

The CO2 Newsletter, created, published, and edited by William N. Barbat, ran from 1979 to 1982.

In 2025, the family of Mr. Barbat donated an original set of all issues to Dr. Marc Hudson, and agreed that these could be digitised and placed online as a resource for anyone who wants to understand how long we've known about the carbon dioxide and global warming problem.

CO₂ Newsletter

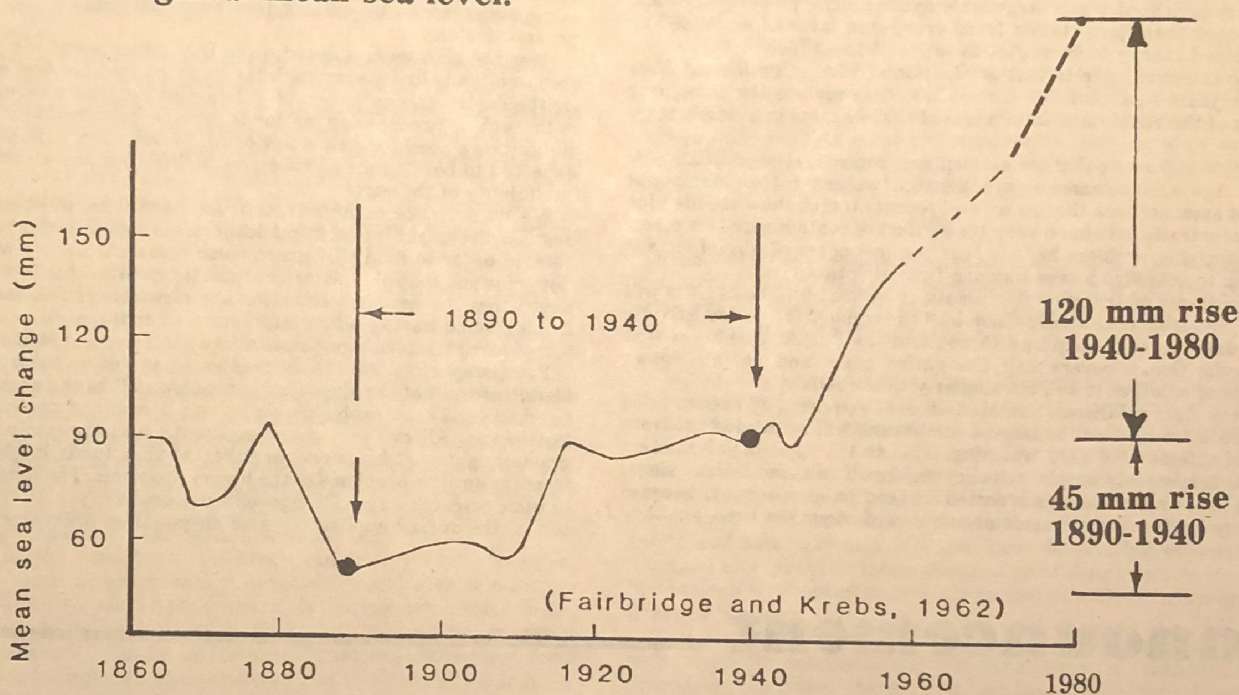
Volume 3, Number 2

Jan.-Feb., 1982

A bimonthly summary of advances in knowledge of the CO₂-greenhouse problem, and of the social, political, and economic implications.

Accelerating sea level rise is attributed to climate change

Trend in global mean sea level:



(Modified after Etkins & Epstein; reproduced from SCIENCE)

Robert Etkins and Edward S. Epstein of NOAA reported in SCIENCE 15 January 1982 that more than 50,000 cubic kilometers of polar ice must have been discharged into the oceans during the past 40 years—and especially since 1970—to account for that part of the observed 120 mm (4.7 inch) sea level rise which cannot be attributed to thermal ocean expansion. Although the authors allow that the apparent consistency between sea level changes and relatively modest global warming, as observed in air temperatures, may be spurious, they propose that this rising sea level is a significant indication of climate change as may be due to increasing concentrations of atmospheric CO₂.

The authors offer an independent check of their findings by noting

that a transfer of this great ice mass away from the earth's rotation axis as dispersed meltwater would change the earth's moment of inertia and thereby retard the earth's rate of rotation. Their calculated value of the retardation rate that should be expected due to ice discharge in the last 40 years accounts for about three-fourths of the observed reduction in the earth's angular velocity during the same period.

The discharge and melting of a large volume of polar ice would extract latent heat, they note, which would significantly reduce the sensible net increase in global mean surface temperatures.

CO₂ Newsletter is published bimonthly by Wm. N. Barbat Associates (Energy Consultants), P.O. Box 24, Teton Village, Wyoming 83025. Deadlines for contributed articles and letters are Jan. 1, March 1, May 1, July 1, Sept. 1, and Nov. 1. U.S. subscription rates: Companies, institutions, or agencies \$40 per year, which allows for unlimited 'in-house' reproduction rights; individuals and university libraries \$20 per year (6 issues). Back issues \$2.50 each to non-subscribers; \$1.25 each to subscribers. Foreign airmail, if sent from the U.S., add \$4.

European subscription rate inclusive of postage: Swiss francs 48.—per year (6 issues).

Telephone: News or subscription information [307] 739-9799.

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"The worst thing that can happen to a good cause is not to be skillfully attacked, but ineptly defended."

—Frederic Bastiat

Editorial

The House Science and Technology Subcommittees' hearings that were postponed to mid-March are expected to air DoE's proposed cut-back in funding of CO₂-greenhouse research from \$12 million in 1982 to \$8 million in 1983, and a general cut-back in the entire CO₂ program.

We strongly support thrift and efficiency in government, and we concur that certain aspects such as climate modelling can be better handled by other agencies such as NOAA and NASA. We are also heartened to know that concurrently with cutting back, DoE is assembling a 'mitigation group' which will be more engineering-oriented than scientific. Collectively scientists seem to shun the off-the-shelf technologies such as nuclear-fission and large-scale hydroelectric power (which are still cheaper than fixed-station fossil energy) in favor of outmoded or undeveloped energy technologies to supplant fossil fuels.

Our greatest concern is that acquisition of hard scientific data has been for years—and still is—*far too slow* to convince the remaining skeptics of the reality and imminence of CO₂ impacts in a timely manner.

—People still argue that the atmospheric concentration of CO₂ in the last Ice Age was the same as pre-industrial values, rather than about half that amount, even though several recent studies show the high Ice Age concentrations to have been the artifact of contaminated ice cores. The underlying problem here is that too few cores of glacial ice are available to establish a case immune from skepticism.

—Tracer-gas distribution (for assessing oceanic uptake of CO₂) will be analyzed from data already acquired throughout the entire Atlantic before data are to be acquired throughout the Pacific. One notes that the Pacific Ocean covers half the entire globe and no one knows beforehand whether it will act similarly to the Atlantic.

—Many General Circulation Models, each requiring 100 hours or so of computation time on the largest computers, will be needed to assess regional effects of a CO₂ warming. This is the type of information which is desperately sought by policy-makers. The 1- and 2-dimensional climate models are being advocated instead to save money, because they may require only seconds or minutes of computer time, but they mostly re-plow old ground.

—Ocean weather stations have been supplying areal temperature data over time on the entire column of the upper ocean, which is beginning to provide a precious insight into the influence of large-scale air-sea interactions on climate. Sacrificing these ocean weather stations as a cost-cutting measure destroys the geophysical continuity, which at first glance might not seem all that serious. For analogy, though, one can imagine how far along our perception of the CO₂-greenhouse problem would be today if Keeling's atmospheric monitoring of CO₂ had fallen victim permanently to similar cost-cutting in the early 1960s (as it did temporarily in the race to put a man on the moon). If scientists were faced with a long gap in the CO₂-monitoring records, skeptics might completely shred the presently accepted argument that CO₂ has relentlessly been climbing for the past quarter century.

—Presently climatologists have no regionally detailed paleoclimatic analogs on which to base their expectations of what a warmer earth will be like. While the Hypsithermal (Altithermal) Age has been studied in considerable detail, this age appears to represent warming only of the Northern Hemisphere, which was apparently offset by a simultaneous cooling of the Southern Hemisphere.

This brief list is not meant to exclude other very worthwhile scientific programs, but is intended to provide a few illustrations of the implied urgency to acquire as much geophysical, geochemical, climatological and paleoclimatological data as may be needed, even though we cannot be certain that such information will ultimately prove valuable.

Over the past several decades the U.S. government has pre-empted research funds by its very high tax rates on incomes and estates, and by the destructive influence of inflation on corporate earnings. Along with such a pre-emption of funds goes a responsibility to sustain civilization's need for new knowledge. In this case, that knowledge is expected to bear on man's collective ability to influence the future inhabitability of the earth.

We do not necessarily advocate the sacrificing of other programs deemed necessary by political leaders, as defense and social safety nets, in order to fund CO₂-greenhouse research. Rather we challenge Congress and the Administration to come up with 'creative financing,' a term from the private sector for the clever expediences needed to finance home buying when interest rates continue to be propped up more than 10 percentage points above the annual inflation rate.

For perspective, the CO₂-greenhouse problem, the acid-rain problem, and most of the air-pollution problems all have a common source: fossil fuels. These problems also share a common remedy: supplant fossil fuels. All of the U.S. government's atmospheric pollution programs might well be joined together so that funds might be shifted from the smaller problems to the bigger problems. The funds now going to basic research on the CO₂-greenhouse problem are a very small fraction of the overall expenditures on air-pollution programs.

Announcement

(The following announcement is from the AAAS.)

"Rising Atmospheric Carbon Dioxide and Plant Productivity, an International Conference"

"R.B. Russell Agricultural Research Center, Athens, Georgia, May 22-23, 1982"

"The American Association for the Advancement of Science announces a major international conference to assess what is known and not known regarding the responses of cultivated and non-cultivated plants and ecosystems to increasing levels of CO₂, and to identify the research needed to understand the direct biological effects. The Conference Proceedings are expected to be a definitive reference until the results of the recommended research become known..."

"Background: Between 1958 and 1980, the carbon dioxide content of the atmosphere increased about 8 percent. Projections of future fossil fuel consumption suggest that levels will continue to rise. This could eventually cause a 'greenhouse effect' warming and induce a global

climatic change. The future distribution of temperature and precipitation, and the impacts on the biosphere of an altered climate regime, are unknown. The Conference will consider the interaction of possible climatic change and the direct biological effect of CO₂ levels 100 to 500 ppm higher than at present, and will identify the research needed to exploit CO₂ enrichment so as to increase the productivity of important crop and native species..."

"How to apply: Participants will be drawn from a wide variety of disciplines, from university, government and industry, and from the United States and other countries. The Conference is an opportunity for the most knowledgeable experts to speak with one voice about a complex and urgent issue. Those interested should immediately write AAAS (address below) enclosing a curriculum vitae and list of publications, and specifying the Panel or Panels for which they wish to be considered. Very limited supplemental funds are available for travel and lodging expenses. **Applications must be received by March 10, 1982.**

"Correspondence to: David M. Burns, Director, Climate Project, American Association for the Advancement of Science, 1776 Massachusetts Avenue NW, Washington, DC 20036."

Excerpts from recent reports

From 'The Rise of global Mean Sea Level as an Indication of Climate Change' by Robert Etkins and Edward S. Epstein, *SCIENCE* 15 January 1982:

"Abstract. Rising mean sea level, it is proposed, is a significant indicator of global climate change. The principal factors that can have contributed to the observed increases of global mean sea level in recent decades are thermal expansion of the oceans and the discharge of polar ice sheets. Calculations indicate that thermal expansion cannot be the sole factor responsible for the observed rise in sea level over the last 40 years; significant discharges of polar ice must also be occurring. Global warming, due in some degree presumably to increasing atmospheric carbon dioxide has been opposed to the extraction of heat necessary to melt the discharged ice. During the past 40 years more than 50,000 cubic kilometers of ice has been discharged and has melted, reducing the surface warming that might otherwise have occurred by as much as a factor of 2. The transfer of mass from the polar regions to a thin spherical shell covering all the oceans should have increased the earth's moment of inertia and correspondingly reduced the speed of rotation by about 1.5 parts in 10⁶. This accounts for about three quarters of the observed fractional reduction in the earth's angular velocity since 1940. Monitoring of global mean sea level, ocean surface temperatures, and the earth's speed of rotation should be complemented by monitoring of the polar ice sheets, as it is now possible by satellite altimetry. All parts of the puzzle need to be examined in order that a consistent picture emerge.

From 'Dispelling myths on carbon dioxide', by Edward Friedman and Robert Schwart, *The Bulletin of the Atomic Scientists*, November 1981:

"... Despite their importance in the climate system, both atmospheric transparency and surface reflectivity are being significantly altered by man.

"Man's major impact on transparency of the atmosphere is likely to result from the burning of fossil fuels, and destruction of forests, both of which produce carbon dioxide. Although transparent to invisible light, so that it does not impede the sun's ability to warm the earth and its atmosphere, carbon dioxide is nearly opaque for infrared energy and therefore tends to trap heat in the atmosphere.

"... Nearly all climatologists agree that if carbon dioxide increases to double that of the pre-industrial level, ... major climatic impacts will be felt.

"Policymakers have thus far done little but listen to the scientific debate on the carbon dioxide problem. Although it is often wise to adopt a wait-and-see attitude on questions where there are uncertainties and controversies on the physical science aspects of a problem, in this case we may be postponing action for the wrong reasons ...

"Myth: there will eventually be sufficient information on the climatic system to predict long-term changes on a scale useful to policymakers.

"Beyond the generalization that there will probably be markedly different distributions of climate in 50 years, policymakers would like to have predictions of the physical impacts on a scale of space and time relevant to economic and political processes. Barring a major breakthrough, however, such results seem far off.

"... Major unsolved problems involving meteorological parameters—such as precipitation, evaporation and oceanic diffusion rates—are likely to persist for years, despite research efforts to improve the reliability of long-range forecasts. The quality of model predictions degrades rapidly as the scale of interest is reduced from global to zonal to regional. And prediction of the timing of the induced changes or the change in climate variability on a regional scale is probably too distant to assist in the decision-making process.

"Myth: Energy and deforestation projections can be relied on to predict carbon dioxide emissions.

"... small mistakes in projections can erase decades of planning time.

"Myth: Ethics is unimportant in dealing with the problem

"... endowing future generations with [national parks, national monuments, or wildlife preservation regions] is relatively inexpensive, whereas actions to control carbon dioxide emissions may be costly for our own generation and perhaps for posterity as well. Decisions taken now to prevent future climate-induced risks will thus be based on 'discount' values and the preferences of present societies.

"If responsibility is to be measured in terms of carbon dioxide contribution, then the developed countries should bear the main costs of control, mitigation strategies and socio-economic impacts, because they will be principally responsible for an eventual doubling of concentra-

tions and because they hold the major fossil fuel resources.

"Myth: No action can be taken now to help us in the future.

"Hoisting a 'do nothing now' flag, waiting patiently until the course of natural climate can be better predicted or the 'expected' impacts occur, is a tempting policy response. Whether it is a valuable guide for sound future climate-society planning is highly questionable, however. .

"A main task for future decision-makers, then, is to see that our information about the climate system, as it affects socio-economic activities, is applied most appropriately. In this sense, nations can even act unilaterally to minimize the effects of significant, and at present unpredictable, global changes."

From "'Greenhouse effect' scenario: U.S. to suffer, Russia to thrive", unsigned article in *ROCKY MOUNTAIN NEWS* (Denver, CO) January 14, 1982:

"Washington (AP) — The potential 'greenhouse effect' of increased carbon in the atmosphere could help Soviet agriculture but have the opposite effect on farming in the United States, an environmentalist told a congressional hearing Wednesday.

"Russell E. Train, president of the World Wildlife Fund—U.S., said present rates of growth in the global use of coal and other fossil fuels could cause the amount of carbon in the atmosphere to double by 2050.

"This could increase average global temperatures by about 2 degrees centigrade, 'with progressively greater increases as you move toward the poles, said Train, a former Environmental Protection Agency Administrator.

"He said the warmer climate would mean 'a marked improvement' in agriculture in northern areas of the Soviet Union, where farming is marginal.

"On the other hand, the rich grain belt of the United States would find temperatures rising about 5 degrees centigrade, 'with an accompanying sharp reduction in rainfall,' Train told a Joint Economic Committee hearing on the role of coal in revitalizing the economy.

"Since burning coal gives off considerably more carbon dioxide than oil or natural gas, Train suggested it might not be a good idea to let 'world economies become "hooked" on the use of coal. . ."

From 'Private Sector/Government Cooperation in Realizing the Potential of Coal', Prepared Statement of Jan W. Mares, Assistant Secretary for Fossil Energy, U.S. Department of Energy, before the Joint Economic Committee January 13, 1982:

"... In the environmental area, the Administration remains fundamentally committed to streamlining the current labyrinth of standards, regulations, permit procedures, data gathering, and other processes confronting coal producers and users. The question is not so much the stringency of regulations per se, as the uncertain and cumbersome nature of the regulatory process. A better balance can be attained between energy and environmental values without compromising public health and safety. Specifically, for concerns such as carbon dioxide (CO₂) and acid rain, a better understanding of their relationship to fossil fuel usage is needed before precipitous and possibly unnecessarily costly action is taken.

"The potential climatic effects of CO₂ are the subject of recent widespread domestic and international concern. Atmospheric CO₂ accumulation is a global phenomenon, increasing with time, to which the U.S. is expected to contribute a declining share. Yet, the questions of CO₂ accumulation, its origins, and its impacts on world weather trends remain unresolved, with substantial disagreement over whether a direct link can be made between CO₂ levels and fossil fuel consumption, and the magnitude of climatic change for any assumed CO₂ increase. The uncertainty is one of the driving forces for developing non-fossil technologies, however, fuel replacements in the U.S. have historically taken 60 years or more. Hence, fossil fuel usage is expected to continue at a high level for the next several decades. In the meantime, much work needs to be done to better understand—and predict—the effects of increased levels of CO₂ on climate and vegetation.

"The current emphasis for action is on developing a better scientific understanding of CO₂ and its potential effects through multi-agency research effort. The program is aimed at removing the substantial uncertainties associated with predicting or monitoring the effects of CO₂ from fossil fuel combustion. . ."

From 'Transient Climate Response to Increasing Atmospheric Carbon Dioxide', by K. Bryan, F.G. Komro, S. Manabe, and M.J. Spelman, SCIENCE 1 January 1982:

"Abstract. The ocean's role in the delayed response of climate to increasing atmospheric carbon dioxide has been studied by means of a detailed three-dimensional climate model. A near-equilibrium state is perturbed by a fourfold, step-function increase in atmospheric carbon dioxide. The rise in the sea surface temperature was initially much more rapid in the tropics than at high latitudes. However, the fractional response, as normalized on the basis of the total difference between the high carbon dioxide and normal carbon dioxide climates, becomes almost uniform at all latitudes after 25 years. Because of the influence of a more rapid response over continents, the normalized response of the zonally averaged surface air temperature is faster and becomes nearly uniform with respect to latitude after only 10 years."

From 'Carbon dioxide, Climate and Man', by John Gribbin, published by IED, London, 1981, available from Earthscan, 10 Percy Street, London W1P 0DR, 2.50/\$6.25 per copy:

"EXECUTIVE SUMMARY

"... More CO₂ in the atmosphere means a warmer earth. . .

"Since 1957, atmospheric CO₂ has risen from 315 to 335 ppm: an increase of 6%. Since 1860 it has risen by at least 14% — and maybe 25%.

"The main current source of CO₂ is fossil fuels, with cutting and burning forests probably a close second. . .

"A projection of present energy trends suggests that by 2025, CO₂ emissions will be six times those of 1974. In 1974, the western countries produced 54% of the world's CO₂; by 2025 the western share will be only 20% . . .

"This scenario suggests a doubling of atmospheric CO₂ by about 2030.

"Computer models are very crude and inaccurate. But the computers now agree that doubling CO₂ would increase global temperatures by about 2°C — maybe as little as 1°C or as much as 5°C. . .

"A warming of 5°C might be enough to melt the Antarctic ice sheet, raising sea level by 5 meters (16 feet). Some climatologists think this could happen in 50 years, but most say it would take well over 100 years . . .

"A global rise of 2°C would not be evenly spread. Comparison with a warm period 4000-8000 years ago suggests that North America would be drier and so produce less grain, but that N and E Africa, the Middle East, India, Mexico and W. Australia would be wetter, producing more grain. . .

"Examining the differences between very warm and very cold years in recent decades suggests that global warming would be most noticeable near the poles, and that some areas might even be cooler. Europe, Russia and the USA would all be warmer and drier. . .

"These changes would be bad for agriculture in developed countries, but would probably increase Third World rice yields. . .

"CO₂ levels might be reduced slightly by growing more forests. This would probably be too expensive. . .

"Burning less fossil fuel would reduce CO₂ emissions. This is an argument for nuclear power — but also for solar and other renewable energy sources. . .

"International agreement on action to control CO₂ is unlikely, because while the US is in favor of action, Europe is not enthusiastic, the USSR is unconvinced, and the Third World might see itself benefiting from a warmer earth. . .

"The CO₂ problem should not be allowed to polarise into an argument between coal and nuclear power. But irrevocable commitments to new fossil fuel programmes should not be made — in the developed world at least. . ."

From 'Two Views on the Carbon-Dioxide Problem', TECHNOLOGY REVIEW November/December 1981:

I. 'Reduction at the Source', by Don G. Scroggin and Robert H. Harris:

"A significant buildup of carbon dioxide in the earth's atmosphere, primarily from the increased burning of fossil fuels (coal, oil and natural gas), may induce a global warming . . . by the middle of the next century. This poses the risk of severe long-term changes in the global climate and the biological systems shaped by it; some have called the CO₂ problem the most important long-term environmental issue con-

fronting humanity. But although the changes expected in any particular region of the globe remain uncertain — altered precipitation and temperature may cause sizable and uneven shifts in agricultural patterns and thereby produce changes in social, economic, and political arrangements — a general scientific consensus has emerged that, given business as usual, significant CO₂-induced changes in global climate will eventually become manifest.

"Reducing the growth in the global use of fossil fuels is an obvious response, but some scientists believe it may already be too late to avoid significant climatic changes. Instead, they urge policymakers to concentrate on **adapting** to these changes and mitigating their effects. . . But such a view is too pessimistic; it underestimates human potential and assumes that continued global economic growth is inconsistent with a deemphasis on fossil fuels (and an emphasis on renewables). . .

"... it now appears that cumulative cooling from any known countervailing factors will be modest. . .

"The impacts of CO₂-induced temperature changes on world agricultural production might well be dramatic. . . Although growing seasons in some regions could be extended by the warmer climate, plant pests and diseases, which currently reduce the world's agricultural output by about 25 percent, could be favored by a warmer climate and thus further reduce agricultural productivity. . .

"Decision Making Under Uncertainty

"The carbon-dioxide problem poses an extraordinarily difficult dilemma: To respond now to a threat with still-uncertain scope and timing might require unnecessary commitments of resources. But to postpone action until climatic change is detected entails the risk of being unable to prevent further harmful changes that could prove irreversible for centuries.

"If today's most widely accepted models are correct, a CO₂-related global warming should be observable within the next two decades. . . One previous study . . . suggests that a warming of as much as 0.4°C from CO₂ buildup may already have occurred between 1880 and 1970, but a clear warming trend has not yet been observed.

"... much as a massive flywheel absorbs a large amount of energy as it gradually reaches a high speed, the oceans could substantially postpone the time when an increase in temperature could be detected.

"Given the large momentum behind any climatic changes, remedial measures taken only after these effects were observed would be much less effective than any taken now. Thus, the policymaker's dilemma is that when the 'signal' announcing the gradual global warming from CO₂ is finally identified, the pattern of change will already be well established. It may then be too late to prevent continued climatic change, even if the countries of the world agree to try. . .

"Policymakers essentially have three options: to establish an upper limit on atmospheric CO₂ by curtailing growth in fossil-fuel use, to take steps to adapt to the inevitable changes and mitigate the consequences, and to take no action until harmful impacts are observed. . .

"Strike Before the Earth is Hot

Under the assumption that the world community will eventually be driven to limit atmospheric CO₂ to avoid harmful climatic changes, the rate of growth in fossil-fuel use during the next decade will critically affect the world's flexibility at that time . . . the more rapid the increase now, the sooner must be its reduction. . . Second, an earlier peak in fossil-fuel use requires a steeper decline following that peak . . .

"... By delaying the date when such use must begin to decline, less drastic measure would be required and a more gradual phaseout could occur.

"Gradual changes are almost always more easily accommodated, in terms of both economic and social costs, than precipitous changes. Historically, it has taken 50 to 100 years for new energy technologies to replace old ones. Thus, in addition to the momentum of the climatological system, an economic momentum also resists sudden changes in direction. If an international response to the CO₂ problem is delayed one or two decades until a CO₂-induced global warming is identified, the world may already have significantly increased its reliance on fossil fuels, and economic and institutional inertia could make it extremely difficult to reverse this trend. . .

"Setting an Example

"... Some nations may benefit from the new climate and be understandably reluctant to cooperate in a global effort to reduce CO₂ emissions — particularly if the 'winner' nation is a developing country that plans to expand its pre capita energy consumption. . .

"But the Third World's economic growth can be consistent with international measures to control CO₂ buildup . . . high levels of energy efficiency and reliance on renewable resources could be incorporated into the economies of developing countries. . ."

From 'Some requirements for a ¹³C tree ring record to study the global carbon reservoirs', by Pieter Tans, Proceedings of the International Meeting on Stable Isotopes in Tree-Ring Research, New Paltz, NY, May 22-25, 1979. (U.S. CONF-790518, December 1980).

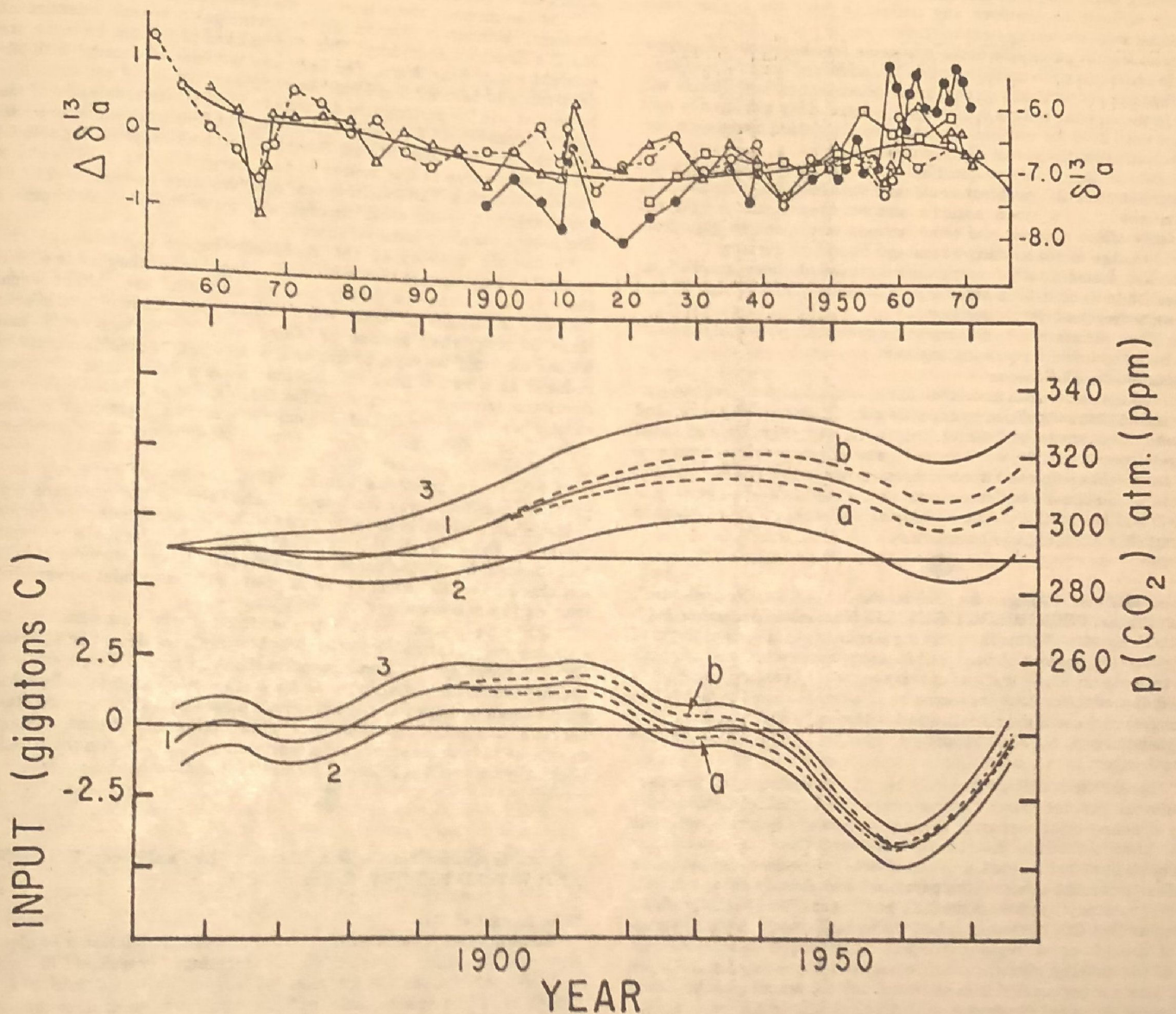


Figure 2: **Upper figure:** Tree ring data from four Dutch trees and cubic spline fitted curve, forced to reproduce the measured decrease in the atmosphere between 1956 and 1978 (Keeling et al., 1979, Nature 277, 1221-123). **Lower figure:** behavior of the biosphere as deduced from spline curve. Lower curves, left ordinate: net biospheric release to (positive) or uptake (negative) of CO₂ from the atmosphere. Upper set of curves, right ordinate: atmospheric CO₂ level changes around steady state value of 290 ppm. The curves 1, 2, 3 correspond to different assumptions ($\pm 0.2\text{‰}$) on the value of the steady state atmospheric ¹³C/¹²C ratio. In curves a and b the kinetic fractionation factor of air-sea exchange has been varied, -6‰ and -22‰ respectively.

II. "A More feasible Social Response", by Lester B. Lave:

"... According to various predictions, the increased carbon dioxide will warm the earth's climate, change precipitation patterns, and alter oceanic movements. However, the atmospheric changes will likely remain unmeasurable until at least the turn of the century and the effects will not be of substantial magnitude until well into the next century..."

"A Virtual Inevitability"

"Policies designed to lessen carbon-dioxide emissions are inherently unattractive. Fossil fuels are currently the cheapest source of energy; proscribing them would be difficult and expensive... it would be extremely difficult to convince any nation to bear the higher costs associated with switching to other fuels."

"Three lags in particular make prospects for abatement of carbon-dioxide emissions quite unlikely before the middle of the next century... the first is a recognition lag: conclusive proof that carbon dioxide will cause large, adverse effects does not yet exist, and we will have to wait at least until 2000 for confirmation that the simulation models are correctly predicting the global climatic change..."

"A second lag involves deciding on a solution. The perceived seriousness of the CO₂ problem would vary with location, affluence, and alternatives... a small nation's abatement program would not noticeably affect climate, and some nations who stand to gain from climatic change might actually encourage fossil-fuel burning."

"Finally, assuming that worldwide agreement were reached on policies, there would be a third lag in switching to alternative fuel sources, a decades-long proposition."

"... Thus, if society is to do something about this potential problem, the emphasis should be on adapting to it..."

"Adaptation for all Seasons"

"... will governmental and other decision makers perceive the problem and implement policies to expedite adaptation?... Will social and economic institutions be able to keep pace with climatic and social change? In other words, will our social and economic institutions respond to the changing conditions or break down under the pressure?"

"... Carbon-dioxide buildup can provide a rationale—but more probably it will be a catalyst—for enhancing society's ability to adapt to and exploit a changing environment..."

From "Will the Changes be Unbearable?" by Ellen Ruppel Shell, Senior Editor, TECHNOLOGY REVIEW November/December 1981:

"The thickening CO₂ blanket may force radical changes in patterns of energy use long before global fossil-fuel supplies are seriously diminished. Atmospheric concentrations of this seemingly benign by-product of fossil-fuel production have increased by 15 percent since the late 1800s... Burgeoning world industrialization is the well-established cause of this phenomenon, but what should—or even can—be done is a matter of hot debate..."

"... Researchers at Brookhaven National Laboratory and elsewhere estimate an increase of two to three degrees in global temperature for every doubling of atmospheric CO₂ concentrations over preindustrial levels. However, little hard data were available to support this hypothesis until last August, when an article in *Science* reported that a significant increase in world temperatures had already occurred."

"... The study sparked immediate controversy and alarm with its assertions that CO₂ increases, if left unchecked, could lead to the creation of 'drought-prone regions in North America and Central Asia as part of the shifting climatic zones, erosion of the West Antarctic ice sheet with a consequent rise in sea level, and the opening of the fabled Northwest Passage.' However, scientists reacted to the report with caution."

"If there is a .4°C increase in temperature already, and it's quite reasonable to believe there is, then the CO₂ problem is a very real one," comments Robert Watts, professor of mechanical engineering at Tulane University and a consultant at the Institute of Energy Analysis in Oak Ridge, Tenn. "But detecting such an increase is terribly difficult because of fluctuations caused by natural background effects."

"However, Watts adds that all models have shown that a two-to-three-degree increase in world temperatures is 'inevitable if we continue to burn fossil fuels at our present rate.'... Scientists predict that the most serious effect would be change in rainfall patterns that could turn northern Canada into a very lush farm area, while rendering the American prairies as dry as the Dust Bowl of the 1930s. The further an area is from the equator, the more its temperature will rise—a 2°C global increase would result in about a 7°C increase near the poles. Hence, the melting of glacial ice and the subsequent flooding of coastal cities is far from impossible."

"During the Ice Age the earth was only 2½°C cooler than it is today," Watts says. "If temperatures increase by 2°, it will be warmer than it's

been for thousands of years and there's no telling what will happen."

"Kicking the Habit"

"What can or should be done to prevent CO₂-induced temperature increases depends on the amount inconvenience, cost, and setback society is willing to endure. The measures offered by a panel of scientists at a recent meeting of the American Chemical Society (ACS) in New York all necessitated either a sharp reduction in fuel consumption or a steep increase in energy costs—highly unpopular alternatives. However, panel member Meyer Steinberg of Brookhaven pointed out that a technique that may seem extravagant by today's standards could prove a bargain in the future. 'Economics,' he said, 'is a moving target.'..."

"At the moment there is really no 'Technological fix' for the CO₂ problem," comments Marvin Miller, principal research scientist at M.I.T.'s Energy Laboratory. "The alternatives presented by some are straight out of *Star Wars*. The only way we have of dealing with the problem is to restrict fossil-fuel consumption," an act of self-discipline he admits will be particularly difficult in light of the conclusion of the international World Coal Study, published last year, that massive coal reserves in the United States, Soviet Union and People's Republic of China could serve as the 'bridge to our energy future'... Miller says models show that if all available coal reserves were burned for fuel, atmospheric CO₂ levels could theoretically go as high as 1200 ppm—a decidedly unhealthy concentration."

"While the authors of the coal-study report acknowledge this possibility and suggest that it be studied more fully, they contend that there is no evidence to 'justify limiting fossil-fuel use.' Miller warns that this is unrealistic: 'If we start burning the coal now, and discontinue burning when serious problems begin to surface, we'll have waited too long,' he says, adding that a severe CO₂ buildup cannot be reduced at whim. Others caution that as less-industrialized nations develop economies predicated on fossil fuels, the problem will become even more pronounced and difficult to reverse, particularly since greenhouse effects are likely to be most unpleasant in northern, already developed countries..."

"While many scientists agree that there should probably be a gradual transition away from fossil fuels, there is no consensus on a realistic alternative. Many opponents of fossil fuel also oppose nuclear power on the grounds that it—like fossil fuels—presents no ready technological fix for the potential problems it poses. But most also admit that renewable sources such as solar, wind, and tidal power are a long way from becoming viable on a large scale."

"We simply can't stop burning fossil fuels immediately—the economy won't stand for it," says Greg Marland, a staff geologist at Oak Ridge Laboratory who participated in the ACS panel. "But if Hansen's .4°C increase is borne out, we're in for some serious problems. I guess it comes down to the same old scientist's plea—a good deal more study needs to be done before any firm recommendation can be made. Though even if we fully understand the extent of the CO₂ problem right now, I'd doubt anyone could really tell us what to do about it."

From "Is Mother Nature Going Berserk?" by Paul Recer, U.S. NEWS AND WORLD REPORT, February 22, 1982:

"The Impact of Man"

"Some studies present evidence that modern civilization may also affect the weather. Slash-and-burn farming, practiced in many undeveloped nations, sends tons of smoke particles into the atmosphere. Smokestacks, auto exhaust and high-flying airplanes also add to pollution."

"Such activities... put 500 million to 600 million metric tons of dust into the atmosphere annually—enough, perhaps, to contribute to chilling of the earth."

"One man-made pollutant may have the opposite effect. The worldwide burning of fossil fuels, such as coal, oil and gasoline, gives off tons of carbon dioxide (CO₂) daily. Scientists monitoring the atmosphere have documented a 15 to 25 percent increase in carbon dioxide since the Industrial Revolution began in the late 1700s."

"Robert Etkins and Edward S. Epstein of the National Oceanic and Atmospheric Administration theorize that the carbon-dioxide greenhouse effect has melted more than 10,000 cubic miles of polar ice in Antarctica. They believe that melted ice has caused the worldwide sea level of the oceans to rise since 1940 by more than 4 inches, about triple the rate of the previous half century."

"The major fear is that the massive Western Antarctica ice sheet could melt. That would raise the world sea level by about 18 feet—enough to flood parts of Florida, Louisiana, Texas and New Jersey and leave about 11 million Americans homeless."

"The melting of the entire ice sheet of the Antarctic continent would raise the sea level by about 250 feet, enough to flood most of the world's major cities, according to one estimate.

"Also of concern is that the greenhouse effect would change weather patterns, triggering drought in the cropland of the U.S. Midwest, the Soviet Union and China, while increasing rainfall in Europe and Africa.

"Some scientists disagree with the Etkins-Epstein conclusion because the earth has actually cooled during the last three decades. The NOAA scientists suggest that the cooling may, in fact, further prove their theory because melting ice would temporarily absorb heat from the ocean and the atmosphere, causing a modest decrease in temperatures."

From 'The Smoldering Earth', by John Matill, TECHNOLOGY REVIEW, July 1981:

"Coal is burning out of control in at least 300 locations in the United States, . . . adding measurably to the atmospheric burden of carbon dioxide (CO₂).

"Having just completed the first nationwide catalog of accidental coal-mine and waste-dump fires, J.R. Herring of the U.S. Geological Survey's Denver office told the American Chemical Society early this spring that such inadvertent coal burns are a serious problem that deserves a higher place on the nation's environmental agenda. . .

"Once ignited, coal burns stubbornly from the outcrop into the buried seam and from the wastepile into the mine, its speed determined by its oxygen supply. Temperatures can be very high—1600°C, enough to melt rocks and open vents through which oxygen feeds the inferno and from which steam and pollutants pour. . .

" . . . The largest now burning, in a 60-foot thick coal seam near Gillette, Wyo., has left 1,400 square kilometers pockmarked and fuming. Dr. Herring calculates that this fire has released CO₂ equal to one-sixteenth of the present atmospheric burden. Another fire in nearby Sheridan, Wyo., has burned beneath 3 square kilometers in 30 years and consumed 30 million tons of coal. He estimates that fires in U.S. coal mines, outcrops and wasteheaps produce about 500 trillion Btus of energy annually, and worldwide, perhaps 10 times as much. . .

(Continued from previous issue of CO₂ Newsletter)

From 'Carbon Dioxide and Climate: The Greenhouse Effect', Hearing before the Subcommittee on Natural Resources, Agricultural Research and Environment and the Subcommittee on Investigations and Oversight of the Committee on Science and Technology, U.S. House of Representatives, July 31, 1981:

"Mr [Roger] REVELLE: . . . if you could use up all the oil in the world and all the known natural gas, you would probably not cause a doubling of carbon dioxide, it is the coal option that really makes the difference.

"the total amount of carbon locked up in fossil fuels is somewhere between 5,000 and 1,000 billion tons. Ninety percent of that is coal. Ninety percent of the coal exists in three countries, the U.S., the Soviet and China and if the scenarios are right those are the countries that are going to be most affected by the CO₂ problem. . .

"The effects will be felt most by countries that can make the difference, by using or not using, exporting or not exporting coal.

"Mr. [Lester] LAVE. . . Nobody will incur the kind of cost necessary to give up fossil fuels before we have a [definitive judgment that models are in fact predicting the effect of CO₂ correctly]. If we look at the timing, it will be the end of the century before we begin to get reasonably definitive tests. . .

"Any time we do anything internationally, it takes decades to get anything resembling agreement. Even after you get agreement, trying to go away from fossil fuels to some other source is extremely difficult.

"Just putting the capital in place after you have the technologies all developed takes an enormous amount of time. . .

"I am not being sanguine about CO₂ effects, but I see no way to circumvent them.

"Mr. [Albert] GORE. But that is not the most intelligent response for civilization, is it?

"Mr. LAVE. Given that we still have some uncertainty at the moment, it is hard to think about a justification of really major costs at this point, to use less fossil fuels.

"Mr. GORE. The obvious near-term response is to seek a much more rapid elimination of the uncertainties involved.

"Mr. LAVE. That is correct.

" . . . "Mr. [George] BROWN: . . . It seems to me that obviously one of the courses we should be looking toward is alternative options to the combustion of fossil fuels, particularly coal.

"There are a number of options being explored in the area of research, including fusion, nuclear, and the various forms of solar.

"I would just like to raise one question which was sort of stimulated by Roger's comments.

"Under the present circumstances, what we have is a large draw-down in the world's fossil fuel supply, increasingly coal; a similarly large drawdown in the biomass resources of the globe due to deforestation, urbanization, desertification, various other things of that sort.

"Roger, you suggested that the use of biomass as a fuel, as long as it was done on a replacement basis, made no net increase in the carbon dioxide balance in the atmosphere. The present situation is that the destruction of biomass is being translated into carbon dioxide in the atmosphere, but this leads to the assumption that if we were to reverse our biomass policies and begin an aggressive reforestation program, use the net annual growth as fuel, we could perhaps both reduce our use of coal and by virtue of the net increase in global biomass we could reduce the carbon dioxide in the atmosphere at the same time.

" . . . the only thing that bothers me is, I haven't the vaguest idea what kind of numbers we are talking about. I heard . . . that there was a potential for increasing our production of energy from biomass, from somewhat around one quad up to as much as 8 quads with responsible policies.

"I do not know what the overall capability in terms of equivalent amounts of coal, for example, are from increasing the net biomass. . .

"Mr. REVELLE . . . that figure of 8 quads is a figure provided by the Congressional Office of Technology Assessment. In terms of coal, that amounts to about 250 million tons of coal, just for the United States. . . If you look at the less-developed countries which are in the tropics and where most of the remaining forests are, I reckon with the use of fast-growing trees like *Leucaena*, *Casuarina*, and *Sesbania*, which will produce up to 30 tons of dry wood per hectare per year, that all present world energy use could be accounted for by biomass grown on something like 400 million hectares, which is about one-tenth of the present forest area of the earth.

"What you would have to do is to replace the existing tropical trees, which gives ecologists horrors, with these fast-growing trees, and harvest them on a regular cycle of about 4 or 5 years. What you want particularly is a tree like the ones I mentioned, which fix nitrogen so you don't have to fertilize the forest, as opposed to eucalyptus where you would have to fertilize.

"If there is one kind of institute that I think should be established internationally, it is a biomass research institute.

" . . . Mr. [Stephen] SCHNEIDER. . . we are again back to the rate problem. Just to give you an idea, Roger Revelle said 400 million hectares would be needed, and a standard figure for clearing a new hectare of agriculture land is \$1000 per hectare . . . You come up with \$400 billion

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just to do the clearing. . .

"Again, what is the long-term renewable resource we are heading toward?"

"Whether or not to use coal or any other mix depends upon whether you think the end that you are heading to is worth taking some risks in the transition.

"Mr. BROWN: Roger's figures make a point just in terms of strictly energy conversion. But looking at the broader question of curtailing the carbon dioxide problem without focusing on the production of energy crops, any biomass crop is going to have the benefit of taking carbon dioxide out of the atmosphere and to the degree that we could say double the amount of biomass on the globe, whether we used it for energy or used it for food would be immaterial; we would be some number reduce the amount of carbon dioxide in the atmosphere.

Mr. SCHNEIDER: That is true, but it would be transient. If you could increase the size of the biosphere, you take some pulse of carbon dioxide out.

"... Mr. GORE. If DOE cuts out the effort to narrow the uncertainties involved here, what chance is there that the research will be picked up elsewhere?"

"Mr. LAVE. . . It would be extremely difficult to find a pot of money outside of DOE to support this research. . .

"Mr. GORE. This hasn't been put in any block grants to local communities or States?"

"Mr. LAVE. That is correct.

"Mr. GORE: You haven't seen any interest on the part of civic clubs in picking up the research? I take it the answer is no, then.

"Dr. Smagorinsky, is there any reason why elected policymakers in the Congress of this country should conclude that this whole thing has been blown wildly out of proportion and that it is just science fiction or just someone's fantasy?"

Mr. [Joseph] SMAGORINSKY: I would say that there is absolutely no basis for reacting that way.

"... Mr. GORE: It is true, is it not, that this began on the fringes of science to the extent that a very few individuals made the argument and the vast majority of scientists couldn't make themselves believe that it was real, and that over the last several years the hypothesis has gained adherents exponentially; that it now represents the mainstream view in the atmospheric sciences?"

"Mr. SMAGORINSKY. I believe you are right, sir, based on what we now know.

"Mr. GORE: Moving up the pyramid, is it also true that the mainstream of science now agrees that the effects will include a big increase in the sea level? . . .

"Mr. SMAGORINSKY. Well, big is an 'iffy' statement. . . If you are

only talking about a secular melting of sea ice, then I do not think 'big' is warranted. If you are talking about something catastrophic, such as the dropping of the Antarctic ice shelf into the sea, this could give rise to a big change in sea-land, but such a possibility is highly speculative.

"... Mr. SCHNEIDER. . . What counts is ice that is now on land.

"The time scales for changing significantly most parts of landed ice are really hundreds to thousands of years. There is only one exception, which is a major argument; that is the piece of the west Antarctic shelf which has a shelf which is floating, the floating shelf is also pinned on some islands so it serves as a physical restraint to the ice back on the Antarctic.

"The question is, if you warm up by 5 degrees or more, can you break up the shelf, not melt it, just break it up so you can get what they call a surge. . .

"One of the chief problems is trying to figure out just what that ice sheet is doing. What bothers me is that it may take us another two decades before we begin to have an answer to that question. It is very expensive research; people do not even know how old the ice sheet is.

"... so little is known about the change of that ice sheet and so little evidence in the past that you have to start building theories and models, and that is just what the community does. And when you have an unverified theory. . . it is very hard to show them that this is going to happen. . .

"Unfortunately, the consequences of it, if it occurs, are very large. We are stuck trying to decide whether to hedge against this possibility without any way to verify, really. . ."

"Dear Mr. Barbat:

"I am in the process of compiling a 1982 Quarterly Calendar of Carbon Dioxide conferences, workshops, seminars and symposia for the Carbon Dioxide Research Division of the U.S. Department of Energy. This calendar will list events which are sponsored by public, private and international organizations in the U.S. and other countries. It will include events which address such CO₂ related topics as the carbon cycle, climate effects, first detection, fossil fuels, human effects, vegetation effects, as well as other related topics. The first issue of the calendar is scheduled to be mailed to U.S. Department of Energy contractors and to other interested groups and organizations on the 15th of March.

"If you are aware of any CO₂ related conferences, workshops, seminars and symposia to be held this year, please contact me at the (following) address..."

Rayola Dougher
Institute for Energy Analysis
1346 Connecticut Avenue NW
Washington, DC 20036

February 3, 1982

Potential CO₂ problems for U.S. agriculture

The forthcoming conference on "Rising Atmospheric Carbon Dioxide and Plant Productivity" will simultaneously address two vitally important agricultural problems, namely the effects of a CO₂-induced climate change in combination interactively with increased CO₂ partial pressure effects on plant productivity. The actual climate changes expected in particular regions throughout a range of CO₂ concentrations 100 to 500 ppmV higher than present (that is, 440 to 840 ppmV) are still quite speculative. However, generalized climate changes such as higher summer temperatures at mid and high latitudes, increased aridity in areas now farmed without irrigation, and increased precipitation in presently arid areas might be treated generically in combination with greater CO₂ fertilization.

Presently it is possible to make some educated guesses about potential agricultural impacts for CO₂-induced climate changes in the U.S. for certain climate analogies or model results, without regard to increased CO₂ fertilization.

The global warmth of the 1930s may well recur before the end of the century at the present projections of the CO₂ buildup, that is, before 400 ppmV is reached. According to J.E. Weaver's (1968) report on the Midwest, the 1930s warmth was accompanied by very arid and windy conditions in the short-grass prairie (the high plains grazing belt and wheat belt) with soil moisture dropping to as low as 2 percent in summer, and with reduced summer rainfall, hotter summer days and lowered water-tables occurring in the tall-grass prairie (corn belt). Unless genetic engineering can somehow overcome changes such as these, the net effect of such conditions would be to reduce feed-grain production in the U.S. substantially as the wheat belt shifts to the corn belt, and the corn belt contracts or migrates northward into Canada.

Lesser impacts on growing conditions may occur elsewhere in the

U.S. except possibly for drier conditions in the Great Valley of California and reduced runoff from the Sierra Nevada Mountains.

Hermann Flohn (1981) has provided a zonal climate model for analyzing potential climatic changes that may be associated with CO₂ levels of 560 to 680 ppmV, or roughly a doubling of pre-industrial CO₂, which could occur about 2030-2050 with a projected exponential CO₂ buildup. Roger Revelle interprets this model to show that the overall runoff of the Colorado River system in the southwestern U.S. may be expected to drop by 50 percent. Unless offset somehow by water imports, the remaining runoff may largely go to municipal water systems, with green lawns and golf courses and massive irrigation projects passing into history. What irrigation survives may be trickle irrigation which is comparatively labor- and equipment-intensive.

Examining Flohn's model further, an expected 14 percent reduction of precipitation at 40° north latitude plus higher temperatures may cause the Great Lakes and many other small lakes in that region to become receding pools, with an attendant decline in humidity in that region. The whole interior of the U.S. might become arid or semi-arid, with a great loss in production from non-irrigated farms.

As an extreme case, the great global warmth that prevailed in the Triassic Period 200 million years ago (which might correspond to runaway CO₂ production with positive CO₂ feedbacks within 2 centuries) can be expected to make present agricultural belts and coastlines completely unrecognizable. San Diego's hot, dry climate might be displaced to the Vancouver, B.C. region.

Houston's year-round hot climate might be displaced to Winnipeg, Manitoba, and Tallahassee's subtropical climate might be displaced to the area around St. John's, Newfoundland. The Great Lakes would likely become evaporative salt flats.

— W.N.B.