of CO₂. Half (the change since 1950) is 1,200 billion tons. Let's call this fact #5:

5. There were 2,400 billion tons of CO₂ in the atmosphere in 1950; 3,600 billion tons now, give or take a sigh or two.

Here are two more facts. I haven't seen them challenged anywhere. They're a little looser, but probably in the ballpark, considering the respectable places where I read them.*

6. Human activity currently releases 6 billion tons of CO₂ year.

7. Non-human activity (oceans, trees, Pinatubo, Mauna Loa, etc.) releases 200 billion tons of CO₂ per year.

If #6 and/or #7 is seriously wrong, then please accept my apology for the nonsense that follows. But

* S. H. Schneider, *Scientific American* 261 #3, Sept. 1989, p. 73.

† From an old joke. The punch line is: "Careful! Don't step in the oompah."

if they are anywhere near right, then please read on.

Now compare fact #5 with fact #6. Simple division tells you that if every molecule of human-released CO₂ at the current rate of production stayed in the atmosphere, it would take another 200 years for the post-1950 change to be matched. Or looking backward, since minus 200 years takes us back to before the Industrial Revolution, it means that if every CO₂ molecule from every factory, car, steam engine, barbecue, campfire, and weenie roast that ever was since the first liberal climbed down out of a tree right up until today was still in the atmosphere, it still wouldn't account for the change in CO₂ since 1950.

Fact #7 has been going on for a long time, a lot longer than any piddling 200 years. Comparing #5 and #7 means it takes about 12 years for the average CO₂ molecule to be recycled back out of the atmosphere.

Given the above, here are some conclusions that nobody can argue with and still claim to be a reasoning creature:

8. Human activity, carried out at the present rate indefinitely (more than 12 years) cannot possibly account for more than 6 per cent of the observed change in CO₂ levels.

9. Entirely shutting off civilization—or even killing everybody—could only have a tiny effect on global warming, if there is any such thing.

Dan Rather may find the above argument very abstruse. To anyone trained in science, however, it is so absolutely trivial, so mind-bogglingly simple, that you may be 100 per cent certain that every last person calling himself an "atmospheric scientist" or suchlike not only would understand it immediately *but has actually carried it out for himself already*. Thus the final fact:

10. Every geoscientist knows and believes #9.

The strangest part of all is that the very people who should be yelling: "Oompah! Oompah!"† are among the ones perpetrating the scam and beating up on George Bush for not going along with it.

That leaves two questions that neither one of us knows how to answer:

- Q1. Why do all these supposedly educated, supposedly sane people want to end civilization?

- Q2. Since humanity can't possibly be causing the CO₂ level to go up, isn't it time to start wondering about what *is*?

Thank you for your attention.

L. L. Van Zandt
Professor of Physics
Purdue University
West Lafayette, Ind.

Dear Mr. Van Zandt: That is truly beautiful, your demonstration. Thank you for sending it along. Cordially,
—WFB

WHAT TO DO ABOUT GREENHOUSE WARMING: LOOK BEFORE YOU LEAP

S. Fred Singer
Roger Revelle
Chauncey Starr

Greenhouse warming has emerged as one of the most complex and controversial environmental and foreign-policy issues of the 1990s.

It is an environmental issue because carbon dioxide (CO₂), generated from the prolific burning of oil, gas and coal, is thought to enhance, by trapping heat in the atmosphere, the natural greenhouse effect that has kept the planet warm for billions of years. Some scientists predict drastic climatic changes in the 21st century.

The scientific base for a greenhouse warming is too uncertain to justify drastic action at this time.

It is a foreign-policy issue because, for a number of reasons, the United States has taken a more cautious approach to dealing with CO₂ emissions than have many industrialized nations. Wide acceptance of the Montreal Protocol, which limits and rolls back the manufacture of chlorofluorocarbons (CFCs) to protect the ozone layer, has encouraged environmental activists at international conferences the past three years to call for similar controls on CO₂ from fossil-fuel burning.

These activists have expressed disappointment with the White House for not supporting immediate action. But should the United States assume "leadership" in a hastily-conceived campaign that could cripple the global economy, or would it be more prudent to assure first, through scientific research, that the problem is both real and urgent?

We can sum up our conclusions in a simple message: *The scientific base for a greenhouse warming is too uncertain to justify drastic action at this time.*

There is little risk in delaying policy responses to this century-old problem since there is every expectation that scientific understanding will be substantially improved within the next decade. Instead of premature and likely ineffective controls on fuel use that would only slow down but not stop the further growth of CO₂, we may prefer to use the same re-

sources—trillions of dollars, by some estimates—to increase our economic and technological resilience so that we can then apply specific remedies as necessary to reduce climate change or to adapt to it.

That is not to say that prudent steps cannot be taken now; indeed, many kinds of energy conservation and efficiency increases make economic sense even without the threat of greenhouse warming.

THE SCIENTIFIC BASE

The scientific base for greenhouse warming (GHW) includes some facts, lots of uncertainty and just plain lack of knowledge—requiring more observations, better theories and more extensive calculations. Specifically, there are reliable measurements of the increase in so-called greenhouse gases in the earth's atmosphere, presumably as a result of human activities. There is uncertainty about the strength of sources and sinks for these gases, i.e., their rates of generation and removal. There is major uncertainty and disagreement about whether this increase has caused a change in the climate during the last century. There is also disagreement in the scientific community about predicted future changes as a result of further increases in greenhouse gases. The models used to calculate future climate are not yet good enough because the climate-balancing processes are not sufficiently understood, nor are they likely to be good enough until we gain more understanding through observations and experiments.

As a consequence, we cannot be sure whether the

S. Fred Singer ('57) is professor of environmental sciences at the University of Virginia and served as the first director of the U.S. weather satellite program, among several government positions.

Roger Revelle ('43), professor of science and public policy at the University of California at San Diego, is former director of the Scripps Institution of Oceanography. He is a member of the National Academy of Sciences and last year received the National Medal of Science.

Chauncey Starr ('68) is the president emeritus of the Electric Power Research Institute and former dean of engineering at the University of California at Los Angeles. He is a member of the National Academy of Engineering. Last year he received the National Medal of Technology.

"What to Do About Greenhouse Warming: Look Before You Leap,"
Cosmos, Vol. 1, No. 1. pp. 28-33

ABOUT THE AUTHORS:

As director of the Scripps Institution of Oceanography, **DR. ROGER REVELLE** (who died in 1991) initiated the program of global CO₂ measurements that is widely credited with focusing world attention on the greenhouse effect. Dr. Revelle has served as science advisor to the U.S. Department of the Interior and as director of the Harvard Center for Population Studies, and ~~was~~ **was** a professor of science and public policy at the University of California at San Diego. A member of the National Academy of Science, Revelle was awarded the National Medal of Science in 1990.

DR. S. FRED SINGER was the first scientist to predict the increase in atmospheric methane--an important greenhouse gas--from human activities. Dr. Singer has served as chief scientist at the U.S. Department of Transportation and as deputy assistant administrator of the Environmental Protection Agency. He was the first director of the U.S. weather satellite program and developed the currently used satellite technology for measuring ozone in the upper atmosphere. He was also Dean of the School of Environmental and Planetary Sciences at the University of Miami. A professor of environmental sciences at the University of Virginia, Singer currently directs The Science & Environmental Policy Project in Washington, D.C. His most recent book is Global Climate Change (Paragon House, 1990).

Winner of the 1990 National Medal of Technology, **DR. CHAUNCEY STARR** is the founding president of the Electric Power Research Institute in Palo Alto, California, former president of Atomics International, and former dean of engineering at the University of California at Los Angeles. A widely respected expert on nuclear energy and a member of the National Academy of Engineering, Starr has designed nuclear reactors and fuel cycles and has published seminal papers on technical and societal risk analysis.

next century will bring a warming that is negligible or a warming that is significant. Finally, even if there are a global warming and associated climate changes, it is debatable whether the consequences will be good or bad; likely some places on the planet would benefit, some would suffer.

GREENHOUSE GASES (GHG)

It has been common knowledge for about a century that the burning of fossil fuels would increase the normal atmospheric content of carbon dioxide (CO_2), causing an enhancement of the natural greenhouse effect and a possible warming of the global climate. Advances in spectroscopy in the last century produced evidence that CO_2 —and other molecules made up of more than two atoms—absorb infrared radiation and thereby would impede the escape of such heat radiation from the earth's surface. In fact, it is the greenhouse effect from naturally occurring CO_2 and water vapor (H_2O) that has warmed the earth's surface for billions of years; without the natural greenhouse effect ours would be a frozen planet without life.

Precise measurements of the increase in atmospheric CO_2 date to the International Geophysical Year of 1957-58. More recently it has been discovered that other greenhouse gases, i.e., gases that absorb strongly in the infrared, have also been increasing—at least partly as a result of human activities. They currently produce a greenhouse effect nearly equal to that of CO_2 , and could soon outdistance it.

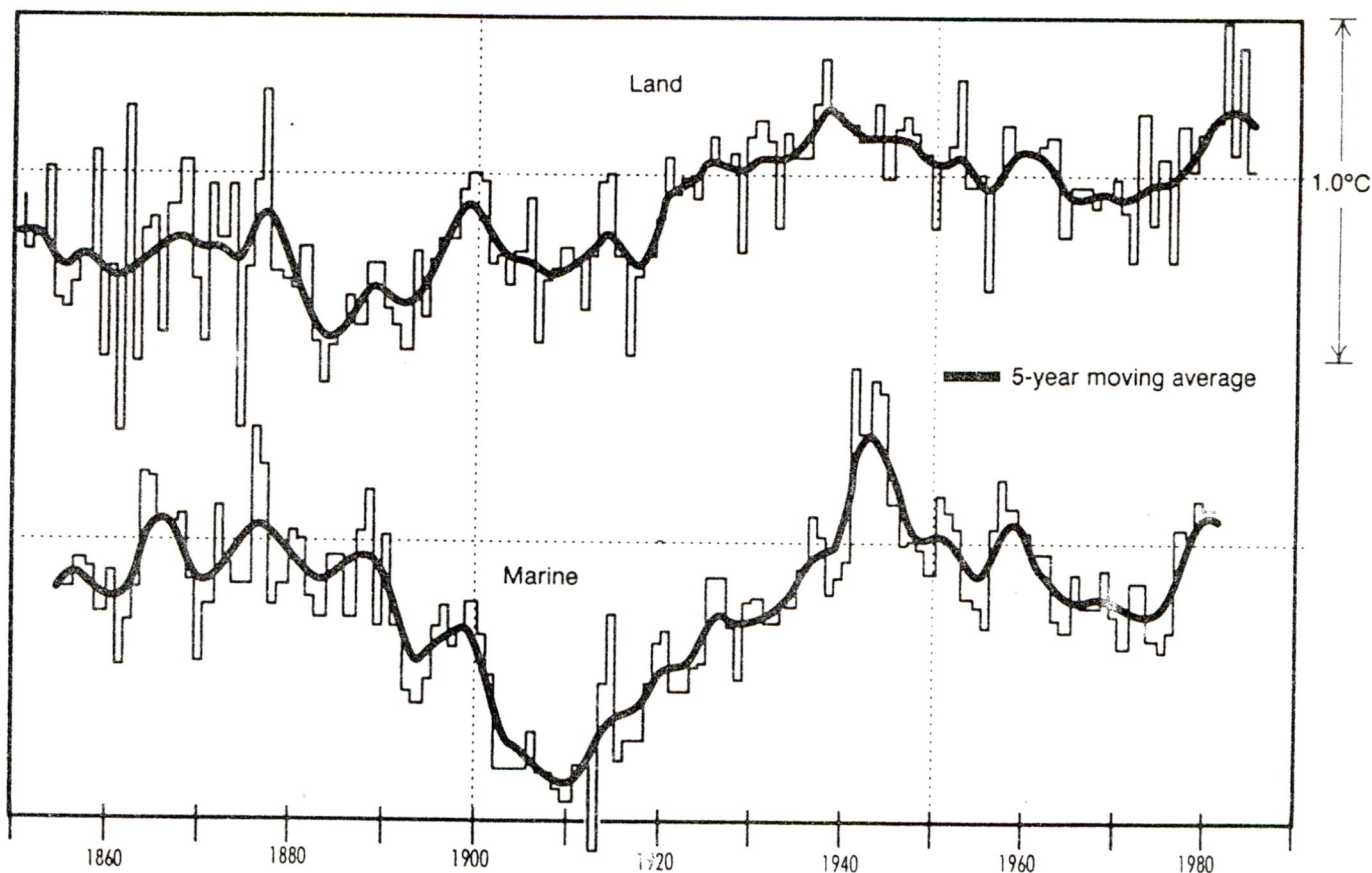
Methane (CH_4) is produced in large part by sources that relate to population growth; among these are rice paddies, cattle, landfills, forest fires, coal mines and oil field operations. Indeed, methane, now 20 percent of the greenhouse gas effect but growing twice as fast as CO_2 , has more than doubled since pre-industrial times; it would soon become the most important greenhouse gas if CO_2 emissions were to stop.

Nitrous oxide (N_2O) has increased by 10 percent, most likely because of soil bacterial action promoted by the increased use of nitrogen fertilizers.

Ozone (O_3) from urban air pollution adds about 10 percent to the global greenhouse effect. It may decrease in the U.S. as a result of Clean Air legislation but increase in other parts of the world.

CFCs manufactured for use in refrigeration, air

Yearly Average Temperatures in the Northern Hemisphere



Note the major increases before 1938, when greenhouse gas concentrations were low, and the sustained cooling to 1975. Though temperatures remained near record levels during the 1980s, there was no clear upward trend.

Source: Nature 322

conditioning and industrial processes are making an important contribution but will soon be replaced by less-polluting substitutes.

Water vapor (H_2O) turns out to be the most effective greenhouse gas by far. It is not manmade, but is assumed to amplify the warming effects of the gases produced by human activities. We don't really know whether H_2O has increased in the atmosphere or whether it will increase in the future—although that's what all the model calculations assume. Indeed, predictions of future warming depend not only on the amount but also on the horizontal and especially the vertical distribution of H_2O , and on whether it will be in the atmosphere in the form of a gas or as liquid cloud droplets or as ice particles. The current computer models are not complete enough to test these crucial points.

THE CLIMATE RECORD

The issue now is whether the 25 percent increase of CO_2 in the atmosphere, mainly since World War II, calls for immediate and drastic action to limit and roll back global energy use. Taking account of increases in the other trace gases that produce greenhouse effects, we have already gone halfway to an effective GHG doubling—something that cannot be reversed in our lifetime—and, according to the prevailing theory, locked in a temperature increase of about 1.6 degrees Celsius.

But has there been a climate effect caused by the increase of greenhouse gases in the last decades? The data are ambiguous to say the least. Advocates for immediate action profess to see a global warming of about 0.5 degrees C since 1880, and point to record global temperatures in the 1980s and the warmest year on record in 1990. Most atmospheric scientists tend to be cautious, however; they call attention to the fact that the greatest temperature increase occurred *before* the major rise in greenhouse gas concentration. It was followed by a quarter-century decrease between 1940 and 1965 when concern arose about an approaching ice age! Following a sharp increase during 1975-80, there has been no clear upward trend during the 80s despite some very warm individual years and record GHG increases. Similarly, global atmospheric (rather than surface) temperatures measured by Tiros weather satellites show no trend in the last decade.

Scientists Kirby Hanson, Thomas Karl and George Maul of the National Oceanic and Atmospheric Administration (NOAA) find no overall warming in the U.S. temperature record, contrary to the global record assembled by James Hansen of the National Aeronautics and Space Administration (NASA). Using a technique that eliminates urban "heat islands" and other local distorting effects, they confirm the temperature rise before 1940, followed, however, by a general decline. Reginald Newell and colleagues at the Massachusetts Institute of Technology (MIT) report no substantial change in the global sea-surface

temperature in the past century; yet the ocean, because of its much greater heat inertia, should control any atmospheric climate change.

Perhaps most interesting are the NOAA studies that document a relative rise in night temperatures in the U.S. in the last 60 years, while daytime values stayed the same or declined. This is just what one would expect from the increase in atmospheric greenhouse gas concentration. But its consequences, as University of Virginia climatologist Patrick Michaels and others have pointed out, are benign: A longer growing season, fewer frosts, no increase in soil evaporation.

It is therefore fair to say that we haven't seen the huge greenhouse warming, of between 0.7 and 2.5 degrees C, expected from the conventional theories. Why not? This scientific puzzle has many suggested solutions:

- The warming has been "soaked up" by the ocean and will appear after a delay of some decades. Plausible—but there is no evidence to support this theory until deep-ocean temperatures are measured on a routine basis, as suggested by Scripps Institution oceanographer Walter Munk. Feasibility tests are currently underway, using a sound source at Heard Island in the South Indian Ocean and a global network

ANOTHER ICE AGE COMING?

Global temperatures have been declining since the dinosaurs roamed the earth some 70 million years ago. About 2 million years ago, a new "ice age" began—most probably as a result of the drift of the continents and the buildup of mountains. Since that time, the earth has seen 17 or more cycles of glaciation, interrupted by short (10,000 to 12,000 years) interglacial or warm periods. We are now in such an interglacial interval, the Holocene, that started 10,800 years ago. The onset of the next glacial cycle cannot be very far away.

It is believed that the length of a glaciation cycle, about 100,000 to 120,000 years, is controlled by small changes in the seasonal and latitudinal distribution of solar energy received as a result of changes in the earth's orbit and spin axis. While the theory can explain the timing, the detailed mechanism is not well understood—especially the sudden transition from full glacial to interglacial warming. Very likely an ocean-atmosphere interaction is triggered and becomes the direct cause of the transition in climate.

The climate record also reveals evidence for major climatic changes on time scales shorter than those for astronomical cycles. During the past millennium, the earth experienced a "climate optimum" around 1100 A.D., when Vikings found Greenland to be green and Vinland (Labrador?) able to support grape growing. The "Little Ice Age" found European glaciers advancing well before 1600 and suddenly retreating starting in 1860. The warming reported in the global temperature record since 1880 may thus simply be the escape from this Little Ice Age rather than our entrance into the human greenhouse.

of microphones, but data over at least a decade will be needed to provide an answer.

- The warming has been overestimated by the existing models. Meteorologists Hugh Ellsaesser (Livermore National Laboratory) and Richard Lindzen (MIT) propose that the models do not take proper account of tropical convection and thereby overestimate the amplifying effects of water vapor over this important part of the globe. Other atmospheric scientists suggest that the extent of cloudiness may increase as ocean temperatures try to rise and as evaporation increases. Clouds reflect incoming solar radiation; the resultant cooling could offset much of the greenhouse warming. Most intriguing has been the suggestion by British researchers that sulfates from smokestacks—the precursors of acid rain—may have played a role in producing an increase in bright stratocumulus clouds.

- The warming exists as predicted, but has been hidden by offsetting climate changes caused by volcanoes, solar variations, or other natural causes as yet unspecified—such as the cooling from an approaching ice age. (Some, like Robert Balling of Arizona State University, consider the warming before 1940 to be a recovery from the “Little Ice Age” that prevailed from 1600 to about 1850; if correct, this would imply no net warming at all in the past century due to GHW.) Each hypothesis has vocal proponents—and opponents—in the scientific community; but the jury is out until better data become available.

MATHEMATICAL MODELS

Indeed, there is much to complain about when it comes to predictions of future climate, but there is really no alternative to global climate models. “Models are better than handwaving,” claims Stephen Schneider of the National Center for Atmospheric Research (NCAR)—but how much better? Half a dozen of these General Circulation Models (GCM) are now running, mostly in the United States. Even though they use similar basic atmospheric physics, they give different results. There is general agreement among them that there should be global warming; but, with an effective GHG doubling, the calculated average global increase ranges between 1.5 and 4.5 degrees C! These predicted values were unchanged for many years, then crept up and have recently dropped back to the lower end of the range. Just during 1989 some of the modelers cut their predictions in half as they tried to include clouds and ocean currents in a better way. Further, there is serious disagreement among the models on the regional distribution of this warming and on where the increased precipitation will go.

The models are “tuned” to give the right mean temperature and seasonal temperature variation, but they fall short of modeling other important atmospheric processes, such as the poleward transport of energy via ocean currents and atmosphere from its source in the equatorial region. Nor do they encom-

pass longer-scale processes that involve the deep layers of the oceans or the ice and snow in the earth’s cryosphere, nor fine-scale processes that involve convection, cloud formation, boundary layers, or that depend on the earth’s detailed topography.

There are serious disagreements also between model results and the actual experience from the climate record of the past decade, according to

Yet there is hope that research, including satellite observations and ocean data, will provide many of the answers within this decade.

Ellsaesser. Existing models retroactively predict a strong warming of the polar regions and of the tropical upper atmosphere, and less warming in the southern hemisphere than the northern—all contrary to observations. Yet there is hope that research, including satellite observations and ocean data, will provide many of the answers within this decade. Faster computers will also allow higher spatial resolution and incorporate the detailed and more complicated interactions that are now neglected.

IMPACTS OF CLIMATE CHANGE

Assume what we regard as the most likely outcome: A modest average warming in the next century—well below the normal year-to-year variation—and mostly at high latitudes and in the winter. Is this necessarily bad? One should perhaps recall that only a decade ago when climate cooling was a looming issue, economists of the National Academy of Sciences’ National Research Council calculated a huge national cost associated with such cooling. More to the point perhaps, actual climate cooling, experienced during the Little Ice Age or in the famous 1816 New England “year without a summer,” caused large agricultural losses and even famines.

If cooling is bad, then warming should be good, it would seem—provided the warming is slow enough so that adjustment is easy and relatively cost-free. Even though crop varieties are available that can benefit from higher temperatures with either more or less moisture, the soils themselves may not be able to adjust that quickly. But agriculturalists, like Sherwood Idso of the U. S. Department of Agriculture and Yale professor William Reifsnyder, generally expect that with increased atmospheric CO₂—which is, after all, plant food—plants will grow faster and need less water. The warmer night temperatures suggested by Patrick Michaels, using the data of Thomas Karl,

translate to longer growing seasons and fewer frosts. Increased global precipitation should also be beneficial to plant growth.

Keep in mind also that year-to-year changes at any location are far greater and more rapid than what might be expected from greenhouse warming; and nature, crops and people are already adapted to such changes. It is the extreme climate events that cause the great ecological and economic problems: Crippling winters, persistent droughts, extreme heat spells, killer hurricanes and the like. But there is no indication from modeling or from actual experience that such extreme events *would* become more frequent if greenhouse warming becomes appreciable. The exception might be tropical cyclones, which—Balling and Randall Cerveney argue—would be more frequent but weaker, would cool vast areas of the ocean surface and increase annual rainfall. In sum, climate models predict that global precipitation should increase by 10 to 15 percent, and polar temperatures should warm the most, thus reducing the driving force for severe winter-weather events.

We can be putting into effect policies and pursue approaches that make sense even if the greenhouse effect did not exist.

There is finally the question of sea-level rise as glaciers melt—and fear of catastrophic flooding. The cryosphere certainly contains enough ice to raise sea level by 100 meters; and, conversely, during recent ice ages, enough ice accumulated to drop sea level 100 meters below the present value. But these are extreme possibilities; tidal-gauge records of the past century suggest that sea level has risen modestly, about 0.3 meters. But the gauges measure only *relative* sea level, and many of the gauge locations have dropped because of land subsidence. Besides, the test locations are too highly concentrated geographically, mostly on the U.S. East Coast, to permit global conclusions. The situation will improve greatly, however, in the next few years as precise absolute global data become available from a variety of satellite systems.

In the meantime, satellite radar-altimeters have already given a surprising result. As reported by NASA scientist Jay Zwally in *Science*, Greenland ice-sheets are gaining in thickness—a net increase in the ice stored in the cryosphere and an inferred *drop* in sea level—leading to somewhat uncertain predictions about future sea level. Modeling results suggest little warming of the Antarctic Ocean because the heat is convected to deeper levels. It is clearly important to verify these results by other techniques and also get

more direct data on current sea-level changes.

Summarizing the available evidence, we conclude that even if significant warming were to occur in the next century, the net impact to the entire planet may well be beneficial—with some regions enjoying improved climate, some encountering worse. This would be even more true if the long-anticipated ice age were on its way.

In view of the uncertainties about the degree of warming, and the even greater uncertainty about its possible impact—what should we do? During the time that an expanded research program reduces or eliminates these uncertainties, we can be putting into effect policies and pursue approaches that make sense even if the greenhouse effect did not exist.

ENERGY POLICIES

Conserve energy by discouraging wasteful use globally. Conservation can best be achieved by pricing rather than by command-and-control methods. If the price can include the external costs that are avoided by the user and loaded onto someone else, this strengthens the argument for proper pricing. The idea is to have the polluter or the beneficiary pay the cost. An example would be peak-pricing for electric power. Yet another example, appropriate to the greenhouse discussion, is to increase the tax on gasoline to make it a true highway-user fee—instead of having most capital and maintenance costs paid by various state taxes, as is done now. Congress has lacked the courage for such a direct approach, preferring instead regulation that is mostly ineffective and produces large indirect costs for the consumer.

Improve efficiency in energy use. Energy efficiency should be attainable without much intervention, provided it pays for itself. A good rule of thumb: If it isn't economic, then it probably wastes energy in the process and we shouldn't be doing it. Over-conservation can waste as much energy as under-conservation. (For example, destroying all older cars would certainly raise the fuel efficiency of the fleet, but replacing these cars would consume more energy in their manufacture.) If energy is properly priced, i.e., not subsidized, the job for government is to remove the institutional and other road blocks:

- Provide information to consumers, especially on life-cycle costs for home heating, lighting, refrigerators and other appliances.
- Encourage—but not force—the turnover and replacement of older, less efficient (and often more polluting) capital equipment: Cars, machinery, power plants. Some existing policies that make new equipment too costly go counter to this goal.
- Stimulate the development of more efficient systems, such as a combined-cycle power plant or a more efficient internal-combustion engine.

Use non-fossil-fuel energy sources wherever this makes economic sense. Nuclear power is competitive now, and in many countries is cheaper than fossil-fuel power—yet it is often opposed on environmental

grounds. The problems cited against nuclear energy, such as disposal of spent nuclear fuel, are more political and psychological than technical. To address safety concerns, nuclear engineers are focusing on an "inherently" safe reactor. Nuclear energy from fusion rather than from fission may be a longer-term possibility, but the time horizon is uncertain.

Solar energy, and other forms of renewable energy, should also become more competitive as their costs drop and as fossil-fuel prices rise. Solar energy applications are restricted not only by cost; solar energy is both highly variable and very dilute; it takes a football field of solar cells to supply the total energy allocated to the average U.S. household. Wind energy and biomass are other forms of solar energy, competitive in certain applications. Schemes to extract energy from temperature differences in the ocean have been suggested as inexhaustible sources of non-polluting hydrogen fuel, once we solve the daunting technical problems.

DIRECT INTERVENTIONS

If greenhouse warming ever becomes a problem, there are a number of proposals for removing CO₂ from the atmosphere. Rebuilding forests is widely talked about, but may not be cost-effective; yet natural expansion of boreal forests—those in high-latitude regions—in a warming climate would sequester atmospheric CO₂. A novel idea, proposed by California oceanographer John Martin, is to fertilize the Antarctic Ocean and let plankton growth do the job of converting CO₂ into bio-material. The limiting trace nutrient may be iron which could be supplied and dispersed economically.

If all else fails, there is always the possibility of putting "venetian blind" satellites into earth orbit to modulate the amount of sunshine reaching the earth. These satellites could also generate electric power and beam it to the earth, as originally suggested by

The net impact to the entire planet may well be beneficial—with some regions enjoying improved climate, some encountering worse.

Peter Glaser of A. D. Little. Such schemes may sound farfetched, but so did many other futuristic projects in the past—and in the present, like covering the Sahara with solar cells or Australia with trees.

CONCLUSION

Drastic, precipitous—and, especially, unilateral—steps to delay the putative greenhouse impacts can cost jobs and prosperity and increase the human costs of global poverty, without being effective. Stringent controls enacted now would be economically devastating—particularly for developing countries for whom reduced energy consumption would mean slower rates of economic growth—without being able to delay greatly the growth of greenhouse gases in the atmosphere. Yale economist William Nordhaus, one of the few who has been trying to deal quantitatively with the economics of the greenhouse effect, has pointed out that "... those who argue for strong measures to slow greenhouse warming have reached their conclusion without any discernible analysis of the costs and benefits. ..." It would be prudent to complete the ongoing and recently expanded research so that we will know what we are doing before we act. "Look before you leap" may still be good advice. ■

SCIENCE AND ENVIRONMENTAL POLICY PROJECT

NEWS RELEASE

FOR IMMEDIATE RELEASE

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SCIENCE AND ENVIRONMENTAL POLICY PROJECT JOINS THE INSTITUTE FOR CONTEMPORARY STUDIES, PLANS EXPANSION OF PROGRAMS

WASHINGTON, D.C., MAY 30, 1992--The Science and Environmental Policy Project has joined the San Francisco-based Institute for Contemporary Studies (ICS) as an independent affiliate, effective May 1, 1992.

ICS occupies a leadership role in the United States in promoting self-governance and the entrepreneurial spirit. Its programs focus on five areas critical to a stable political system and a productive economy: governance, entrepreneurship, education, social policy, and environmental policy.

According to SEPP Director Dr. S. Fred Singer, the integration of these two dynamic and highly respected research organizations will enable SEPP to greatly expand the scope and effectiveness of its programs and provide ICS with an unmatched capability to anticipate trends in global and national environmental concerns--certain to be among the most contentious and controversial policy areas of the next decade.

SEPP was founded in 1990 as a comprehensive research effort to study and document--through publications and symposia--the relationship between scientific data and the development of federal environmental policy. In recent months, a SEPP survey of U.S. participants in the Intergovernmental Panel on Climate Change (IPCC) Report and the Project's "Statement by Atmospheric Scientists on Greenhouse Warming" have exploded the myth of "scientific consensus" on climate catastrophe, revealing that those scientists who hold alarmist views make up something less than 20 percent of the whole.

Project publications include two edited volumes and numerous articles on global climate change, stratospheric ozone, acid rain, air pollution, and other topics, as well as the just-released report, *The Greenhouse Debate Continued: An Analysis and Critique of the IPCC Climate Assessment* (140 pp.), and a work in progress on "Cancer and Chemical Risk," by Dr. Gerhard Stoehr, SEPP Director of Chemical Risk Assessment. A symposium, "How well does environmental policy track science?," organized by SEPP, drew a standing-room-only crowd at the 1992 annual meeting of the American Association for the Advancement of Science.

MORE...

Members of the SEPP Board of Directors are S. Fred Singer, ICS President and CEO Robert B. Hawkins, Jr., ICS Executive Director Sam T. Harper, SEPP Executive Director Candace C. Crandall, and Prof. Aaron Wildavsky of the University of California, Berkeley. An international advisory board of distinguished scientists is also being assembled.

Offices for The Science and Environmental Policy Project are now located at 2101 Wilson Blvd., Suite 1003, Arlington, Virginia 22201. New phone numbers are:

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Global Warming

Document Originally
Attached to
Following Page

THE GLOBAL WARMING HOAX

I. The Next Ice Age

On June 24, 1974, Time magazine's Science section featured an article titled "Another Ice Age?" The article noted that worldwide temperatures had been falling for decades and warned of baleful consequences already starting to appear:

...a growing number of scientists are beginning to suspect that many seemingly contradictory meteorological fluctuations are actually part of a global climatic upheaval. However widely the weather varies from place to place and time to time, when meteorologists take an average of temperatures around the globe they find that the atmosphere has been growing gradually cooler for the past three decades. The trend shows no indication of reversing. Climatological Cassandras are becoming increasingly apprehensive, for the weather aberrations they are studying may be the harbinger of another ice age.

"Telltale signs" of global cooling are everywhere, Time wrote, "from the unexpected persistence and thickness of pack ice in the waters around Iceland to the southward migration of a warmth-loving creature like the armadillo from the Midwest."

Who was to blame for plummeting temperatures? Man, of course:

Man, too, may be somewhat responsible for the cooling trend. The University of Wisconsin's Reid A. Byron and other climatologists suggest that dust and other particles released into the atmosphere as a result of farming and fuel burning may be blocking more and more sunlight from reaching and heating the surface of the earth.

Needless to say, global cooling threatened disastrous consequences:

Whatever the cause of the cooling trend, its effects could be extremely serious, if not catastrophic. Scientists figure that only a 1% decrease in the amount of sunlight hitting the earth's surface could tip the climatic balance, and cool the planet enough to send it sliding down the road to another

ice age....

Global cooling hysteria continued through the mid-1970's. On April 28, 1975, Newsweek proclaimed the arrival of "The Cooling World." Accompanied by charts illustrating the continuous and dramatic drop in temperatures that took place between 1940 and the 1970's, Newsweek's article warned that cooler temperatures and shorter growing seasons portended a disastrous decline in agricultural production:

The central fact is that after three quarters of a century of extraordinarily mild conditions, the earth's climate seems to be cooling down. Meteorologists disagree about the cause and extent of the cooling trend, as well as over its specific impact on local weather conditions. But they are almost unanimous in the view that the trend will reduce agricultural productivity for the rest of this century. If the climatic change is as profound as some of the pessimists fear, the resulting famines could be catastrophic.

The recent decline in temperatures, Newsweek wrote, "has taken the planet about a sixth of the way toward the Ice Age average."

Were governments responding adequately to the global cooling crisis? Of course not: "Climatologists are pessimistic that political leaders will take any positive action to compensate for the climatic change...." What should our government be doing to warm up the earth? Well, for example, it could start by "melting the arctic ice cap by covering it with black soot or diverting arctic rivers." Correctly perceiving the unlikelihood that such grand schemes would be carried out, Newsweek closed on a somber note: "The longer the planners delay, the more difficult will they find it to cope with climatic change once the results become grim reality."

You probably haven't heard much about global cooling lately.

The Ice Age scare disappeared without leaving a trace. Instead of global cooling, we are now being bombarded with its negative image: the claim that the earth is inexorably growing warmer as a result of human activity. The popular media generally convey the impression that global warming is an accepted fact. Time's story of January 2, 1989, is typical. Under the headline "Greenhouse gases could create a climatic calamity," Time reported that:

For more than a decade, many scientists have warned that cars and factories are spewing enough gases into the atmosphere to heat up the earth in a greenhouse effect that could eventually produce disastrous climate changes....

The heat waves, droughts, floods and hurricanes [of last summer] may be previews of what could happen with ever increasing frequency if the atmosphere warms 3° F to 8° F by the middle of the next century, as some scientists predict.

Not surprisingly, Time's readers can search this story in vain for any acknowledgement that only fifteen years earlier, the same magazine was predicting the return of the woolly mammoth.

Critics often liken global warming theorists to Chicken Little, but there is one important difference. Chicken Little was wrong, but at least he had his story straight.

II. The Facts About Global Warming

Simply put, the global warming theory holds that human activity generates "greenhouse gases," chiefly carbon dioxide, which allow solar energy to pass through in the form of sunlight, but trap heat radiating out from the earth's surface, thereby warming the atmosphere. In general, there is no doubt that this

"greenhouse" effect" exists. In fact, it makes life on earth possible. The controversial issue is whether human production of greenhouse gases, which commenced in earnest with the Industrial Revolution, is causing an accelerating increase in worldwide temperatures which could threaten the habitability of the earth by creating deserts, melting the polar ice caps, and so on.

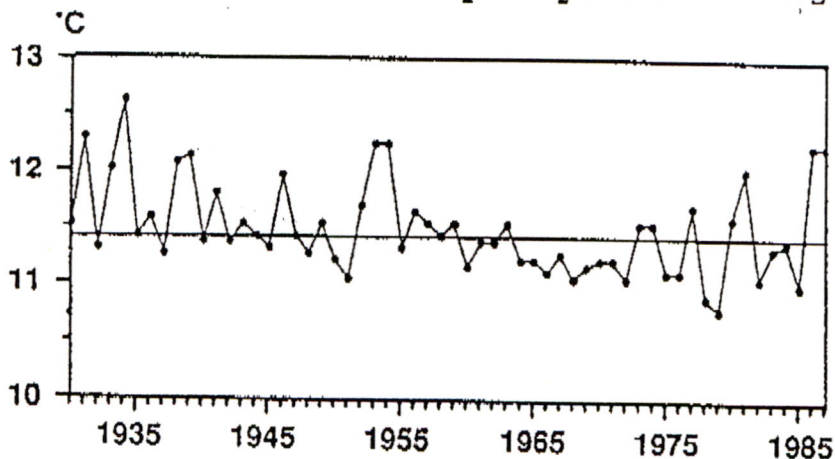
The viability of the global warming theory turns on a series of fundamental questions which, despite their obvious importance, are seldom discussed in depth in the popular press. The first question is whether the earth is in fact getting warmer.

If global warming is valid, worldwide temperatures should have increased gradually from the mid-19th century until approximately 1940. At about that time worldwide production of CO₂ increased dramatically; in fact, the majority of all man-made CO₂ has entered the atmosphere after 1940. Thus, the global warming theory would predict rapidly increasing temperatures from 1940 to the present.

But the temperature record contradicts the predictions of the global warming theory. There has been no steady increase in temperature. Worldwide temperatures were flat in the late 19th century, increased relatively rapidly from about 1890 to 1900, dropped sharply until 1907, then rose gradually until the early 1940's. At this point, when global warming theory would predict the sharpest temperature increases, worldwide temperatures plummeted. The precipitous decline in temperature that started in the early 1940's continued until the late 1970's; hence the fears of another ice age. Since the late 1970's, we have again experienced a period of generally rising temperatures. Thus, on a

world wide basis there is no indication whatever of consistent or long-term warming.

Another way of approaching this issue is by referring to United States temperature records. These records are particularly important because they are relatively accurate, and they cover both a long period of time and a large land mass. The chart reproduced below shows annual average temperatures for the contiguous United States for the years 1930 through 1985, corrected for the urban heat island effect (i.e., the fact that many temperature stations are in urban areas, which are warmer than the surrounding countryside). The chart shows no perceptible warming trend:



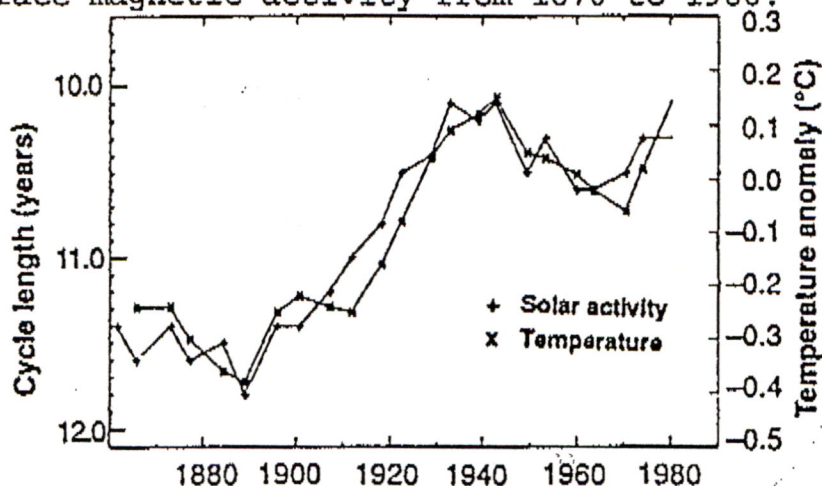
It is these data, among others, that caused the George C. Marshall Institute, which is composed of some of America's most eminent scientists, to write earlier this year: "The predictions of the greenhouse theory are contradicted by the temperature record to such a degree as to indicate that the anthropogenic greenhouse effect has not had any significant impact on global climate in the last 100 years."

Rather than a steady warming, the temperature record shows variations that are apparently random. This leads to a second question: Is there a good explanation for fluctuations in

temperature, which accounts for both the cooling trends and the warming trends of the past century? There is. As every child knows, it is the sun that heats the earth. It should come as no surprise to learn that variations in solar energy are closely correlated to temperatures on earth.

The surface magnetism of the sun can be measured, and satellite observation has shown that when the sun's surface magnetism changes, its energy output also changes. An increase in solar magnetic activity signals an increase in energy production, while a decline in surface magnetic activity corresponds to a decline in solar energy output.

The chart reproduced below plots global temperatures against solar surface magnetic activity from 1870 to 1980:



It appears obvious that solar energy output is the engine that chiefly drives global temperatures. The vastly differing concentrations of man-made "greenhouse gases" in the atmosphere between 1870 and 1980 had no apparent effect on temperatures.

The data set forth above represent only a small portion of an ever-growing body of information that empirically disproves global warming theory. As a result of this accumulating evidence, two-thirds of the members of the American Meteorological Society and

the American Geophysical Union who were polled by Gallup in March 1992 indicated that they do not believe that recent warming trends have anything to do with the greenhouse effect or with human activity.

The environmentalists who advocate global warming cannot deny the facts, nor can they make their theory consistent with them without abandoning the entire greenhouse enterprise. Consequently, they prefer to ignore the facts altogether, and retreat to the more congenial world of computer models. In fact, every one of the frightening predictions you have read about the inevitability of global warming and its dire consequences is based not on empirical analysis of the facts, but rather on computer modeling. Thus, a third fundamental question is whether the computer models that predict catastrophic increases in temperature are reliable.

Based on what has already been said, this question virtually answers itself. While the various climate computer programs differ in significant respects, all of the programs that predict significant global warming in the future also "predict" steady and substantial warming from the 1940's to the present. It hasn't happened. A computer model is, after all, only a set of assumptions dictated to the computer by its human programmer, and a model that can't even "predict" the past is hardly a reliable guide to the future. The George C. Marshall Institute made the point succinctly:

If the greenhouse effect were as large as any of the results yielded by these computer models, the effect would already have shown up clearly in the temperature record. The fact that the greenhouse "signal" is missing from the record suggests that the computer models have considerably exaggerated the size of the greenhouse effect.

Additional evidence, reported in the last year and based on satellite measurements of global temperatures, indicates that the greenhouse warming produced by a doubling of CO₂ in the next century will be less than 1° C, and may be as small as 0.5° C.

Thus, the global warming scare of the 1980's and 90's has no more substance than the Ice Age scare of the 70's. There is no general trend toward warmer temperatures; fluctuations in temperature are caused by variations in solar activity, not by man; and the computer models that constitute the sole support for the global warming theory are completely unreliable.

In a few years the global warming panic will be forgotten. Someday it may be regarded as a curious instance of popular delusion; the leaders of the movement will be viewed in the same light as those who, not many years ago, sat on hilltops awaiting the end of the world.

In the meantime, however, something rather strange is occurring. In recent years an outpouring of scientific literature has conclusively debunked the doomsday predictions of the radical environmentalists and their allies. Yet this fact has not penetrated the public consciousness. Instead, the popular media have conveyed the impression that global warming is a fact, and that drastic action is needed to combat it. The extent to which the environmentalists and their media friends have succeeded in "selling" the greenhouse theory in defiance of the facts is illustrated by a study done by J. M. Harlin in 1990. Harlin surveyed 100 professors, doctors and lawyers in Alabama about temperature trends in their state. No fewer than 95 out of the 100 said that they had observed a significant warming trend in Alabama

in the past two to four decades, and every one of the 95 said the warming trend was linked to the greenhouse effect. There is only one catch: a significant cooling trend began in Alabama in 1935 and has continued to the present. This dissonance between reality and perception calls for further analysis.

III. The Radical Environmentalists' Agenda

As the greenhouse hypothesis unravels under scientific scrutiny, one might expect environmentalists to breathe a sigh of relief. And, of course, some do. But the hard core of radical environmentalists do no such thing. Instead, they press the global warming case ever more shrilly and hysterically in the popular media. In this effort they are aided by ideologically sympathetic reporters who are predisposed to favor predictions of catastrophe of any kind.

It is not hard to understand why radical environmentalists continue to advocate global warming despite the evidence to the contrary. Global warming is, from their point of view, the ultimate environmental issue. The principal "culprit"--the production of carbon dioxide via the burning of fossil fuels--is the cornerstone of modern prosperity. The "solution" to global warming is simple: remove carbon from the production cycle. This prescription is the radical's dream; it is a blow to the heart of the industrialized world. To make energy scarce by making it prohibitively expensive is neither more nor less than a strategy for impoverishing the United States and the other industrialized nations.

A second feature of global warming that makes it attractive to radicals is that the issue is so broad and so cosmic in its scope that virtually anything can be deemed relevant to it. Thus, it provides a field on which the whole grab-bag of liberal preoccupations can be brought into play. If one casually peruses almost any of the large number of popular books on the greenhouse effect that have appeared in recent years, this fact becomes apparent. A typical example of the genre is a 1990 book called Climate In Crisis by Albert K. Bates, who is identified only as a member of a group called "Plenty USA." Mr. Bates rehashes the familiar, discredited arguments for global warming, and then moves on to his prescriptions for change. His final chapter, titled "Twenty-one Better Ideas," reads like a radical's shopping list.

Not surprisingly, he begins by attacking economic freedom: "Market system democracies in general tend to evolve hierarchies of wealth and economic power on one end and poverty and servitude on the other." Consequently, we must "think deeply about major shifts in economic structure," i.e., adopt socialism. (Is it possible that Mr. Bates is unaware that socialism in eastern Europe created the worst environmental conditions on earth?) But "economic restructuring" is only a beginning.

In addition, Mr. Bates urges that all of the world's governments "provide unrestricted free access to birth control." Mr. Bates is particularly enthusiastic about China's birth control efforts, which are depicted as a model for other nations. How did the Chinese do it? "Couples that had a third child received severe penalties. They had to accept reduced salaries for 14 years, received low priority status in housing and employment, and were

made to pay their children's cost of medical care and schooling." Such measures are difficult to implement in a free society, but they become feasible once "economic restructuring" takes hold.

Population control won't do the trick by itself, of course. Thus, Mr. Bates' "better ideas" include such diverse measures as "Equalize educational opportunities for men and women;" "Improve health care services to the poor;" "Make cities more livable;" "Protect indigenous peoples;" "Redesign buildings;" "Reduce livestock production;" and "Tax military spending."

These proposals have little to do with the climate, but they illustrate how global warming can be turned into a pretext for any left-wing program. In fact, the only proposal in Climate In Crisis that bears directly on global warming is the stock remedy of greenhouse advocates: a tax on carbon. Mr. Bates' version is a \$50 per ton tax on carbon, or perhaps on carbon dioxide emissions (the author is so confused that he doesn't seem to understand the difference, and uses the terms interchangeably). The purpose of such a tax is to make energy expensive enough to discourage its consumption. It would do this, and more.

The economic effects of a tax on carbon have been studied extensively. Most analysis has focused on carbon tax proposals that are designed to stabilize CO2 emissions at 1990 levels--a goal which would probably require a tax well in excess of \$50 per ton. The EPA's Office of Environmental Analysis estimated that such a tax would raise the price of crude oil by 73%, minemouth coal by 240%, utility coal by 165%, and natural gas by 82%. Not surprisingly, the EPA concluded that such a tax would have "an extremely detrimental effect on the U.S. economy." Analyses by

private groups reinforce the EPA's conclusions. For example, CONSAD Research Corporation stated earlier this year that a carbon tax sufficient to stabilize CO2 emissions would "put the U.S. economy into a deep-freeze." A total of 1.6 million jobs would be lost by the year 2005, and 5 million jobs would be "at risk." And, to make matters worse, since the United States relies more on fossil fuels and less on nuclear energy than most other developed countries, an internationally-uniform tax on carbon would put American products at a competitive disadvantage. In short, if poverty is the goal, a tax on carbon is an excellent way to achieve it.

Climate In Crisis is rather pitiful, and may not seem worth the attention devoted to it here. But it does fairly represent the way in which radical environmentalists use global warming as a pretext for a guerrilla attack on the developed world. And there is another reason why Climate In Crisis deserves attention: the book's introduction, which enthusiastically endorses Mr. Bates' ideas, was written by Senator Albert Gore.

Senator Gore characterizes Climate In Crisis as a "valuable addition to the public debate" because it contributes to "awareness among the peoples and leaders of the world about the nature and extent of the problem." Indeed, Senator Gore is in some respects more radical than Mr. Bates. He launches a personal attack against those scientists (i.e., the majority) who decline to jump on the global warming bandwagon: "Those who, for the purpose of maintaining balance in debate, take the contrary view that there is significant uncertainty about whether it is real are hurting our ability to respond." Gore goes so far as to suggest that those who

fail to join forces with the "economic restructuring"/population control/vegetarian/pacifist/tax 'em until they ride bicycles brigade are suffering from a "psychological problem." In view of the scientific evidence reviewed earlier, the arrogant presumption of Gore's comments is breathtaking.

Thus does the lunatic fringe meet the mainstream. Can we assume, in view of Gore's recent selection as vice presidential nominee, that the Democratic Party has signed on with the global warming zealots? Stay tuned.

In any event, whatever the vicissitudes of the current political season, the long term future should not be in doubt. The global warming hypothesis has lost the scientific battle, and popular opinion will follow eventually. The people of the United States, Europe and Japan have no desire to impoverish themselves in service of a scientific myth. And, unlike the radical environmentalists, they do not view government control of everything under the sun as a desirable goal in its own right. Free governments are no more likely to impose population control and mandatory bicycling than they were to paint the polar ice caps black.

In the meantime, the earth may grow cooler, or it may grow warmer, in response to natural cycles that have existed for millennia--although it is unlikely to become as warm as the 11th century, when Greenland was green and the Scandinavians grew grain near the Arctic Circle. Either way, humanity will survive, and so will nature. We have nothing to fear but hysteria itself.

John H. Hinderaker
Scott W. Johnson

Global
Warming

Document Originally
Attached to
Following Page

Weather

Today: Cloudy, thundershowers.
High 70. Low 59. Wind 7-14 mph.
Monday: Clouds, then partly
sunny. High 76. Wind 7-14 mph.
Yesterday: Temp. range: 55-64.
AQI: Good. Details on Page B2.

The Washington Post

115TH YEAR ... No. 178 .K

SUNDAY, MAY 31, 1992

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As Earth Summit Nears, Consensus Still Lacking on Global Warming

By Boyce Rensberger
Washington Post Staff Writer

While most of the planet's heads of state converge on Rio de Janeiro for the Earth Summit to set policy on coping with global warming, most of the scientists who specialize in the subject still can't figure out whether anything unusual is actually happening to Earth's climate.

Scientists generally agree that it has been getting warmer over the last hundred years, but the average rate of change is no greater than in centuries past, and there is no consensus that human activity is the cause.

And while there is no doubt that continued emissions of "greenhouse gases" tend to aid warming, it is not clear that cutting back on emissions could do much to stop a natural trend, if that is what is happening.

Seldom, in fact, has an issue risen to the top of the international political agenda while the facts of the matter remained so uncertain.

For example, in the single most comprehensive effort to synthesize the state of scientific knowledge about global warming, the United Nations Environment Program and the World Meteorological Organization called together several hundred working scientists from 25 countries—most of the top specialists



EARTH
SUMMIT
SYMBOL

with expertise in the subject—and asked them to write a comprehensive report on the situation.

That group, the Intergovernmental Panel on Climate Change (IPCC), produced a 365-page report in 1990 that was the scientific basis for a climate treaty to be adopted in Rio. It concluded that the future warming rate could speed up considerably, with Earth's mean temperature climbing about 2 degrees Fahrenheit by 2025 and 5 degrees by 2100.

That report gave impetus to one of the most ambitious international efforts ever undertaken, yet when read closely the

document gives "certain":

■ There is a na keeps Earth wa be. It's been op scientists have ■ Emissions of activities are pu those gases in t been known for

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See

Is It Getting Warmer, but Is Human Activity the Cause?

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measured to date in an those the Earth is through entirely the report said, "to t, of the observed anced greenhouse utable to those hu- sis of the observa-

present the consensus all the voices calling erts so widely pub- o Rio?

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have tended to be

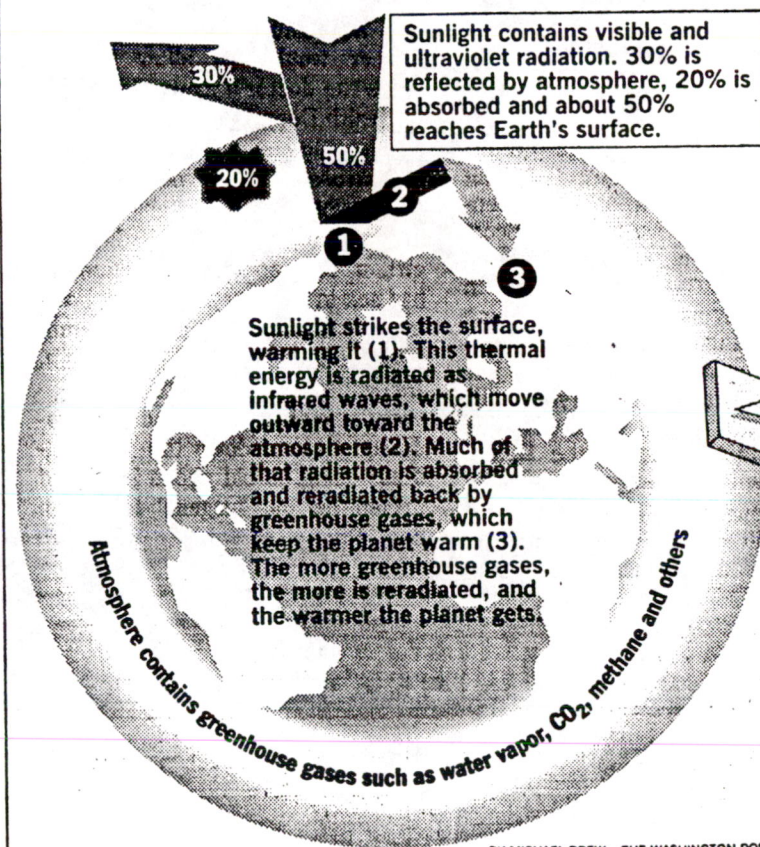
those who express alarm and call for immediate, massive action in the name of prudence. They are most visible because many are backed by large activist organizations and because the news media traditionally give alarm calls prominence. But there are also more circumspect scientists who say the data are still much too uncertain to rush into action, especially expensive action, to curtail greenhouse emissions.

The most prominent climatologist to sound the alarm was James E. Hansen of NASA's Goddard Institute for Space Studies. He triggered much of the current concern by announcing in 1988 that "global warming has reached a level such that we can ascribe with a high degree of confidence a cause and effect relationship between the greenhouse effect and observed warming. It is already happening now."

* One of the alarmists' severest critics is S. Fred Singer, the first director of the U.S. weather satellite program and a well-known skeptic of doomsday scenarios. Yet Singer calls the IPCC report "an excellent compilation . . . filled with appropriate cautions and qualifications." And he agrees that global warming is likely to continue but suspects the rate will be "modest."

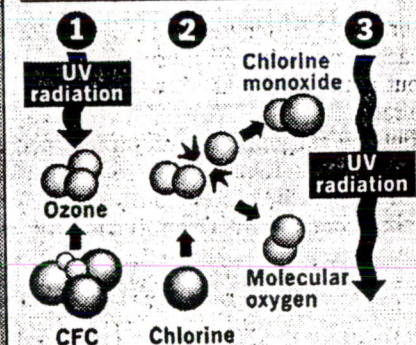
What follows is a guide to the facts behind the issues to be discussed at Rio Wednesday through June 14—drawn heavily from the data published in the IPCC's original report, its update of that report and other analyses by numerous scientists, including the National Academy of Sciences' Greenhouse Warming Synthesis Panel. It may serve as a "tool kit" for nonspecialists who believe the future of the planet should be taken seriously.

SUNLIGHT, HEAT AND THE ATMOSPHERE



OZONE DEPLETION

1. Much of the solar ultraviolet radiation (UV) is absorbed by ozone. The ozone layer is endangered by man-made chlorofluorocarbons (CFCs), which rise into the stratosphere and are broken apart by UV radiation.
2. The resulting freed chlorine atom reacts with the ozone, forming chlorine monoxide and oxygen.
3. UV rays continue to break down chlorine monoxide molecule, releasing the chlorine atom to destroy another ozone molecule. Fewer UV rays are absorbed, and more pass through to Earth's surface.



Trends in History: Wild Climate Shifts

To hear the debate over global warming, you'd think Earth's climate had always been steady as a rock and is only now being forced to change on account of human activity. In fact, for at least the last 2 million years, the climate has been swinging wildly between ice ages (the most common condition) and interludes of warmth—often far more warmth than the planet is now experiencing.

Many climatologists think the chief cause of these repeated swings is a change in the intensity of sunlight as a result of shifts in the tilt of Earth's axis. Even a slight change can cause a significant cooling or warming.

Some scientists note that it takes a change of only a few degrees in average temperature—6 or 8 degrees Fahrenheit—to turn a moderate climate into an ice age or vice versa. Other scientists agree but point out that such changes have been occurring all along without any human input. Extreme climate shifts are perfectly natural. Temperature swings in the past were enough to raise or lower sea level by 400 feet.

There is no way, those other scientists say, to tell whether the recent warm years (in which the temperature rise over the past century has been just 1 degree F) are part of a natural fluctuation or something new. Even if Earth warmed as fast as is predicted by many theories, the rate of change would not necessarily be faster than in the past. Recent studies of ancient climate shifts show that they can occur in just a few decades—the time scale environmental activists are warning about now. This, of course, does not mean it would be easy for people and ecosystems to adapt. Past climate shifts have caused major waves of extinctions.

Tracking natural climate change is complicated by the fact that global temperatures have not simply oscillated between warm and cold. There have been oscillations within oscillations.

Tracking the Big Chill . . .

Take the latest ice age. It began waning about 15,000 years ago. The glaciers began melting, retreating northward. The meltwater made sea levels rise. But about 10,500 years ago, the trend suddenly reversed itself. In less than a century the ice age returned. Temperatures fell, the retreating glaciers advanced again and sea level dropped.

Nobody knows exactly what caused the

change, but many experts suspect the huge volume of melting ice disrupted circulation in the oceans. The meltwater, being colder and less dense than salt water, could have suppressed, for example, the Gulf Stream, which normally heats northern latitudes with tropical water.

The cold period lasted about 500 years; then, as abruptly as the cooling began, a spell of global warming set in again.

By about 6,000 years ago the post-ice age climate reached its warmest, with a global average temperature about 2 degrees F higher than now. Then Earth cooled again, dropping about 2½ degrees. So much water became locked into glaciers that the sea level during Greco-Roman times was six feet lower than it is today.

. . . And the Little Ice Age

Then the roller coaster went up again so that between 2,000 and 500 years ago the Earth was about 1 degree F warmer than now. From about the 10th century through the 13th century, for example, Europe was so warm that Greenland was, in fact, green with plants.

Then global cooling set in again, and about the year 1550 there began an episode now known as the Little Ice Age. It didn't let up until about 1850. Iceland, which today is locked in sea ice only one to three weeks a year, was then icebound five or six months a year. In London, the Thames River froze over every winter, something it didn't do before or after.

Since 1850 Earth has generally warmed, climbing unevenly out of the Little Ice Age. Which brings up one of the contentious points of the current debate. Some experts say the warm years of the last decade are a sign of something new. Others say we may simply still be coming out of the Little Ice Age. They note that we have not yet returned to the warmth of the medieval era, when Scandinavians grew grain near the Arctic Circle.

The warming trend of the past century is by no means smooth. Much of it happened before 1940, when carbon dioxide levels were much lower than they are now. Then the warming stopped and reversed. Global cooling prevailed from 1940 to the mid-1960s, even as industrial activity soared, pouring carbon dioxide into the atmosphere. Some scientists warned then that it might signal a new ice age.

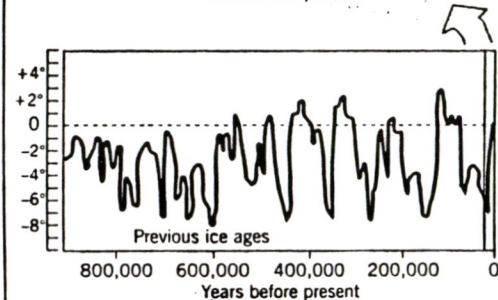
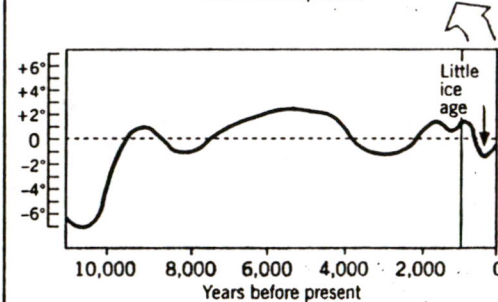
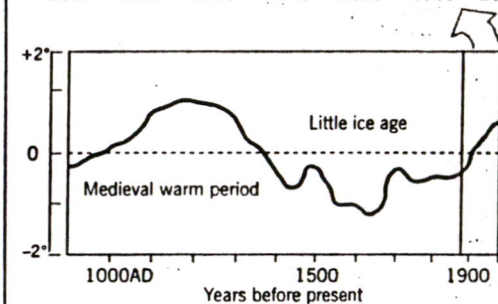
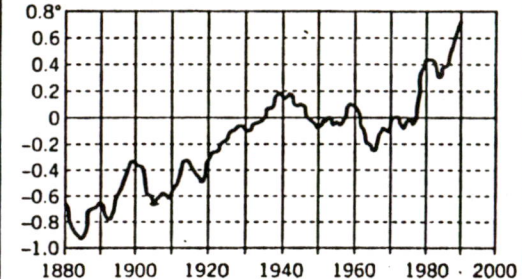
But around 1965, the warming resumed and has been increasing quite rapidly ever since. The eight warmest years of the 20th century have all come since 1979. But as the long view shows, they were by no means the warmest years ever. It was considerably hotter just a few centuries ago.

TEMPERATURE OVER TIME

Earth's average surface temperature has long been fluctuating. Graphs show changes over various scales of time. Each is an expanded version of the shaded portion of the one below. Dotted lines indicate moderate climate.

Top graph shows smoothed curve that eliminates much of the year-to-year variation.

TEMPERATURE CHANGES, IN DEGREES FAHRENHEIT



Sources: Top—NASA Goddard Institute for Space Studies, others—Intergovernmental Panel on Climate Change THE WASHINGTON POST BY TOBEY

Global The Pa

This may be the public notices warm the climate change dep powerful. This year effect from Mount since Indonesia's K According to Almatologist, Pinatub the atmosphere to The cooling effect the warming effect since the beginning Pinatubo's dust expected to stay a atom absorbs sunlight. In addition, th on it, creating a di cloudiness.

This means that cooler than the was sulfur will eventual cline and Earth will Pinatubo's cooling that of Mount Tam caused such a coolin without a summer." several times that s

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Some climate expe crease cloud cover. I are indications that E in cloudiness over the

THE EARTH SUMMIT

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Earth Summit, which begins in Rio de Janeiro, will be the largest ever convened to debate the environment. Leaders of about 120 representatives of hundreds of governments will take part in the event, which the meeting will stress. Participants fall into two broad categories:

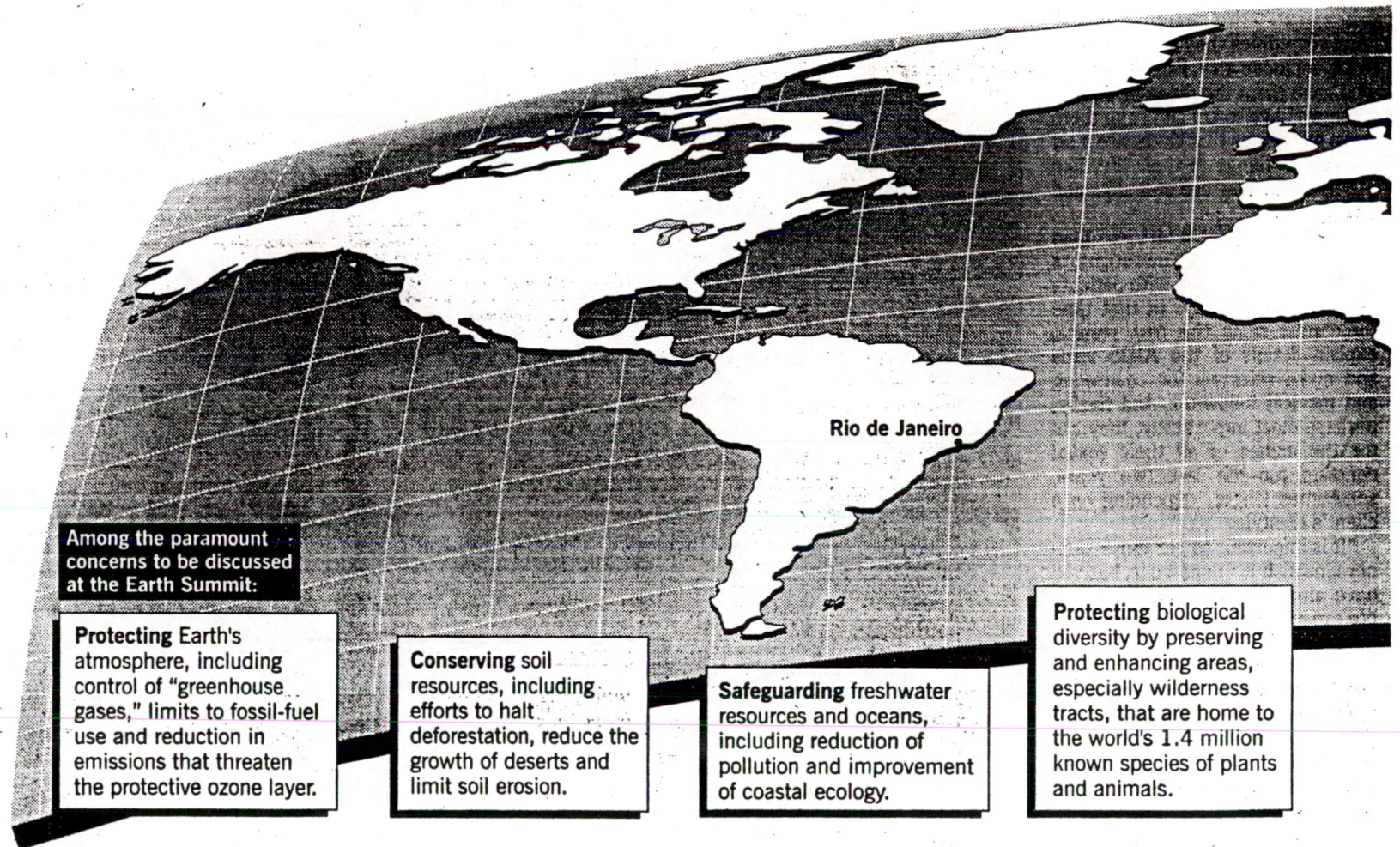
COUNTRIES

Developed countries want to control most environmental issues. Developing countries want the Third World to control their ecological resources.

ISSUES

With rapidly growing and expanding economies putting increasing strain on global ecology, but without compensation in the form of technology transfers.

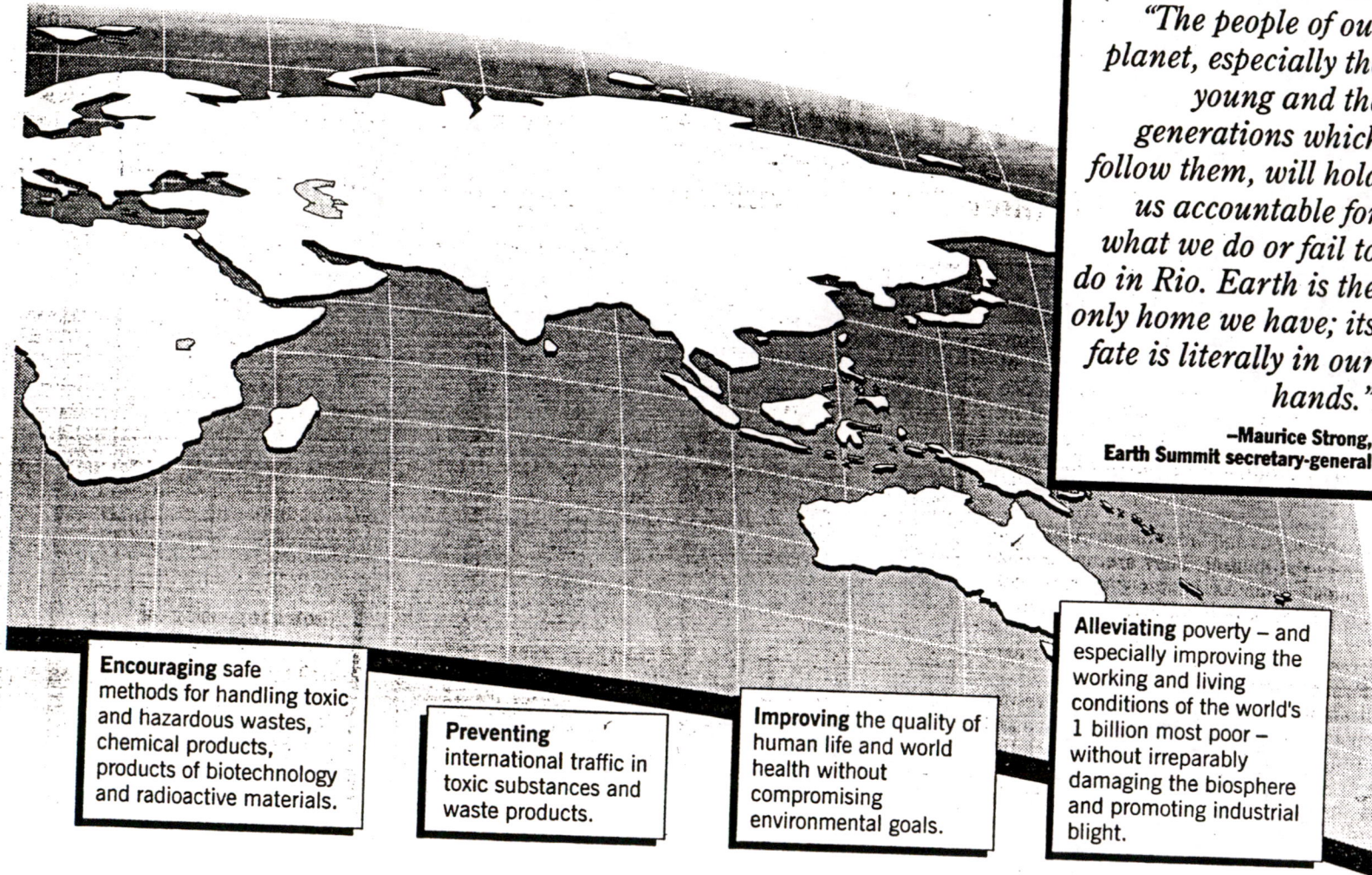
Protecting the environment, and in-hand, because the world's most vulnerable are those most driven to exploit natural resources to survive. As a result, industrialized states will need to contribute \$125 billion annually until the year 2000, more than the current level of assistance.



"How can Ramos claim victory when Congress has not even counted 1 percent of the votes yet?" asked Gabriel Villareal, a lawyer for Co-

THE WASHINGTON POST

THE EARTH SUMMIT



"The people of our planet, especially the young and the generations which follow them, will hold us accountable for what we do or fail to do in Rio. Earth is the only home we have; its fate is literally in our hands."

—Maurice Strong,
Earth Summit secretary-general

Encouraging safe methods for handling toxic and hazardous wastes, chemical products, products of biotechnology and radioactive materials.

Preventing international traffic in toxic substances and waste products.

Improving the quality of human life and world health without compromising environmental goals.

Alleviating poverty — and especially improving the working and living conditions of the world's 1 billion most poor — without irreparably damaging the biosphere and promoting industrial blight.

ON THE TABLE

Formally called the *United Nations Conference on Environment and Development*, the summit meeting will address four

■ TWO LEGALLY BINDING

One commits governments to reducing "greenhouse gases" and to reducing global warming; the other obliges signatories to reduce the rate of plant and animal species extinction.

■ THE 'RIO DECLARATION'

A general set of principles defining the responsibilities toward the environment while pursuing economic development.

■ 'AGENDA 21'

A detailed 800-page "blueprint" for the 21st century by states, industry and organizations. It sets environmental quality between nations for the 21st century. The nonbinding recommendations on air, water and land conservation and resource management, technology transfer among nations, toxic and hazardous waste guidelines and methods of controlling global warming and combating poverty.

■ 'FOREST PRINCIPLES'

A legally nonbinding accord setting standards for the management and preservation of the world's forests.

The summit—authorized by a 1992 resolution as a result of more than two years of negotiations at the 20th anniversary of the first United Nations Conference on Human Environment, held in Stockholm.

BY RICHARD FURNO—THE WASHINGTON POST

The Greenhouse Effect: What It Is, How It Works

When sunlight enters a greenhouse, it passes through the glass and strikes the surfaces inside. Some light is reflected back into space and some is absorbed by the soil and plants. The light's energy is stored as heat. (Earth receives no heat directly from the sun.) The warmed objects then radiate the heat into the surrounding air.

Two things happen at this point. First, the heated air rises—a phenomenon called convection—but is trapped by the glass. This is what accounts for nearly all the temperature rise in a greenhouse but it is not a factor in Earth's atmosphere—which makes "green-

house effect" a misleading term. Second, the heat coming off the warmed surfaces (infrared radiation) is absorbed by the glass, which gets warmer. It is this small warming effect that also happens in the atmosphere.

Most of the gas in the air plays little or no role in the greenhouse effect. Nitrogen and oxygen (which make up 99 percent of dry air) are largely transparent to light and heat. But other gas molecules act like glass. They let light in but capture heat going out. The most abundant of these are water vapor and carbon dioxide.

Environmentalists may damn the greenhouse ef-

fect, but it has been happening for billions of years and it is what keeps Earth from being as cold as Mars, which lacks natural greenhouse gases. If it were not for the natural greenhouse effect, scientists have calculated, Earth's average surface temperature would be about 5 degrees Fahrenheit. The oceans would be frozen solid. Instead the average year-round temperature is about 68 degrees.

Environmentalists don't dispute this. They point not to Mars but to Venus, where a runaway greenhouse effect is blamed for boosting the surface temperature to nearly 900 degrees.

Carbon Dioxide's Growth: A Well-Documented Worry

Contrary to popular conception, carbon dioxide is not the main contributor to the greenhouse effect. Water vapor is. But for all practical purposes, it is virtually ignored in the debates because it is not thought to be increasing significantly, there is not much that can be done about it and you wouldn't want to anyway because we need the rain.

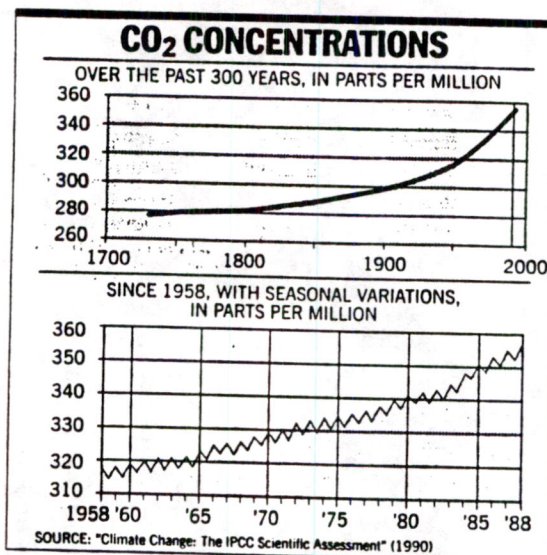
But the concentration of infrared-absorbing gases in the atmosphere is definitely increasing—this is one of the few certainties of the current debate—and the chief contributor to the increase is carbon dioxide, or CO₂. It is growing largely because of human activity. CO₂ is produced by burning any organic matter—from fossil fuels (coal, oil, gas) in giant power plants to wood fires at backpackers' campsites.

Vast amounts of forest clearing also contribute either through burning the wood or simply by cutting it and letting it decay. Wood is a carbon-rich material and both burning and decay convert much of it back into carbon dioxide. This is the same carbon that the trees took out of the atmosphere in the process of photosynthesis as they were growing.

It is a misconception, however, that forests simply take carbon dioxide out of the air and give off oxygen. Plant metabolism consumes oxygen and gives off carbon dioxide just as animal metabolism does. The only time plants consume CO₂ is during photosynthesis, when the consumed carbon is incorporated into carbohydrate compounds and locked away in the tissue of the plant. This occurs only while the plant is growing in size. Once a forest has reached maturity, the amount of carbon dioxide it consumes is equal to the amount it loses during metabolism and from the decay of naturally dead leaves and wood. In other words, a mature forest is in a carbon equilibrium with the environment.

Along with deforestation, large parts of Earth are being reforested—especially in the Northern Hemisphere—and some estimates indicate this growth may be extracting carbon dioxide from the air in quantities comparable to those released by forest burning in the tropics.

Measurements of the concentration of CO₂ in the air over



the last two centuries are extremely good. Samples of air from past centuries have been retrieved from air bubbles trapped in old ice. They show that around 1800—well before the greatest increase of population and industry—the CO₂ concentration was about 280 parts per million. Samples from younger ice show progressively higher levels. Since 1958, direct measurements have been made atop Mauna Loa in Hawaii, far from industrial sources. In what John Firor of the National Center for Atmospheric Research in Boulder, Colo., says "may turn out to be the most important geophysical measurement of the 20th century," the data show uncontestably that the carbon dioxide level has grown every year since.

Today the CO₂ concentration is 356 parts per million—27 percent higher than in preindustrial times—and is growing at about 1.5 parts per million each year. These inarguable facts underlie a large part of the current worry that human-produced carbon dioxide may be enhancing the natural greenhouse effect.

The Other Gases: CH₄, CFCs, N₂O

Experts estimate that carbon dioxide accounts for only about 61 percent of the enhanced greenhouse effect. The other sizable contributors are methane (15 percent), CFCs (11 percent) and nitrous oxide (4 percent).

■ Methane is also known as marsh gas because it is produced by the decomposition of organic matter in marsh bottoms. It is also the main component of natural gas. While the amount of methane—CH₄—being put into the atmosphere is only about 1/50th the amount of carbon dioxide going up, each pound of it has 20 to 60 times the greenhouse effect of CO₂, the effect declining with time because it is taken out of the air fairly rapidly.

About 525 billion tons are released each year (compared with 26,000 billion tons of carbon dioxide), most of it from natural wetlands, rice paddies and flatus of animals. Only about 20 percent of methane comes from industrial activities that offer hope of reducing output, such as gas drilling and landfills.

The atmospheric concentration of CH₄ was fairly steady during recent centuries. Since the mid-1800s, however, it has doubled and is still climbing—twice as fast as the carbon dioxide level—mainly as the result of increasing rice cultivation.

■ Chlorofluorocarbons, or CFCs, are by far the most potent greenhouse gases. They are all human made, mostly for use as solvents, refrigeration coolants and aerosol propellants. They are, pound for pound, 1,500 to 7,300 times as powerful at warming Earth as carbon dioxide. One thing that keeps CFCs from roasting the

Estimating Emissions: Fossil Fuels and Deforestation

Most of the increase in carbon dioxide comes from burning coal, oil and gas for electricity, transportation and heating, as well as from the manufacture of cement, which carbon-containing minerals are burned. The

Deforestation also releases CO₂ but estimates of the amount vary widely, from 0.6 billion tons to 2.5 billion tons. Even at the high end, this would be less than half the carbon

Global Warming: Disparate Impact

Even if Earth warms appreciably in the next few decades, that would not mean it will get warmer everywhere. Indeed, the climate models forecast that some places will cool while the planet as a whole warms.

The bad news, according to some models, is that central North America and Eurasia are likely to get the most heating. The good news is that Antarctica may get colder or, at least, not much warmer. This is good because about 90 percent of Earth's ice is in Antarctica. Though there were early fears that the ice mass could melt and raise sea level by yards, new analyses cited by a National Academy of Sciences panel indicate it is highly unlikely to melt in the next century. In fact, it may accumulate more ice if snowfall increases, as some models predict. This could offset any sea-level rise from other causes.

Greenland's ice, on the other hand, which is about 9 percent of the world supply, is expected to melt around the edges. It is thought to have been doing that for decades, contributing to the sea-level rise of about six inches this century. Forecasts of sea-level rise vary from none to perhaps two feet over the next hundred years.

At worst, this would cause serious flooding of low regions all over the world including a third of Bangladesh and much of the most valuable real estate in Florida, Louisiana and Texas. If the rise happened suddenly, nearly 200 million people would be flooded out.

Far more widespread are the projected effects on agriculture, though not always bad. While the latitudes suitable for specific crops would move north if growing seasons lengthened, a more significant change is likely to be in the distribution of rainfall.

In some scenarios, the United States loses enough rain to cut farm productivity by a third—until cropping patterns adapt—and Russia benefits both from more rain and the warming of parts of Siberia now unsuitable for farming. But climate forecasters emphasize that their regional prognostications are much less reliable than those for the globe overall.

Because carbon dioxide is, after all, plant food, rising CO₂ levels might well act as fertilizer, making plant growth more abundant. This would remove the gas from the air and might boost food production. In the laboratory, plants have responded this way if they had extra soil nutrients and water. But there has been no test in a natural ecosystem.

Natural ecosystems may be the hardest hit if the changes come fast. Temperature zones may move north faster than forests can keep up through natural dispersal of seeds. Margaret B. Davis of the University of Minnesota has developed computer models that show shifting climates will leave many trees standing where they cannot survive. The eastern hemlock, for example, now ranges as far south as the mountains of North Carolina. In one projection, Davis estimates that in 100 years it will retreat to the latitude of New York City; in an alternative projection, she concludes that the tree will not be found south of Maine. Some experts also predict that drier weather will kill many southern temperate forests, turning them to grasslands.

The great unknown is not so much whether it

Computer Models: Fine-Tuning Forecasts

If the computer simulations that predict global warming are right, Earth's climate should already have gotten hotter than it has in recent years.

In other words, the computer models that are the chief basis for forecasts of gloom and doom are flawed. The proprietors of various models have always been the first to point this out, but their caveats are usually overlooked in the popular debate.

The flaw becomes evident not when the computers are asked to simulate future climate but when they are given the climate of the past and asked what it will be like in the present if carbon dioxide levels increase from past levels to those we know exist now.

"What happens is that the computers tell you we should have gotten twice as much warming as we actually have. That tells you there's something missing in the models," said Andrew Solow, a specialist in climate models at the Woods Hole Oceanographic Institution in Massachusetts. "Everybody knows the models are crude."

Another problem is "model drift." When the models are run to predict the current climate, their results are not always the same. Sometimes, Solow said, they "predict" that we should now be in an ice age. To correct for this, computer operators tinker with the program, making "flux corrections." These change the

rate at which simulated phenomena happen—such as the transfer of heat from the ocean to the air. The tinkering continues until the model reproduces the current climate more accurately. Then the models are asked to simulate the future, without knowing if the adjusted flows of energy will stay the same.

Although there are different climate models that give different outcomes, they work much the same way: Earth is divided into a grid of several thousand boxes. The atmosphere in each box is sliced into layers, so is the ocean. The computer treats each layer in each box as a separate parcel of climate.

A set of conditions is fed into the computer for each parcel—temperature, wind, sunlight, carbon dioxide and so on, along with standard formulas for the behavior of gases, liquids and solids.

Then the computer calculates how the phenomena

in each parcel would feed those new numbers, the changes propagated by computer recalculates even time had passed.

Modeled days pass, and a century of climate supercomputers must be run.

In recent years climate models have been used to predict a warming of the middle of the next century, with some models forecasting a rise of several degrees—by the end of