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THE ENERGY MAP  
Who makes it, who uses it - Page 12

JULY 1990

**WORLD**

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# MONITOR

THE CHRISTIAN SCIENCE MONITOR® MONTHLY



## COOLING IT

### THE GLOBAL WARMING DEBATE

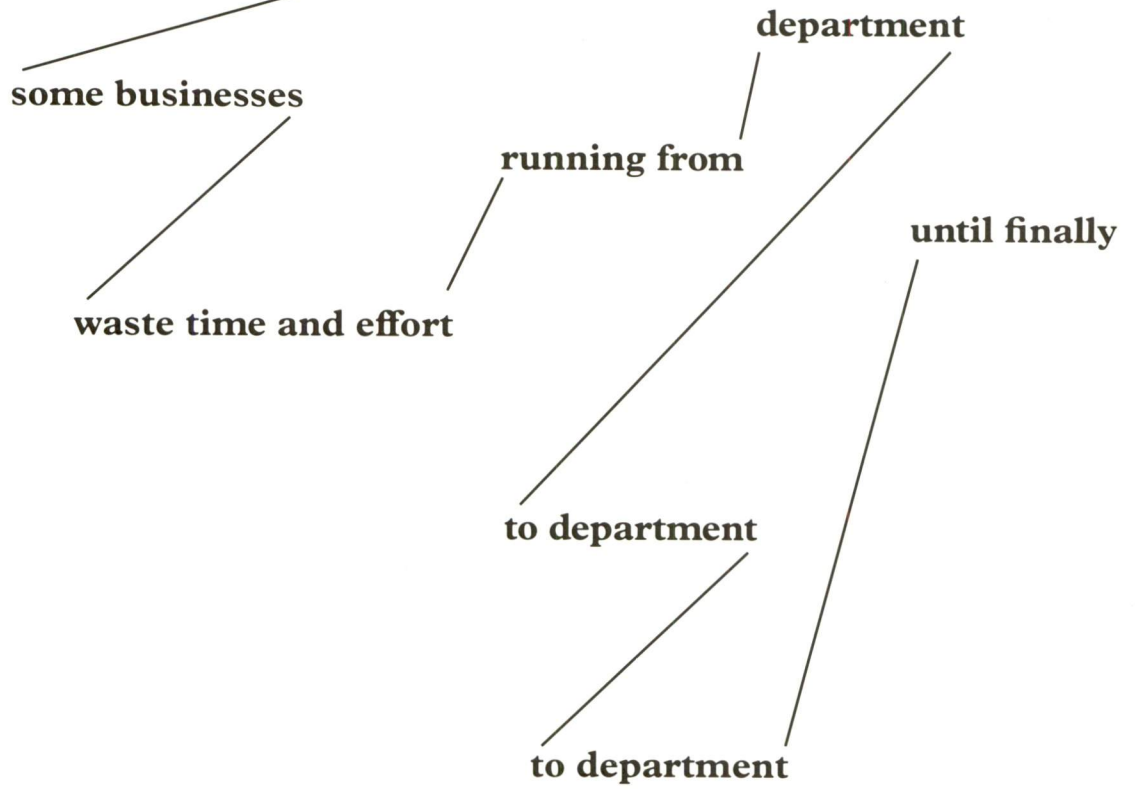
has gotten out of hand. Bush battles other world leaders. Sununu irks environmentalists. Columnists who've never seen a lab are confusing the public. To cool the battle (and cool the next century) an expert explains what we know and proposes an action plan.

By Stephen H. Schneider

**ALSO:**

NUTMEG WARS • REINVENTING MEN  
MY JOB IN JAPAN • EASIER LOANS

**When their systems aren't integrated,**



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FROM THE EDITOR

# Dear Reader,

The Cold War may be over; the Global Warming War isn't.

The battle over whether or not the human race is warming its home planet toward bigger storms, drier farm belts, and flooded coastlines began, quietly enough, among scientists. Then it escalated.

The escalation came in roughly three stages: (1) Overdramatized media accounts of the warming scenario. (2) A contrarian, often unscientific, counterattack by commentators who claimed that the greenhouse effect was an unproven myth and that proposals to slow the buildup of heat-trapping gases in the atmosphere were simply a new attack against industrial growth. (3) A major global policy debate in which leaders of both rich and poor nations are split over how much, if any, worldwide action is needed to slow planetary warming.

This third stage has grabbed headlines because it pits George Bush (who wants more study but little immediate action) against many other leaders. It even divides Bush from his usual staunch ally, Oxford-trained chemist Margaret Thatcher. And, in the realm of political theater, the Global Warming War adds extra drama to the already much-relished struggle between Bush's éminence grise, MIT-trained mechanical engineer John Sununu, and the chorus known collectively as The Environmentalists.

Into this scene once more steps climatologist Stephen Schneider, author of this month's cover story. Those of you who have read WORLD MONITOR from the beginning will remember a previous Schneider cover story, which brought concern over global warming to prominence in Washington. That story was waved prominently and favorably in front of a room full of interagency policy planners and representatives from major scientific bodies in late 1988. Soon thereafter, Schneider and other atmospheric scientists, pro and con, were busy explaining their research at government hearings in the US and other industrial nations.

As the man in charge of interpreting supercomputer climate modeling at America's National Center for Atmospheric Research, Schneider is possibly the most knowledgeable person on earth about what we do and don't know about global warming. He's blunt about what we *don't* know: the effect of volcanic ash, air-borne pollution particles, and variations of solar radiation on the immensely complex equation that forms Earth's climate. He's also blunt about what we *do* know: that a majority of climatologists place the global average temperature rise in the next century at 1.5 to 4.5 degrees C if nothing is done to change current trends.

Dr. Schneider joins those who counsel prudent—certainly not anti-growth or bankrupting—steps by the community of nations to slow down CO<sub>2</sub> buildup.

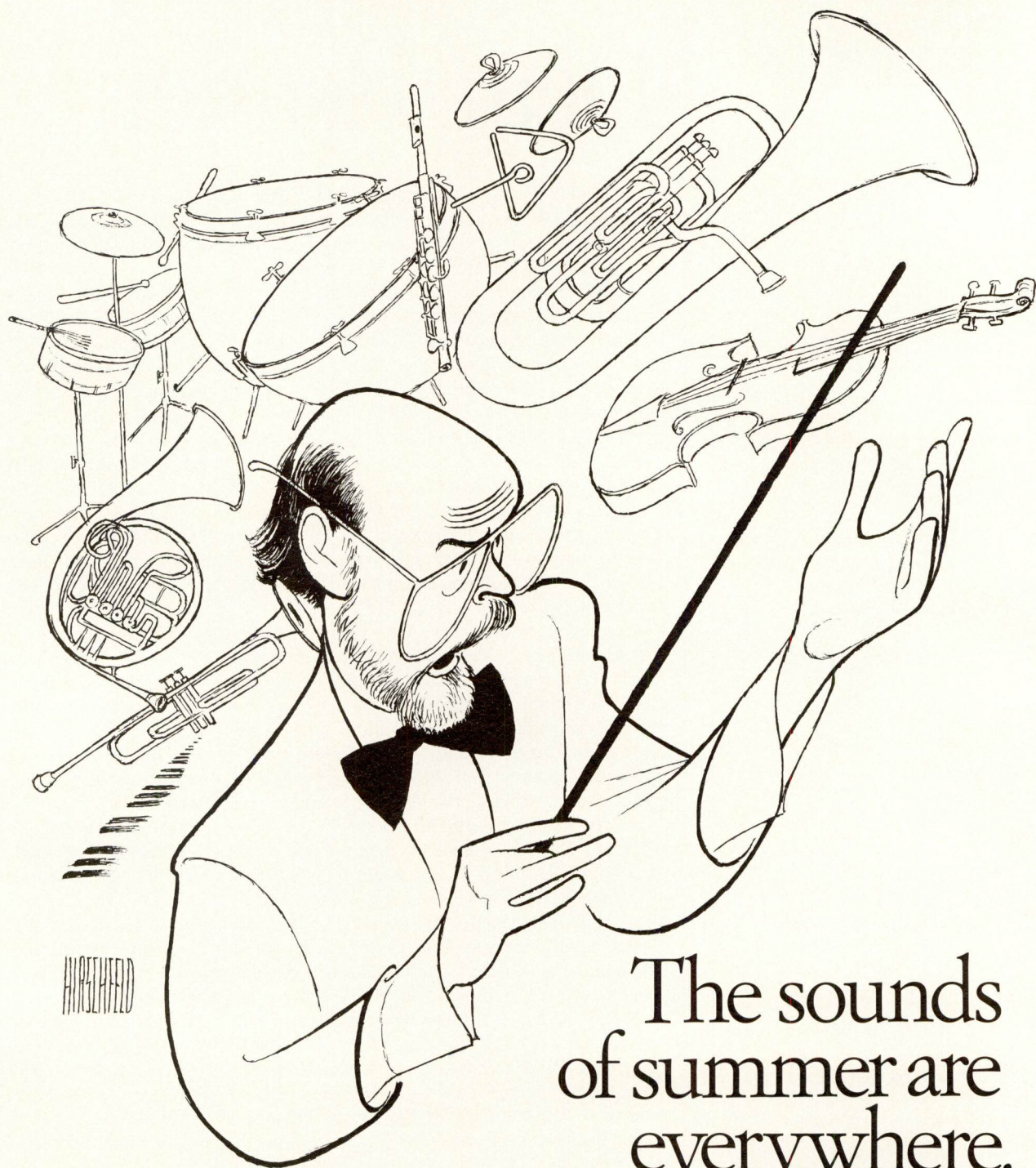
Some of you occasionally complain that big power politics crowd out the affairs of other, quieter peoples on the planet. This month we offer two antidotes: a warm, witty piece detailing the everyday virtues and mysteries of West African village life, and an exploration of Canada's far north and the plight of the Inuit/Eskimo people who spread sparsely all the way from Greenland to Siberia.

That's the warm and cool of it until next month...

Earl W. Foell

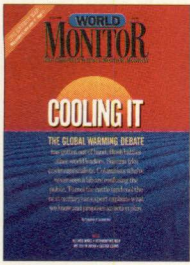
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# WORLD MONITOR

THE CHRISTIAN SCIENCE MONITOR MONTHLY

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Sun symbolizes heat of "greenhouse" controversy—and light of reason to maintain perspective.

Cover photo and reproductions on pages 30, 33, 35, and 38 © Rob Atkins/The Image Bank

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With products worth their weight in gold, the Spice Islands lured Western fleets centuries ago. Today a different turbulence echoes from Indonesia to post-invasion Grenada.

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## LETTERS

### 'SAVING CENTRAL AMERICA'

Bruce Babbitt's otherwise excellent article (May) completely omitted any mention of Belize, the one country in the region unique in the stability of its political institutions, the nonviolence of its people, the near absence of racial and ethnic prejudice, and the thoughtfulness of its government and in particular its longtime prime minister, George Price. Belize is such a model of what can be accomplished by a truly national commitment to the common good that it deserved special mention by Mr. Babbitt.

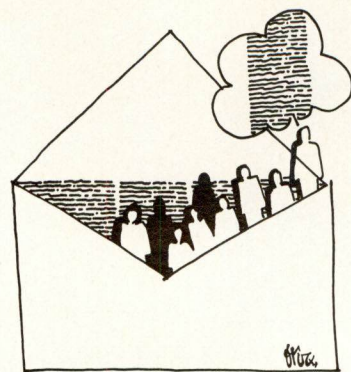
BRUCE STRATTON  
Springfield, Ill.

Babbitt refers to the upset win of Chamorro as spelling "the end of a failed Marxist economic experiment." This experiment was neither Marxist nor a failure. The Sandinista efforts certainly contained some Marxist elements, but a mixed economy was encouraged, great wealth remained in the hands of the rich who chose to stay in Nicaragua, collectives were quickly replaced by cooperatives when they were seen to be unpopular and ineffective. Religious observations continued central to Nicaraguan public as well as private life.

The experiment did not fail: It was sabotaged. If I were to set up an experiment in my lab, and someone came in and turned off the gas, smashed the glassware, and killed a number of skilled technicians, that would not be called a failed experiment. It would be called a crime. Yet this is what our government did to the Sandinista experiment in Nicaragua.

MARIA D. PETERS  
Southampton, Penn.

The Nicaraguan economy contained several socialist elements in it along with market-controlled features. This means it was a mixed economy. Such an economy cannot be painted with the brush "Marxism" unless one pays little heed to truth. The Sandinistas consistently promoted programs to encourage economic development of the private sector, but the majority of the industrial owners or large farmers re-



sponded by "decapitalizing" their enterprises. Rather than investing further in their company or farm to increase production, the owners would commonly reduce their current level of investment and deposit the excess money in banks in Miami.

ANDREW C. MILLS  
Manson, Iowa

### 'CLOWNS ON WHITE HORSES'

Re the At Large column (May) on the humor of Václav Havel and others: Presidents and dignitaries must frequently perform like clowns to maintain public popularity. Ex-president Reagan entertained with disconnected microphones, posing on a horse, chopping wood, etc. President Bush entertained with inane rhetoric on pork rinds, broccoli, and American-made assault rifles. These gimmicks are essential to maintain public popularity among the uninformed masses, while leaders circumvent important political issues.

EDWARD WIEDERHOLD  
La Porte, Ind.

### 'THATCHER'S BATTLE OF BRITAIN'

Richard Critchfield's analysis of Britain (May) includes a reference to "football violence at Sheffield, Bradford, Brussels, and Glasgow." The incident referred to at Sheffield—the Hillsborough tragedy of April 1989—was not caused by an act of violence. Overcrowding, questionable police supervision, and poor safety standards at the stadium were the major causes of the incident.

ALISTAIR BUDD  
London, England

Several of Britain's contributions to science and to medicine are mentioned. Perhaps less significant, but noteworthy, were what are regarded as the three greatest developments in naval

aircraft carrier technology: the angled flight deck, the steam catapult, and the mirror landing system. The US Navy uses all three of these technologies.

EARL E. EIGABROADT  
 Captain, US Army, Ret.  
 Port Orchard, Wash.

#### 'THE BALTIC WAY'

Walter Clemens has not only a remarkably thorough grasp of Baltic realities but also a keen eye for subtleties (May). Gorbachev has irreparably painted himself into a corner. After admitting that Estonia, Latvia, and Lithuania were illegally annexed by the Soviet Union in 1940, he stubbornly clings to the fiction as if the Baltic countries still were Soviet (or Russian) feudatories. To call his bluff, one wants to cite Article 2 of the Treaty of Peace between Russia and Estonia of Feb. 2, 1920: "Russia unreservedly recognizes the independence and autonomy of the State of Estonia, and renounces voluntarily and forever all rights of sovereignty formerly held by Russia over Estonian people and territory."

JUHAN KANGUR  
 Bridgeton, N.J.

#### 'NOTES FROM PRACTICALLY EVERYWHERE'

I was very much interested in the Old News article (March). Being the daughter of a farmer, "Horse Collars" caught my eye.

And now a hoofnote: Would you be interested to know the horse collar served another purpose? When the family was expecting another member, a new horse collar was purchased to use in place of the now popular playpen. Until the baby was able to crawl out of it, it was placed on the floor to hold the baby like [today's] infant carrier. But of course you could not carry the collar. After the child started crawling out of it, the horse got a new collar.

JANICE SIMMONS  
 Sierra Vista, Ariz.

Comments from readers are welcome. Please write to Letters, WORLD MONITOR Magazine, One Norway Street, Boston, MA 02115, and include your address and daytime and evening telephone numbers. Letters may be condensed for publication. We're sorry they cannot be individually acknowledged.

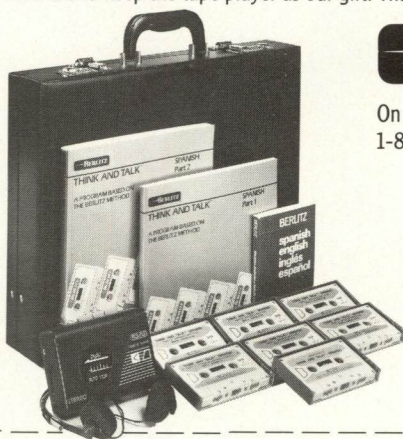
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## INDONESIA

### Nuclear Power's Third-World Growth

**A**N INTERNATIONAL ATOMIC-ENERGY seminar planned for early September in Jakarta, Indonesia, will explore ways of financing nuclear power projects in developing countries. The spread of such power elsewhere has been outlined by a United Nations body, the International Atomic Energy Agency (IAEA), which is sponsoring the seminar. As of last year, five nations—France, Belgium, South Korea, Hungary, and Sweden—used nuclear power for roughly half of their electricity. Altogether, 13 countries rely on such plants for at least 1/4 of their electricity. There have been delays and setbacks in the expansion of nuclear energy in the US. Recently a planned nuclear plant was canceled in Czechoslovakia. A Czech energy minister has said: “The public does not want any nuclear energy at all.” Still nuclear energy’s overall share of electricity production increased in 15 countries over the past year and accounted for 1/6 of the world’s total generated electricity. And the 1,854.5 terawatt-hours (a terawatt is a trillion watts) attributed to nuclear generation worldwide is nearly as much power as all sources of electricity produced in 1958. (For a look at consumption and production of all forms of energy, please see The Map, page 12.)

## THE WORLD

### Children in the Workplace

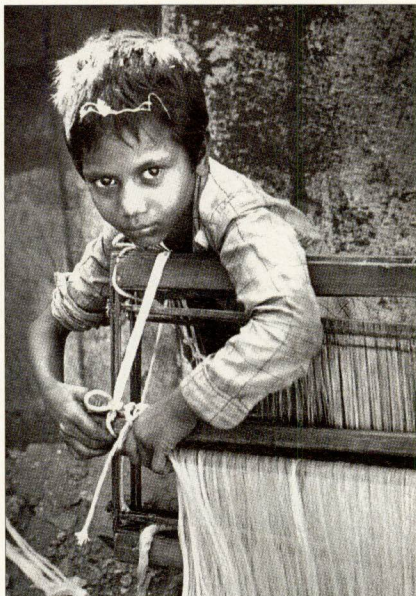
**C**HILD LABOR IN THE WORLD’S INDUSTRIAL sector has decreased dramatically in recent years, according to a recent report by the International Labor Organization (ILO), which attributes the decline to legislation and enforcement, new technology requiring skilled adult labor, and rising income in many parts of the world (which reduces families’ need for children to work). But the ILO reports pressure by concerned and aware citizens is essential in combating “morally indefensible” child labor in areas where children are still at great risk of exploitation: third-world agriculture, where dangerous insecticides and machinery are frequently misused; domestic service, sometimes thinly veiled slavery; and the so-called

# NOTES

F R O M

PRACTICALLY EVERYWHERE

“urban informal sector,” small enterprises that employ children in activities ranging from pencilmaking to prostitution. While seeing poverty as the root of the problem, the ILO report finds that



Threading power loom in Bhiwandi, India Photo: Melanie Stetson Freeman

“experience in various developing countries shows that children can be effectively protected even while they and their families are poor.”

### Global Networking Opportunities

**T**HE WORLD’S PRIVATE TELECOMMUNICATIONS industry should take advantage of more lenient international regulation and advances in digital networks in preparing now for an

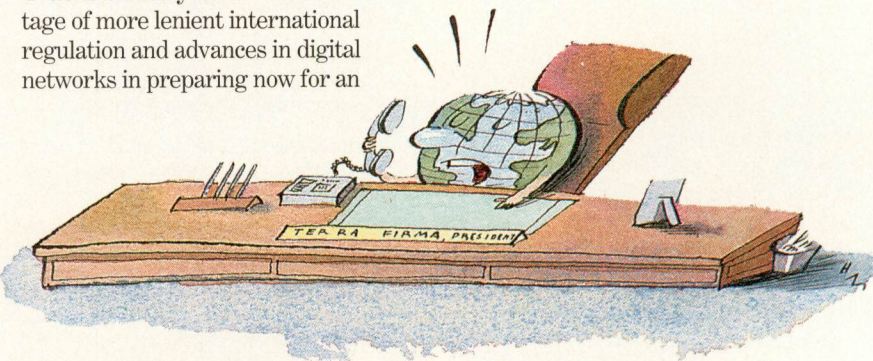


Illustration by Hal Mayforth

“explosion in the demand for private networking” that is resulting from the globalization of businesses, says a senior consultant at Arthur D. Little Inc., a corporate-communications agency with offices in more than 15 countries. Telephone carriers who want to be competitive should, for example, devise time-saving features, strive for technological uniformity, and treat customers as “partners rather than subscribers” in supporting users’ business objectives, he says.

## EUROPE

### Happy 1992 Holidays

**T**HERE’S ALWAYS ONE THING MORE AS the European Community works toward its 1992 goal of economic unity. Now it’s being advised to coordinate national holidays if it’s going to work at all. London’s Financial Times has figured that on 35 days of the year there is a holiday somewhere in Europe, but only two—Christmas and New Year’s Day—are celebrated by all.

## HUNGARY

### Playwright President II

**T**HE INTERIM PRESIDENT OF LIBERATED Hungary, Arpad Goncez, is known in his country as a playwright and head of its National Writers Association. But his writings are not as widely known elsewhere as those by Vaclav Havel, the playwright president of neighboring Czechoslovakia. This month the Hungarian leader’s collected works become available for the first time in English translation when Garland Publishing of New York brings out “Plays and Other Writings of Arpad Goncez” on July 23.

## New Success for Old Theater

**M**ORE PROOF THAT IN HIGH-TECH JAPAN classic arts are carefully preserved: The 750-seat Kanamaru-za theater was built in 1835 for Kabuki dramas—opera-scale productions of pantomime, dance, and song—that have endured since the early 17th century. The Kanamaru-za was fully refurbished a few years ago, and today getting in is “like trying to obtain a ticket to a Rolling Stones concert,” according to the Japan Times. The theater, which is in Kotohira, on the island of Shikoku, goes beyond mere close-to-the-actors, tatami-mat seating. A large revolving section of the stage is turned not electrically but as in the past—by a team of strong men pushing from below.



Applying Kabuki makeup in Tokyo

Photo © Dave Bartruff

## The Company Isn't Everything Anymore?

**T**HEY AREN'T CALLING IT NETWORKING yet, but in effect that's what many young Japanese workers have begun to do. No longer content to work overtime every night or to confine their contacts to the companies they work for, employees in their 20s and 30s are forming after-work study groups called “benkyokai.” One such group is Access Planet, which holds monthly meetings to hear speeches from business leaders and attracts both men and women to its membership. In a nation where lifetime

employment with one company is still the norm, the objectives of study-group members range from meeting people from different walks of life to learning more about their own specialties. (To read how one American learned to work in Japan, please see page 50.)

## OLD NEWS

### Rhodes Country

**O**N JULY 17, 1890, MINING MAGNATE CECIL Rhodes was inaugurated prime minister of Britain's Cape Colony, which later became part of South Africa. He was the empire builder who dreamed of Britain recovering the United States and ruling “the whole civilized world.” He was the founder of the still existing Rhodes scholarships to Oxford University—though, according to a biographer, he never could have won one himself since he was neither scholar nor athlete and lacked such other qualifications as exhibiting an interest in one's schoolmates. For all the controversy surrounding Rhodes's business and political dealings, philosopher



Photo © Bettmann Archive

Oswald Spengler used him to exemplify the industrialist become statesman, the person who “has really ceased to feel his enterprise as his own business, and its aim as the simple amassing of property.” Today, with South Africa in the midst of changing political and racial policies, Rhodes may be remembered as one who said both “I am no negrophilist” and “my feeling is that the best man must come to the front whatever his race may be.” **WJM**

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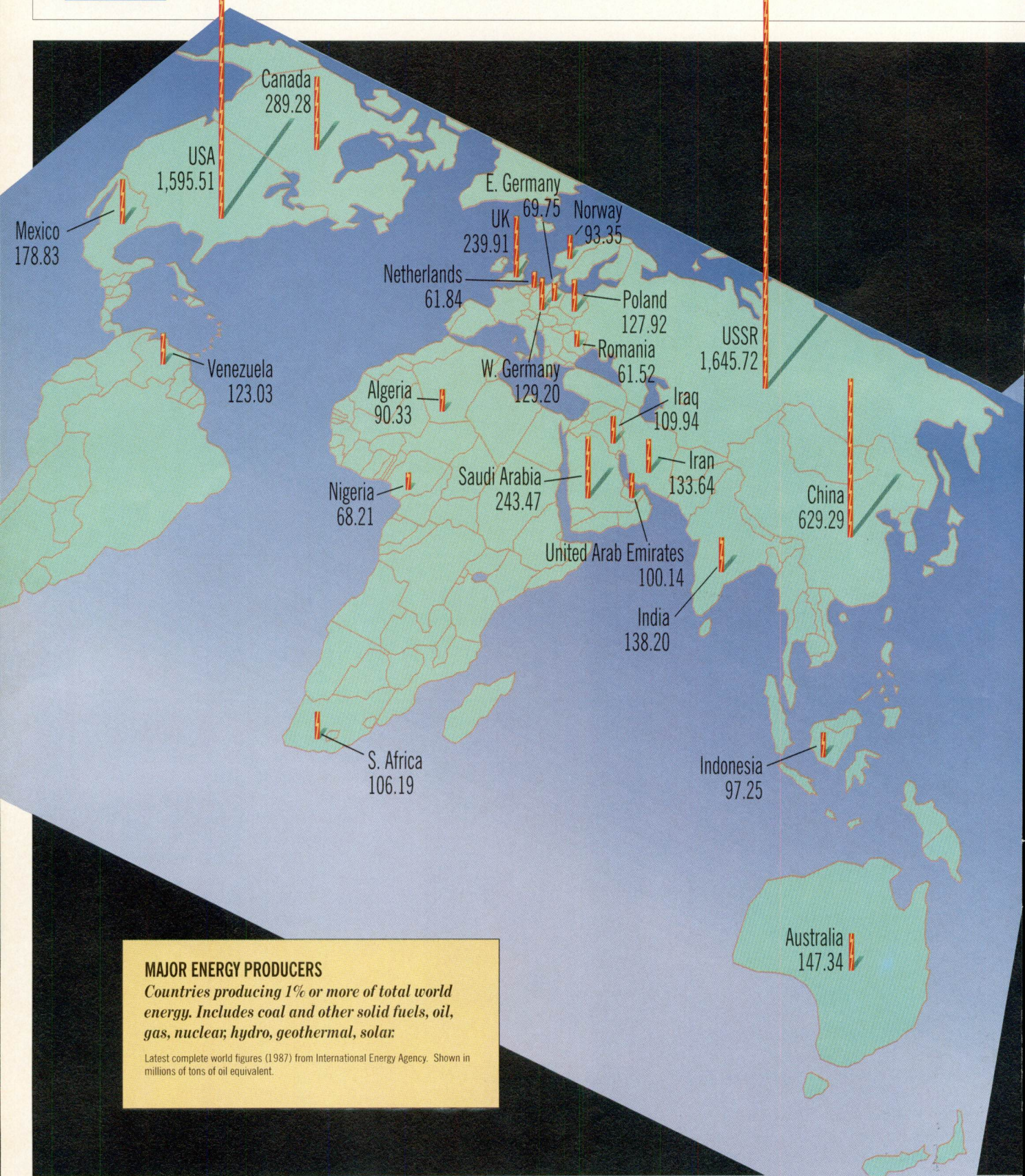
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# ENERGY



**MAJOR ENERGY PRODUCERS**

*Countries producing 1% or more of total world energy. Includes coal and other solid fuels, oil, gas, nuclear; hydro, geothermal, solar.*

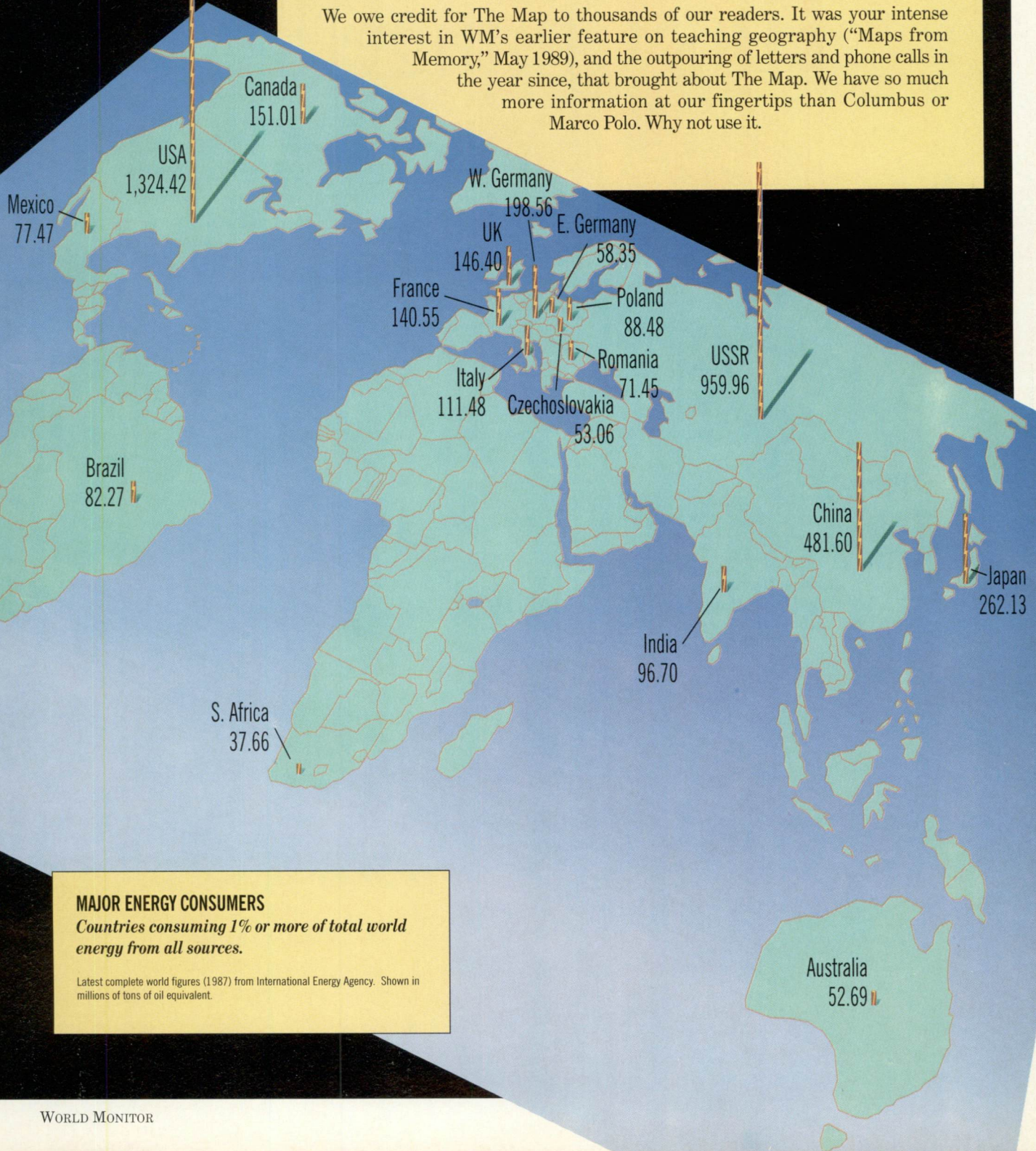
Latest complete world figures (1987) from International Energy Agency. Shown in millions of tons of oil equivalent.

## Introducing The Map:

Who reads the most books? What nations spend more on cosmetics than advanced education? Does Tokyo lie north or south of Washington? Where do the highest percentages of two-spouse careers occur? How does oil flow to Europe? Is Cuba closer to Mexico or Miami? For answers, watch this space.

With this issue, WM starts a new monthly department, The Map. Our aims: (1) To translate into clear graphic form significant information about peoples and nations. (2) To help readers learn and remember geography. Each month cartographer Dave Herring will highlight some important comparison or trend.

We owe credit for The Map to thousands of our readers. It was your intense interest in WM's earlier feature on teaching geography ("Maps from Memory," May 1989), and the outpouring of letters and phone calls in the year since, that brought about The Map. We have so much more information at our fingertips than Columbus or Marco Polo. Why not use it.



### MAJOR ENERGY CONSUMERS

*Countries consuming 1% or more of total world energy from all sources.*

Latest complete world figures (1987) from International Energy Agency. Shown in millions of tons of oil equivalent.

By Walter C. Clemens Jr.

GUEST SPEAKER

# How Commuting Has Changed!

— First it was suburbs to city, then coast to coast, then continent to continent. Now it's (gulp) world to world.

Illustrations by  
Tim Carroll

Walter C. Clemens Jr. is currently bi-worlding it as a member of the joint study group of the New York-based Council on Economic Priorities and the Moscow-based Institute of USA and Canada Studies. He teaches at Boston University. His book "Can Russia Change?" has just been published by Unwin Hyman in Boston.

**B**I-COASTAL IS OUT. BI-CONTINENTAL IS IN. Bi-world may be coming. And who knows what's next?

A few years back, bi-coastal commuting was the thing in the United States. Workweek in the Big Apple; weekends at Malibu. Or, for certain Nobel Prize winners, the fall term at Harvard; the winter and spring at Stanford.

But even the colonial ancestors of today's American bi-coastal commuters went farther afield. Many were bi-continental:

Benjamin Franklin felt at home in London and Paris as well as in Philadelphia and New York. Franklin, a poor boy, did not win admittance at Harvard, but he gave swimming lessons in England and later sent back British scientific instruments to the college on the Charles.

Benjamin Thompson, later known as Count Rumford, had to leave Boston (after he became known as a British spy) to make his mark in London, Paris, and Munich—but he left money to Harvard and also West Point. These two New Englanders grew up to become a patriot and, in Thompson's case, an ex-patriot, but both were bi-continental.

The first regular bi-continental commuter may have been David Frost, who began zipping between the US and Britain regularly in the 1960s to do weekly television shows in both New York and London. Now, even without cheap supersonic flights, many a traveler flies regularly from the United States to Europe on jumbo jets. Indeed, some New Yorkers believe they can ski more easily and cheaply in the Alps than in the Rockies.

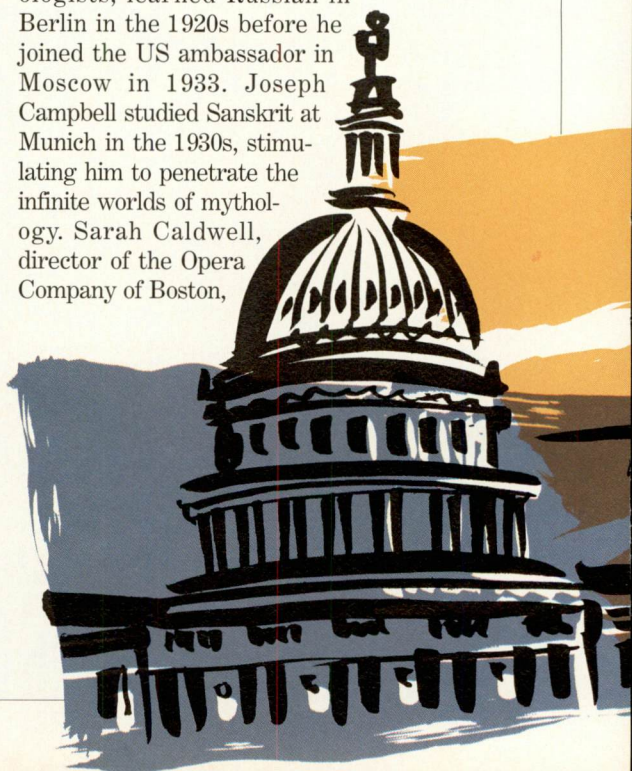
## FADE OUT, FADE IN

Already, however, bi-continentalism is fading. Both fashion and necessity dictate *bi-world* contacts linking the first (Western) and second (Communist) worlds. I got a taste of this nearly two decades ago when a Soviet diplomat visited my home in the Boston suburbs.

"We have the same kitchen linoleum," he noted, pointing to the red and brown brick pattern known to millions of Americans. Where did he get it? "My father-in-law [Ambassador Nikolai T. Fedorenko] bought it when he was stationed at the UN."

But it turned out that my house had an item brought from Russia that was as familiar to the younger Soviet diplomat as my kitchen floor. It was Tolstoy's "War and Peace"—we both had the "Detgiz" (Children's Publishing House) edition published in 1958, acquired by me when I studied at Moscow University that year. From different political worlds, we esteemed the same Old World literature.

For centuries Americans have had a romance with German universities, which helped to make some of them not only bi-continental but also bi-world. George F. Kennan, dean of American Sovietologists, learned Russian in Berlin in the 1920s before he joined the US ambassador in Moscow in 1933. Joseph Campbell studied Sanskrit at Munich in the 1930s, stimulating him to penetrate the infinite worlds of mythology. Sarah Caldwell, director of the Opera Company of Boston,



observed a great deal about opera in East Germany, a center of culture officially located in the "second" world.

At the turn of the century a Moscow-born scholar with a German name, Ivan N. Klingen, led a team of agronomists through Asia for several years and collected more than two tons of seeds and seedlings, including thousands of tea plants and orange trees. He wrote a book called "Among the Patriarchs of Agriculture in the Peoples of the Near and Far East: Egypt, India, Ceylon, China." Caucasian teas were improved as a result of his labors.

Klingen's book was reissued in 1960 just after Soviet leader Nikita Khrushchev made his pilgrimage to Iowa to collect hybrid corn and began prescribing cornpone recipes for his countrymen. Perhaps there was a message: Klingen helped the agriculture of the Russian Empire by his foreign expedition; Khrushchev did the same for the Soviet Union.

Today a mounting stream of commuters shuttles between the first and second worlds. It began with diplomats, spies, and journalists, plus some wrestlers, ballerinas, and Armand Hammer. The nucleus then expanded to other joint venturers, lawyers, and rug merchants. It broadened in 1988 to include art auctioneers and Soviet artists, some of them financed by the auctioneers. Soviet hockey players now play in America, and US baseball players are testing Moscow's Astroturf.

In 1989 dissident scientist Andrei Sakharov visited his relatives and friends in the US twice, elab-

orating the sharp attacks on Soviet realities that he delivered to the Congress of People's Deputies. Last September the leader of the Soviet parliamentary opposition, Boris Yeltsin, also courted American opinion.

### THE GLASNOST FACTOR

Glasnost and perestroika have been good to bi-worldism. Studying in Moscow a few years ago, Harvard graduate student Bruce Allyn got the idea to invite top Soviet researchers to Harvard seminars on how to control conflict. At first his idea seemed preposterous—to people in both worlds. Within a year or so things changed. Sergo Mikoyan, son of the former Soviet president Anastas Mikoyan and director of Moscow's Latin American Institute, has become a regular visitor. In early 1989 he was joined by physicist Sergei Khrushchev, son of Nikita Khrushchev.

Sergei had not been to the United States since 1959, when he shared his dad's disappointment at being refused admission to Disneyland (on security grounds). An accomplished survivor, he easily coped with heckling followers of libertarian Lyndon Larouche at a 1989 Harvard gathering.

One result of these meetings is a joint Soviet-US book called "Windows of Opportunity: From Cold War to Peaceful Competition in U.S.-Soviet Relations" (Ballinger, 1989). The introduction, "Competition Without War," is by Graham T. Allison, former head of Harvard's John F. Kennedy School of Government,

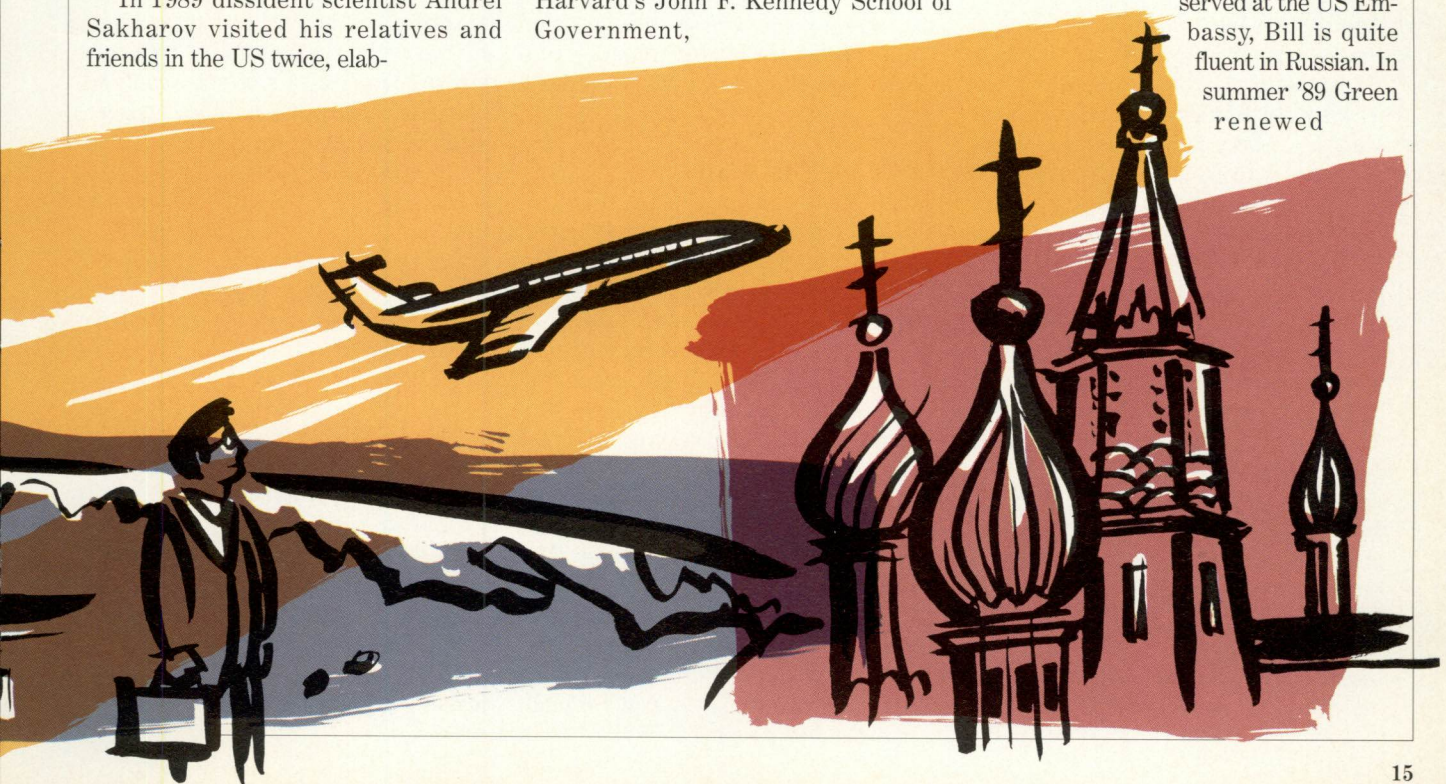
and Georgi Arbatov, head of Moscow's Institute of USA and Canada Studies. Both these men are veteran bi-worlders.

The book's 10 chapters have an arresting format: If an American drafts a chapter, a Soviet (such as Mikoyan) comments; if a Soviet (such as Arbatov's son, Aleksei) provides the thesis, an American (such as Robert S. McNamara) provides a comment if not an antithesis. Readers can make their own synthesis.

### PENTAGON BI-WORLDISM

The US and Soviet Pentagons have developed their own forms of bi-worldism. Maj. Gen. Sergei Akhromeyev, retired from heading the Soviet General Staff in December 1988, has become a regular commuter. In 1987 he visited the Pentagon while Soviet leader Mikhail Gorbachev glad-handed the pedestrians of Washington. In 1988 Akhromeyev had even more fun, donning Indian war bonnets, attending rodeos, visiting an aircraft carrier—a tour reciprocated by his US counterpart, Adm. William J. Crowe Jr., in 1989. In summer 1989 Akhromeyev was back in Washington, where he testified for hours to Congress on security matters, interrupted during committee recesses to sign autographs.

One of Crowe's "flag interpreters" (good enough for an admiral) is one of my colleagues, Boston University professor William C. Green, a reserve naval officer. Having studied at a Soviet high school some years ago while his father served at the US Embassy, Bill is quite fluent in Russian. In summer '89 Green renewed



his bi-worldism. First he helped play host to Soviet sailors from three warships at Norfolk, Virginia; he then traveled on one of two US warships visiting Sevastopol on the Black Sea.

Neither Green nor Soviet Ambassador Yuri V. Dubinin had ever seen such a display of American warmth for visiting Soviets as they encountered in Norfolk. Dubinin flew directly to Moscow to urge Kremlin approval for a comparable welcome for the US fleet. The chief Soviet admiral at Norfolk came to depend on Green as his No. 2 interpreter and got so used to him that he started treating him the way he does his own lieutenants—roughly. The admiral's occasional gruff bark, however, could be taken as a compliment to Green's abilities and as a step forward in bi-worldism.

In Sevastopol, Green and hundreds of other American seamen were simply overwhelmed by Soviet hospitality. Several received gifts, such as a hand-carved model of a sailing vessel, so valuable that US law forbids individual sailors from keeping them. Instead they must be turned over to a naval museum.

Both navies hope to exchange visits this year, at San Diego and Vladivostok. The Soviets have even proposed joint maneuvers for some future date!

### SOVIET COMMUTER

Another frequent visitor to the United States is Andrei A. Kokoshin, a senior researcher at Arbatov's American studies institute. In spring 1989 I met him at Harvard, where he gave two seminars after he, like Akhromeyev, testified before a US congressional committee.

"What a relief to be away from Washington!" Kokoshin said in Cambridge. "I've got friends at NSC [the National Security Council], the State Department, the Hill—there's almost no time to breathe in Washington."

From Cambridge, Kokoshin planned a couple of days in Canada and then back to Russia. While he has not been elected to the Supreme Soviet, he heads its commission inspecting Soviet compliance with the unilateral arms reduction moves Gorbachev has announced. This job takes Kokoshin all over Eastern Europe as well as the USSR. Thus, he is bi-coastal (Elbe to the Pacific) as well as bi-continental and bi-world. He is also

one of the few Soviet *institutchiki* to have a wife who is in the same institute and with whom he writes articles.

More such activities are in the offing. The Council on Economic Priorities, a nonprofit corporation in New York, has worked out a plan with Arbatov's institute and others whereby Soviet and US researchers will explore together how military budgets could be cut; how dual-use (military and civilian) technology could be regulated; how conventional and nuclear forces could be minimized while stab-

ility of relations is maximized.

ility of relations is maximized.

A typical case study compares the responsiveness of defense and civilian industries to challenges of innovation and international competitiveness. Perhaps the Americans may have some ideas on how to retrain the 100,000 career officers Gorbachev plans to let go in the near future.

### ADVICE FROM THE WEST?

Would the Soviets ever listen to advice on such matters? Dr. Alexander King, president of the Club of Rome, has an interesting tale to tell. His organization (which sponsored the book "Limits to Growth" and other studies of the "world problematique") was sharply castigated by Soviet ideologists for "bourgeois pessimism" and "non-Marxist eclecticism" in the late 1970s and early 1980s.

In 1986, however, Kirghiz novelist Chingiz Aitmatov invited King (an Englishman) and other intellectuals (first and third world) to a discussion of global problems at the Central Asian resort Issik-Kul. Among those present were America's James Baldwin, Britain's Peter Ustinov, Turkey's Yasar Kemal,

and Cuba's Lisandro Ortero.

When Gorbachev himself met with the group, it was front-page news abroad and for practically every Soviet newspaper as well as the theoretical journal *Kommunist*.

What was not printed—then—was that Gorbachev pulled King aside and told him: "What you and your club could do for the USSR would be to give useful suggestions on how we can cope in a humane way with our pandemic unemployment problem." Since that time Aitmatov and several other Soviets have become full members of the club and a branch has been formed in Poland.

### FRAGILE FLOWER

Bi-worldism, like *détente*, is a fragile flower, easily crushed. It is buffeted these days not so much by frosty cold war between the superpowers as by the enormous problems within the USSR and other parts of the second world. These issues can easily upset East-West relations if opponents of closer contacts blame nationality unrest or other problems on first-world influences, which Gorbachev once characterized as "cultural vandalism."

There also lurks the issue of symmetry.

"These exchanges will go on only so long as their passports and our money hold out," is how one Western joint-venture expert puts it.

The Soviet side, far deeper in debt than the US, has little to offer except raw materials and glasnost, plus occasional unilateral cuts of tanks and missiles from an arsenal most Soviets agree is too big for their own good.

If bi-worldism persists and grows in meaning, it may lead us into the next millennium, when those who make the transition will become bi-millennial. If bi-worldism really takes off, Americans and Soviets may go on—led perhaps by sci-fi writer Isaac Asimov—to become bi-galaxial.

To get that far, however, bi-worldism will probably not suffice. Probably we'll have to become tri-world or even pentaworld, closing North-South as well as East-West and other gaps.

If that happens—in one millennium or another—we may become one-world.

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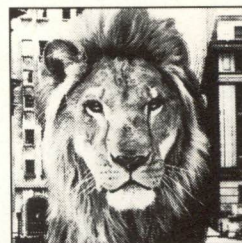
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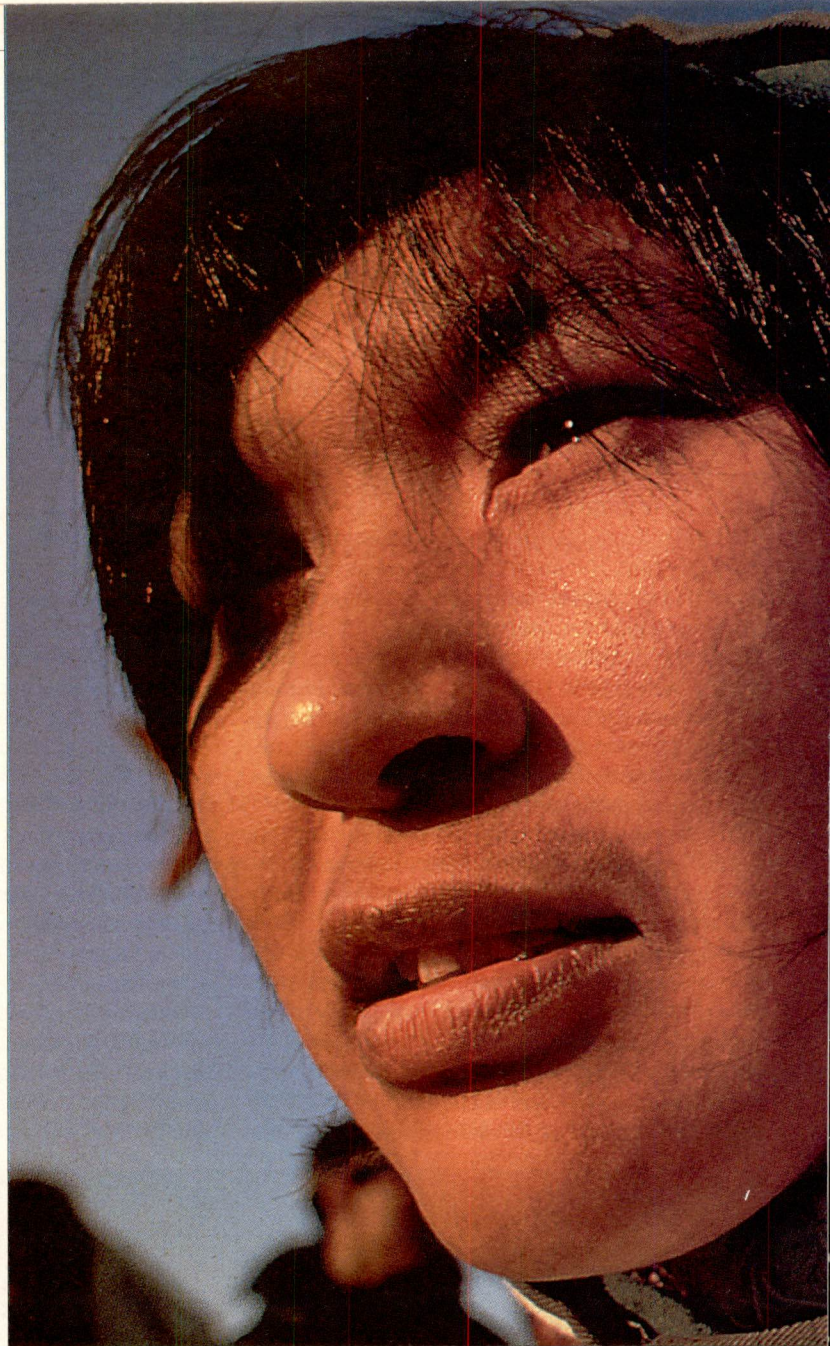
\*Source: IBC/Donoghue's Money Fund Report for the period 2/23/89 through 4/30/90. Reflects the absorption of certain  
Fund expenses which may be terminated. Yield fluctuates. Past performance is no guarantee of future results.

By Cameron Macauley

# CANADA'S NEW ARCTIC

*Siberian visitors. A young elite. Threatened values. Signs of what happens when the modern world spreads to barren lands where wise ancient peoples had been doing very well by themselves, thank you.*

By George Tombs



George Tombs is an award-winning journalist and filmmaker working in English and French. He has covered Europe, and the Americas from the north magnetic pole to Tierra del Fuego, for media in various countries around the world, including The Christian Science Monitor and MonitoRadio. To prepare this story, he visited the Canadian Arctic for the ninth time.

**W**ITH SOME CANADIAN SCHOOL-teachers I waited by the tiny Canadian Arctic airport terminal for the arrival of First Air Flight 804 in Pangnirtung, the hometown of my old friend Jacopoosie. The plane groped over some 6,000-foot peaks and poked through the fog before snarling to a halt in front of us. A little the worse for wear, six native Siberians and their Soviet Georgian translator descended.

"I was very surprised by nature," one of the group told me later. "No bushes, no shrubbery, no trees, only snow, snow, white snow, nothing else."

The comment was the first reaction of Luda Gashilova on her first trip outside of the Soviet Union. With her silken black hair and high cheek-

bones, she could have passed for one of the local Inuit—a name used in preference to the old term Eskimo, especially in Canada. In fact, she is a member of the little Nivkh nation, which lives on Sakhalin Island north of Japan and in the lower Amur River valley of the Soviet mainland.

Ms. Gashilova was accompanied by Siberian Eskimo teachers, products of the Soviet Union's excellent teacher training program for indigenous peoples. All were astonished by the number of pickup trucks in Canada, the absence of lines at food stores, and the fact that property is private.

Since the Soviet Eskimo teachers use some words that the Canadian Inuit understand—like *nanuk* for polar bear—they are considered cousins and therefore all the more welcome. Such teacher exchanges fit into a general pattern of Arctic cooperation between Canada and the Soviet Union that was set in the mid-1980s. Still, the fact that the Inuit are finally meeting the Soviet Eski-



Photo © Jim Brandenburg

mos is extraordinary. For, even today, the Inuit are rooted to the land and memories of the old ways.

It was Jacopoosie who first brought this home to me. I met him during my high school years when I was a volunteer in 8-D, the adolescent ward of the Montreal Children's Hospital. After class I would head over to 8-D to play pool and occasionally *taka*, an Inuit card game, with the patients.

Most youngsters fretted about their pain, but 12-year-old Jacopoosie was different. Was it his copper-colored face or black hair that set him apart? More likely it was his natural dignity.

At home, Jacopoosie said, there was no daylight. Above the Arctic Circle the long night of winter had fallen. It was so cold that a glassful of water tossed in the air stiffened into tinkling shards of ice before reaching the ground. He shook his head as if to say he wished he were there, following the clack and thud of caribou hoofs while the snow shrieked.

Jacopoosie was an Inuk, one of Canada's Inuit.

It took days before he told me of his hometown of Pangnirtung, 1,200 miles to the north. It took a full week before he showed me an Inuktitut-language prayer book tucked under his pillow. After two weeks, he was teaching me to pronounce consonants deep down in my throat as I counted from *pitaqani* to *tishamat*—from one to five.

Peter Freuchen, the Danish explorer who first visited the Arctic in 1906, described the Inuit as a people able "to live where nobody else can." For thousands of years Inuit had managed to survive in the world's harshest climate—spread out over a million square miles of arctic Canada (as well as Greenland, Alaska, and the northeast corner of Siberia). All they had were the simplest of bone and stone implements, and a wise reverence for the rhythms of nature.

It took European explorers and adventurers a long time to appreciate the wealth of knowledge

**GENERATIONS FACING CHANGE:** *Inuit parent and child are part of a people known for surviving with simple means in the hostile arctic environment; now many Inuit ask what the future will hold for their children as traditional society is influenced by commercial influx from the south.*

**I**nuit have ceased to see themselves living at the far edge of 'the white man's world.' They have made the 'circumpolar region' the new international center of their world.

**HUNTERS' CHOICE:** *Igloo builder works on temporary shelter. Very few Inuit now live in ice-block structures, but fishers and hunters—even those who travel by snowmobile—are likely to build one (construction takes only a couple of hours) if they're going to be out overnight.*

Inuit had. Throughout northern Canada, these adventurers left place names recalling their own attempts to subdue nature: Bay of Gods Mercy, Deception Bay, Cape Hopes Advance. (Snafu Beach was a 20th-century addition in the same vein.)

By Freuchen's time, after at least three centuries of various explorers going it alone, a new generation of Europeans had the good sense to ask Inuit how to survive in their hostile landscape. This discovery of Inuit wisdom, perhaps the explorers' most important find, could have started an era of cooperation between European and Inuit.

But this tardy appreciation of Inuit and nature proved to be very short-lived. On the heels of the explorers came missionaries, bureaucrats, prospectors, rum traders, merchants, military strategists,

construction executives, academics, ecologists, and assorted busybodies, all eager to impose their vision of Canada's Arctic and its inhabitants.

### **BIG BUSINESS ARRIVES**

Starting in the 1950s, big government and big business from southern Canada moved into the Arctic. They recognized it as an El Dorado of opportunities for petroleum, lead, zinc, and uranium extraction. They see it today as a vital part of Canada's power structure.

Prime Minister Brian Mulroney has been using the Arctic as a symbol of Canadian national power. His government invited bids from France and Britain to build an \$8 billion fleet of nuclear-powered submarines for arctic defense, only to cancel the program for lack of funds. The Far North is the site of radar defenses and Cruise missile testing, not to mention ground-hugging training flights for NATO jets that particularly infuriate native hunters in the bush.

The economic and strategic stakes are high enough to have crowded Inuit out of the decision-making picture. Canada's 27,000 Inuit—scattered across the Northwest Territories, arctic Quebec, and Labrador—have been divested of their old role as "lords of the Arctic." In just four decades, they have become dependent on policies formulated thousands of miles away. In some communities 90% of the residents are dependent on government welfare.

"Our culture has been eroded," said Mary Simon, an Inuk from Kuujjuaq in arctic Quebec. As president of the Inuit Circumpolar Conference—an international organization that groups Inuit from Greenland, Canada, and Alaska—she practically lives in an airplane these days.

"There hasn't been much of a future for a lot of the young people," she explained. "They have suffered from cultural deterioration, a cultural clash between white society and native people."

This cultural deterioration has taken such forms as spousal assault, alcohol and drug abuse, and a suicide rate several times the Canadian national average. Nova Scotia sociologist Colin Irwin has concluded: "If current trends continue, most of the Inuit living in the Arctic in the year 2025 will be second-generation wards of the state, whose society, economy, and culture may have more in common with an urban slum than with the life their grandparents knew."

Inuit recognize they face challenges more alarming than the historic rigors of wilderness, and they are making a comeback. But they have



Photo © David Hiser/Photographers Aspen



Photo © Nunatsiaq News

**INTERNATIONAL FORUM:** *Mary Simon from arctic Quebec presided at Inuit Circumpolar Conference's general assembly in Sisimiut, Greenland, in 1989, which drew representatives from Siberia and Alaska as well as Canada and Greenland.*

old handicaps to overcome. Their villages are as much as 2,700 miles apart. They use a language, Inuktitut, broken up into nine major dialects and three writing systems (introduced by Moravian, Anglican, and Roman Catholic missionaries).

The 27,000 Inuit are only a fraction of Canada's 737,000 people of native origin—including Iroquois, Athapaskan Indians, and Métis (people of mixed parentage)—who altogether account for only 3% of the national population. Yet Inuit may have the best chance of preserving their distinct society, thanks to their geographical isolation and a relatively low rate of assimilation into English-speaking society.

### REBUILDING A RAVAGED ECONOMY

Now Inuit are rebuilding a ravaged hunting economy. They are pressing Ottawa for the transfer of political power, in order to set up regional governments they themselves will control. In addition, they have forged links with other indigenous peoples, such as their cousins in Siberia. In the process Inuit have ceased to see themselves living at the far edge of "the white man's world." They have made the "circumpolar region" the new international center of their world.

The Inuit Circumpolar Conference (ICC) was established in 1977. It represents 130,000 Inuit from Canada, Greenland, and the United States, and has NGO (nongovernmental organization) status at the United Nations. Its purpose is to strengthen Inuit communications and cultural and artistic links, and to encourage cooperation

in protecting the environment. ICC gives Inuit a much-strengthened voice in international forums like the UN. Once-localized issues have suddenly become multilateral.

"In June 1989 we were awarded the Global 500 award by the United Nations Environmental Program for our work in this area," noted ICC president Simon with satisfaction.

In July 1989, at the ICC's general assembly in Sisimiut, Greenland, representatives of 5,000 Soviet Eskimos, from the Chukchi Peninsula across the Bering Strait from Nome, Alaska, attended an ICC meeting for the first time. In previous assemblies, a chair had been left empty to symbolize their absence. Indigenous people from Canada and the USSR—like the teachers I met at Pangnirtung—are also meeting outside of official forums to explore what they have in common.

Traditionally, the elders are repositories of Inuit wisdom. If I could meet the very oldest of Inuit, wouldn't I be meeting the wisest of them all? Leah Nuturaq was born 104 years ago and doesn't know a word of English. As she spoke, she curled up her legs on her bedspread, displaying embroidered duffel socks she wears inside her boots. Beside her night lamp was a bowl of fresh seal



Map by Dave Herring

brains, and on the walls of her room hung faded photographs of missionaries and ship captains.

"I tell the young people what my elders used to tell me: to listen to the Inuit way of life and not the white man's way," she said brightly. "I listened. I never said no to my elders, I respected them. And I feel that is the reason I have been given a longer life."

Ms. Nuturaq remembered the first time she saw aircraft land near her family's nomadic camp in the

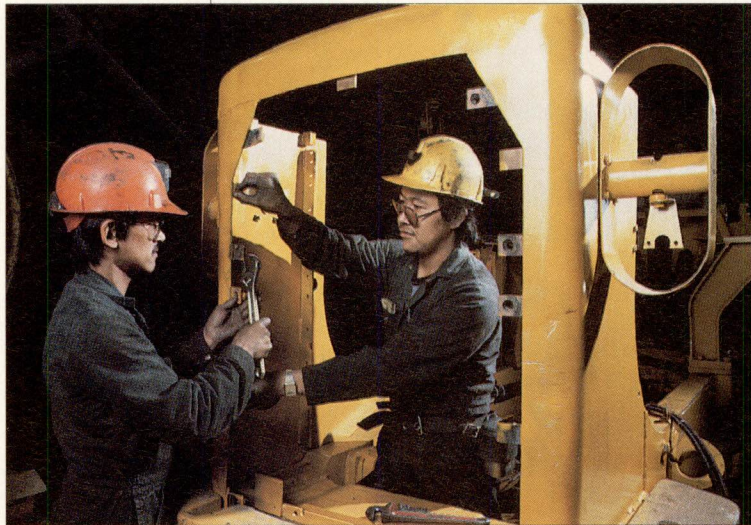


Photo: Nanisivik Mine Ltd.

**MODERN TECHNOLOGY:**

*Inuit workers adjust piece of equipment in Nanisivik Mine. Inuit make up 25% of the work force of the zinc mine, which is one of the major employers in the north Baffin region.*

wilds of Baffin Bay, back before World War II.

"When the time came, I started hearing a noise. I thought it came from the ground. I was standing right next to the tent. I started calling my husband, because I thought it was a bee, and I was scared of bees. I couldn't kill a bee. When I was shouting to my husband, that's when I saw the two planes. I went hiding among big ice blocks on the beach."

From camps like Leah Nuturaq's, Inuit were settled in stable communities in the 1950s and '60s. The advantages were obvious: They would no longer be subject to food shortages or starvation. They could benefit from Canadian health services and formal education. They could make the transition from subsistence to a wage economy.

Yet some government policies, designed to develop the Inuit politically, provoked and antagonized them.

**EDUCATING IN ENGLISH**

For example, children were separated from their families at about 12 years of age and sent to English-language schools far away in southern Canada. Such policies succeeded in creating an elite, able to deal with both the Inuit and the white society. But they also produced a breach between elders like Leah Nuturaq and youngsters.

"In the early years, when the education system was first introduced in our communities, the purpose was to do away with the Inuktitut language," said John Amagoalik, president of the Inuit Tapirisat of Canada, the national association of Inuit. "The children, myself when I was a kid, were put in schools, and we were forbidden to speak our mother tongue.

We were punished if we did that."

As late as the 1950s Inuit didn't know how to stand up to white society. Times have changed. The strongest hope of cultural survival today may well be the education system. It has been revamped to bolster indigenous culture. Inuktitut-language education is now available even to the children (up to fourth grade) of white residents of the Arctic, though there is a lack of qualified teachers.

Only 15% of Inuit finish high school (compared to a national average of 52%). The academic standards of Northwest Territories schools have been lowered in order to pass more students—in theory to get them into better jobs. But many graduates discover that employers are more interested in real skills than a flattering high school diploma.

In the 1970s satellite television opened up new horizons in the Arctic. As in other places, it offered promise as an educational tool. But in many ways it had a negative effect on the traditional community, promoting consumer values, an interest in property ownership, and envy, and resulting in a noticeable increase in theft.

Rosemarie Kuptana, an Inuk from Sachs Harbour in the Far Northwest, describes the initial impact of TV: "It was intriguing, it was entertaining. It replaced the normal activities that we had in the communities, like visiting, playing together, sharing meals, working together. The streets were deserted. And I don't know if the novelty of television has completely worn off in the North yet."

**INNOVATIVE TV NETWORK**

Some 20 channels are available in the Arctic, bringing Detroit news, soap operas, and ice hockey games into every Inuit home. Ms. Kuptana became president of the Inuit Broadcasting Corporation (IBC) and built it into one of North America's best television networks for indigenous people. IBC may, at first glance, seem like a drop in the bucket.

But it is an innovative network, with a string of northern production centers and an interesting output of current affairs, hunting, and entertainment shows. For instance, Blandina Makik created "Takuginai" (meaning "Look and see!"), a children's show with puppets. She is from Igloodik, where a referendum was held in the early 1980s before wary citizens decided to accept television. Ms. Makik is using the medium to bolster language and culture, and bring young and old together again.

"The most important puppets we have on the show are the grandparents," she said. "In traditional Inuit society, grandparents played a very important role in bringing up children and passing down history. I felt the grandparent puppets were very good tools to teach some of the values, some of the stories."

Everywhere I went in the Arctic I saw grandmothers carrying infant grandchildren in the fox-fur-lined hoods of their *amautiq* or traditional coats. The birth rate is high. Demographers predict the population of Canadian Inuit will rise 60%

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from current levels to 41,000 by the turn of the century, putting tremendous strains on housing and community services.

### FURS AND SUBSIDIES

But cultural, political, and demographic gains will not amount to much unless the economy can be turned around. And the basis of the North's subsistence economy, trapping, has been wiped out. It's true trapping became more costly the day snowmobiles mechanized it: Not everyone can afford the \$5,000-\$10,000 outlay per year to hunt on the land by snowmobile. But much of the 90% drop in white fox and hair seal harvests from 1980 to 1985 is attributable to the force of the international anti-fur lobby, which has seriously undermined the Inuit economy. The result is more Inuit dependent on government subsidy.

Wage employment was supposed to bring Inuit into the 20th century. Instead, building Pinetree Line radar bases in Labrador or working in mines in the arctic islands has often proven a temporary occupation, serving to draw many Inuit away from the traditions of the land, only to leave them on the dole and the bottle—permanently.

By 1986, after decades of "development," only one in eight Canadian Inuit had a full-time, year-round job. Over half of all Inuit receive some form of government assistance during the year.

One proposed way to strengthen the northern economy is to recognize hunting as a form of paid employment. A hunter support program is being considered by the government of the Northwest Territories. It would in effect pay people for their hunting effort, and to some extent displace welfare.

The program would also encourage consumption of "country food." Even though Inuit lived on the land for generations, many expend their social assistance money on store-bought food, which is phenomenally expensive, since it has to be shipped great distances—in some instances 4,000 miles—by sea, or by jet, which is even costlier.

The Inuit of Labrador are counting on a land claims settlement. In December negotiators for Inuit and the federal government agreed in principle on a massive new land claims settlement. It will give the Inuit in the eastern Northwest Territories surface rights to 225,000 square kilometers or some 87,000 square miles (nearly the size of Oregon) plus subsurface rights to 36,000 square kilometers (14,000 square miles) and \$580 million (Canadian) spread out over 14 years. Moreover, Inuit of the western Arctic signed an agreement with government in 1984, and Inuit of Quebec in 1975 after a massive hydroelectric project had been launched in the latter province's James Bay region.

"The [1975] James Bay agreement has provided us with more opportunities to get involved politically and economically in the region," Mary Simon told me. As an Inuk of arctic Quebec, she is a beneficiary of the agreement. "So I think it has been in many ways a positive step, but we've had a lot of difficulties with implementing the agreement."

### WHAT'S AT STAKE

Before taking over the presidency of the Inuit Circumpolar Conference in 1986, Ms. Simon was president of Makivik Corporation, the Inuit holding company set up by the James Bay agreement. Makivik now runs a regional airline, a travel agency, a deep-sea fishery, and a fuel distributing agency. Quebec Inuit also have a fledgling regional government.

New organizations such as these are helping Inuit maintain their identity as a distinct people, bound to the land but very much bound to the modern world as well. After a few decades of total dislocation, and despite gnawing social problems, a new Inuit leadership is now providing direction.

"It's the nonmaterial things in our culture that are at stake," concludes Rosemarie Kuptana. "Like the altering of our traditional values and attitudes, our pride, our sense of being a distinct culture, our language. Our people, that's what's at stake."

Jacopoosie would know what she meant.

WM

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sensation. Every time I started at a new programming job, I had to learn how to do all the same things in a slightly different way. And on a computer you must do things exactly right, or it doesn't work.

Communicating with a computer is a bit like talking to a person who understands when you say, "It is hot outside," but who looks at you blankly when you say, "It's hot out."

In America this rigid stupidity of computers often breeds a sort of love-hate relationship between programmers and their machines. In an attempt to establish the kind of long-suffering rapport that flowered so naturally among my computer buddies back home, I said to Mr. Ikeda: "This kind of stuff is always a pain in the neck in the beginning, isn't it?"

After the interpreter translated, I saw a spark of annoyance flare in Mr. Ikeda's eyes. He spoke curtly in Japanese, and the interpreter said:

"He says he doesn't understand. He's

trying to teach you how to do it now."

I said nothing, trying to maintain an expressionless face, but I think that was the moment when I realized that Mr. Ikeda's and my mutual understanding of PL/I would not be quite enough.

That week I was given a set of deadlines. I don't mind deadlines. The problem was that I was not sure what the deadlines were for.

## I WAS NOT IN AMERICA

As I pored over the program on which I was supposed to be working, I quickly noticed a stunning peculiarity. For more than 100 pages of PL/I code, there were virtually no explanatory comments. To understand what this means, think of the word "code." Then imagine reading 100 pages of it without a key to understand the code.

I had never seen anything like this before. In America any program on which I had ever worked was loaded with comments. I fumed. Even if Mr. Ikeda had added comments in Japanese, I thought, someone could have translated them.

One day, at the end of my tether, I walked over to Mr. Ikeda with an interpreter and asked him to explain a particularly abstruse section of the program.

Mr. Ikeda looked up from his terminal and fixed me with a withering glare. It was a glare with which I would become quite familiar over the next few months.

"Chernin-san," he said through the interpreter, "will have to analyze the code."

I glared back at him, then turned on my heel and strode off to my desk.

I probably should have known better than to do what I then decided to do. I asked Mr. MacTavish to arrange a meeting with Mr. Yatsunami and Mr. Ikeda. This meeting was ostensibly for discussing my concerns about other groups providing the data necessary for me to meet my deadlines. The real reason for the meeting was to let Mr. Ikeda know that he couldn't push me around.

Maybe it would have worked in America. But, as I was reminded whenever I looked up, I was not in America.

could never have foreseen difficulties between us.

It was my first day on the job, and I was accompanied to the offices by two foreigners—Mr. MacTavish of Scotland and Mr. Plimpton of Arizona—who had arranged my contract. (Japanese companies rarely contract foreigners directly; it is usually done through agencies such as MacTavish's and Plimpton's.) We shook hands with Mr. Yatsunami, the department head who had first interviewed me, and then I was introduced to Mr. Ikeda.

Mr. Ikeda was a thin man, about 30, maybe 5-foot-7. He shook my hand limply and gave me a shy, friendly smile. He seemed like a nice person.

Then the five of us sat down in a small windowless room to discuss my project. Unfortunately, I spoke no Japanese, and the only person who really knew what I was going to have to do was Mr. Ikeda, who spoke no English.

## YOU BOTH SPEAK PL/I

I was given a copy of the computer program I was going to be working with. The language was PL/I—no different from the PL/I used in the United States—and there was a certain comfort in seeing familiar constructs. But I didn't have any idea what this program was designed to accomplish.

I wondered aloud whether there might be any communication problem, considering the language barrier between Mr. Ikeda and me, but Mr. Plimpton smiled and said: "You'll understand each other because you both speak PL/I."

Truer and falsier words were never spoken.

The first clouds appeared on Mr. Ikeda's and my horizon later that morning.

Mr. Ikeda, along with an interpreter, sat down at a terminal with me in order to orient me to The Company's computer system. As Mr. Ikeda displayed the screen menus used to do various routine computer housekeeping chores—creating and editing files, running programs—the interpreter translated. The screen menus, with their Japanese menu choices, passed in a blur, and I soon realized that I would learn this system only by repetition.

Japanese menus or no—it was a familiarly frustrating

In the short time I had been in Japan, even I had learned that, when communicating with the Japanese, you should strive, above all, for indirectness. Try to say what you want to say without coming out and saying it.

I had begun to learn about this indirectness even as I had interviewed for jobs in Tokyo. Once, while interviewing for a job rewriting translations of Japanese technical documentation, I had asked a prospective employer whether "perhaps it might be possible that" they might start me at a higher rate per page.

An American employer might have just said, "No, the rate is fixed." This Japanese employer, however, never answered the question. Instead, he told me a story about a "very brilliant American" who had worked several years for him.

"When he began to work for us," said the employer, "he was only rewriting about 10 pages a day, and he was very discouraged and about to quit. But I encouraged him, and soon he was increasing to 20 or 30 pages a day. And, by the time he left, he could rewrite 60 pages a day, and he was making about 1.2 million yen a month."

Thus the clever employer had found a way of obliquely encouraging me, but at the same time saying: No, the rate is fixed.

## I WILL TRY MY HARDEST

Unfortunately I had not yet become so clever. I proceeded to try to solve my problems with Mr. Ikeda with all the subtlety of an American bull in a china shop.

At the meeting, there came a point when Mr. Yatsunami said that they were concerned that I wasn't working fast enough.

"Well," I responded, "things would be going a lot faster if the program I was working on had some comments in it."

I said this innocently, as if I were not aware that Mr. Ikeda was the original author of this program.

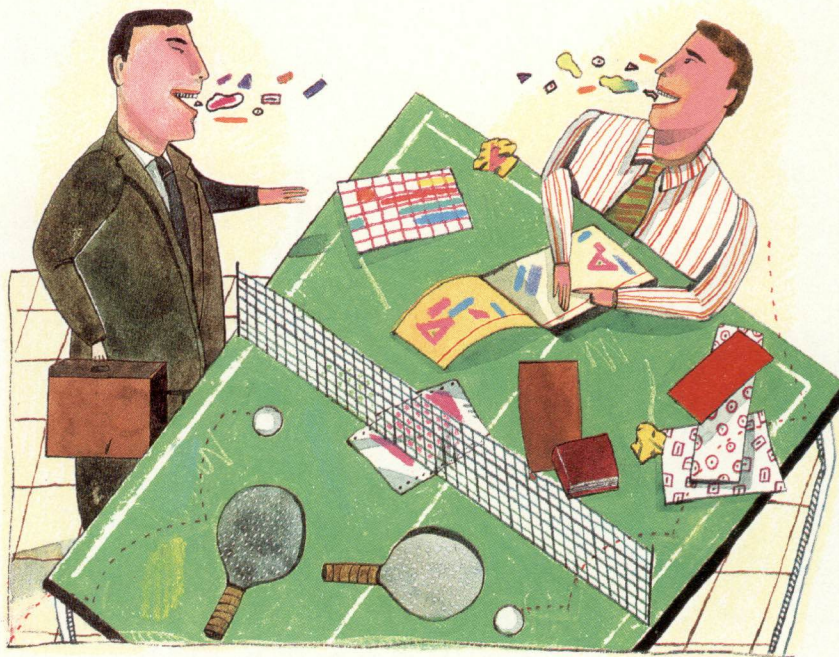
I didn't need to understand Japanese to know that steam was coming out of Ikeda's ears. And, after the meeting, it wasn't really necessary for MacTavish to whisper to me: "Mr. I. seems quite upset."

I had heard stories of Japanese workers who sat next to each other for 40 years, despising each other all the time, but never letting anyone know about it. Mr. Ikeda and I were not so adept at concealing our feelings.

Then I successfully met my first two deadlines. Things began to improve slightly. With the help of an American colleague named Roger, who had lived in Japan for 25 years and spoke fluent Japanese, I was able to start getting the information I needed to do my work. It seemed that Mr. Ikeda grudgingly was beginning to respect at least my programming abilities. And as for me, I also had to admit secretly to myself that Mr. Ikeda was a skillful programmer, too.

However, the real turning point in my relationship with Mr. Ikeda was an event that no one could have predicted.

It was a normal Saturday about three months after I started working: I, along with just about everyone in the department, was at my desk for most of the day. Usually, I



would leave at about three on Saturdays; people would look up, Ikeda would glare, and I would feel guilty. This Saturday, however, I was quite absorbed in what I was doing, and everyone else was drifting out before me, until finally, at about 5:30, it was only Mr. Ikeda and me.

"I am leaving now," he said, in baby Japanese, so that I could understand. I nodded and turned back to my work.

"You leave too," he said.

"Demo watashi wa shigoto shitai," I said. But I want to work.

Mr. Ikeda motioned that he had to lock the steel door at the end of our corridor. I had to leave or I would be locked in.

So we walked down the hall together, talking in simple language about an algorithm I was working on.

Mr. Ikeda locked the door behind us. I still really didn't want to stop working, but my devotion would go only so far. In America, I could have taken the work home, but in American computer shops there were no time clocks. If I took the work home here, I'd have to punch out first. As interesting as the work was, I wasn't going to do it if I didn't get paid.

I thought for a minute, then pointed to a ping-pong table in the lobby and said: "Ikeda-san, watashi wa ima kono algorithm ni tsuite cangaete imasu. Ima shigoto shitai. Moshi ano tsukue ni shigoto shimas, daijobu desu ka?" I was thrilled. After two months of classes, I was actually beginning to speak Japanese. I had said: "Mr. Ikeda, I am now thinking about this algorithm. I want to work now. If I will work at that table, is that okay?"

Mr. Ikeda smiled broadly. "Asoko desu ka?" There? He laughed. "Daijobu desu." Okay.

The following Monday, Mr. Ikeda came over to Roger's desk and, laughing, told a story about "Chyaneen san" (me) with gestures toward the ping-pong table in the lobby.

"That really tickled him," Roger told me later. It dawned on me then that Mr. Ikeda was happy because, on Saturday afternoon, he had realized that I actually cared about my work. By corollary, perhaps one reason he had been nasty before was that he thought I didn't care about the work. But why would he think that, I wondered. Perhaps it was my irreverent attitude—an irreverence extremely common in



routine, and the winter months passed this way.

Then there was an explosion.

I had gotten to be friends with a woman named Miss Inamura, who sat at my group of desks and worked as a translator. At lunchtime, we took turns teaching each other Japanese and English. After a while, there were several other women who sat in on the English classes, and they each took turns teaching me Japanese.

But my favorite was Miss Inamura.

Sometimes we even talked on the phone after work. She would complain about her boyfriend and I would try to say wise things.

Then, one day, I invited a Japanese friend of mine to meet me for lunch at The Company.

Lunchtime was from 12:20 to 1:10 exactly every day. It was announced with a cute little chime tune played over the

American programming shops.

One day, after Mr. Ikeda had introduced a new portion of our project to Roger and me, I said: "Ganbarimasu." I will try my hardest. It was a verb I would hear over and over in Japan. In a softball game, as I went up to bat, someone said: "Ganbatte kudasai." Please try your hardest.

Mr. Ikeda responded to me: "Hai. ganbarimashoo." Yes. Let's try our hardest. It is not difficult to imagine how American computer programmers would respond to such earnestness. They would roll their eyes and mutter to each other: "Give me a break." Then they would go out and try their hardest—grumbling all the while.

## HOW'S IT GOING?

A few weeks after the episode at the ping-pong table, late on a Friday night, Mr. Ikeda pushed himself away from his terminal and walked over to me at mine.

"Doo desu ka?" he said. How's it going?

I don't really know how it happened. He was tired. So was I. It was Friday night—almost time to go home—but all of a sudden somehow Mr. Ikeda was asking me about countries I had visited before I came to Japan. It was the first time we ever talked about anything other than work, and it really was the last.

I asked Mr. Ikeda about his family, and he told me his father worked in the government. He asked me about mine—but how could I say, in Japanese: "My father is director of a Jewish community-relations organization"? Finally I just said that he was in politics.

Soon, though—perhaps sooner than we wanted—we couldn't think of more things to say in language that I could understand, and Mr. Ikeda stood up and said wearily: "Mata ashita." Again tomorrow.

"Mata ashita," I said.

I would be a liar if I said that everything was calm between Mr. Ikeda and me after that. Every week or two we'd have some sort of scrap, and I'd call MacTavish to blow off steam and threaten to quit, and MacTavish would tell me to just "keep plodding along," and I would calm down and go back to work the next day. So everything got to be a sort of

loudspeakers. The chimes always reminded me of Romper Room.

My friend and I returned from lunch at about 1:20, and I brought her back to my department to show her where I worked. I introduced her to Miss Inamura and to Roger and then escorted her to the exit. When I got back, Miss Inamura met me at the door and said sternly: "You should not bring friends to the office."

"Why not?"

"It disturbs people."

I shook my head and sighed. "Okay. It's not such a big deal, but I won't do it anymore."

But Miss Inamura had more on her mind. "People are also angry that you sometimes come back from lunch late."

"I came back from lunch ten minutes late," I snapped defensively. "What's the problem?"

"You've done this other times. You also come back late from the dinner break sometimes."

The dinner break—if you worked overtime, The Company gave you from 5:30 to 6 to eat dinner. I was furious.

It was no wonder, I thought, that nobody else was finishing their work on this project. They were all too busy bowing and following rules. Just last week, Mr. Ikeda had asked me to do a part of the project which previously had been assigned to a Japanese consulting firm. They had had the assignment for nearly three months, and had been unable to make any headway. I finished this assignment in three days. Why was this, I wondered. Certainly it was not because I was such a great programmer.

It was a myth, I thought, this idea of Japanese efficiency.

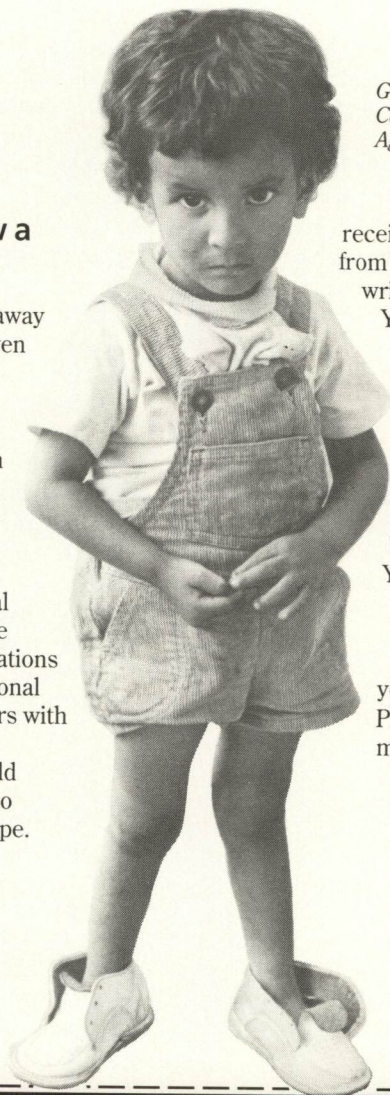
"Look, Miss Inamura," I said finally, "I don't think it's that important whether I come back from lunch at 1:10 or 1:13 as long as I'm doing my work."

"Everyone else is back at 1:10," she said. "You should be too."

"That's ridiculous. I'm the only person on this project who's meeting his deadlines and now people are worrying about my lunch habits. Do you want to know what time I go to the toilet, too? In the United States, I take lunch whenever I want and come back when I'm ready and nobody bothers

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me as long as I'm getting my work done."

"You're not in the United States now," said Miss Inamura, her voice trembling with anger.

"That's for sure," I said, and we both walked away in a huff.

Later that day, I passed Miss Inamura a note asking her to have lunch with me the next day so that we could continue our conversation and clear up "some misunderstandings." Miss Inamura then passed a note back to me:

"It might be convenient for you to do so, but please always try to think about other's convenience too. I cannot meet you for lunch tomorrow.

"If you don't keep the rules here, I think you'll get fired. A couple of months ago, there was a man who was fired because he didn't keep the rules and disturbed us. If you don't change your mind, I'm afraid that I cannot help you.

"I have no word to thank you for teaching me English. But do you think you're helping people you work with? If you tried to be kind and think about others a little bit more, you could have improved this situation. Anyway, I have no time to discuss with you tomorrow. Actually, I don't want to talk with you unless you notice your faults."

I was stunned. How had things gone so far? I looked around me at the people who I had thought were my friends. Which were the ones who now didn't like me?

### I AM SORRY IF I UPSET YOU

That night I was in a rage. I was beginning to hate this country. But back in my tiny apartment, away from the need to spar and defend myself, I found myself wondering whether Miss Inamura had actually been right. If we were being paid by the tick of the clock, wasn't it reasonable that I should be there for all the ticks? Was I, in the name of individualism, treating myself as superior to my friends?

In the end, my simple longing to keep my friends turned out to be stronger than any other feeling I had that evening. I wrote Miss Inamura a letter:

"I am sorry if I have upset you. Out of respect for you, but not out of respect for the rules—which I still find silly—I will do my best to be more punctual..."

From that day on, I always returned from lunch at exactly 1:10. Miss Inamura and I became friends again, and I had to admit that I did feel more a part of the group, now that I was following the rules. It was not the most comfortable feeling for me, but it was far more comfortable than the tension that arose from going too far outside the norm. It seemed that I had learned some kind of lesson about being Japanese.

Perhaps consideration for one's colleagues—a desire not to let them down—is what enables some Japanese companies to produce high-quality products with such apparent efficiency. But it also might have to do with why there are problems in Japanese software projects such as mine—and why so little original software currently comes out of Japan. Because, when it comes down to it, the computer programmer basically works alone. He may plan a project in conjunction with others, but when he sits down at the terminal, he is alone. The group has nothing to do with it. Programming requires individual creativity, and individual creativity requires moving into unknown waters, away from the group.

I don't think it's any coincidence that Mr. Ikeda, by far the most productive and creative programmer I met in Japan, was kind of a lone wolf. Mr. Ikeda was refreshingly rude. When he was angry—which was quite often—I always knew it. There was no attempt to hide his irritation behind polite-

ness. Mr. Ikeda paid lip service to the group, but he seemed quite willing to step away from it as well.

As for Mr. Ikeda's reaction to the whole lunchtime tardiness fracas—I really don't know. As a matter of fact, I don't know if he was even aware that it was going on at all.

But of all my memories of the episode, the sweetest was that of Mr. Ikeda wearily sitting down beside me at my terminal the night I received my letter from Miss Inamura.

I don't know whether he could tell that I was upset, but his voice did seem a little warmer than usual when he said: "Doo desu ka?" How's it going?

I sighed, and said: "Kyo wa taihen deshita." Today was hard.

He looked at me for a moment, then nodded, and turned back to his terminal. We sat side by side for hours into the evening, sunk far into a galaxy of minutiae that the two of us had created. The crazy day receded, and we were alone with our machines in a world that no one else around us could understand. I wearily said a word to each other during those hours, but I was grateful for his presence.

### COME BACK WORK TOGETHER AGAIN

I left The Company in the middle of March. My part of the project was done.

It was late in the afternoon, on my last day at the job, when Mr. Ikeda and I said goodbye. He approached me carrying a small package.

"Chernin-san," he said, "a present."

Inside the package was a "hanko," the small stamp that Japanese use to formally affix their names on papers at banks and the like. For my hanko, Mr. Ikeda had chosen two characters that, taken together, could be pronounced "chya-nin."

My new Japanese name meant "teahouse master"—the man who serves as host at the Japanese "tea ceremony," the highly formalized Zen tea drinking ritual.

In the package which Mr. Ikeda gave me, he had included his address, and a chapter from a book about tea ceremonies. My eyes were drawn to a paragraph saying that the underlying philosophy of the tea ceremony, and the reason for the careful attention to small details, was that "...each encounter with someone, even a friend whom you see often, should be treated as if it were a once in a lifetime occurrence—as if today were the last time you might meet."

There was something else I noticed. Above his address, Mr. Ikeda had written, in English: "Come back work together again." It was an idea that had come up before. Once, struggling for Japanese that I could understand, he had even suggested that I should stay in Japan "until death."

I had listened politely. How could I tell him that I could never live this life forever: always eating lunch by someone else's schedule, working by punch clock, always being polite and never making waves?

Now though, on our last day together, I felt suddenly sad to be saying goodbye.

We stood there alone in the computer alcove where we had spent so much time, and I looked Mr. Ikeda in the eyes. I thanked him profusely in Japanese, and shook his hand.

But somehow this did not seem enough.

So, facing Mr. Ikeda on our last afternoon, I bowed.

In Japan there are many kinds of bows. Sometimes it is just a nod of the head, sometimes a sort of hunching forward of the shoulders. The deeper the bow, the more respect is intended.

I bowed very low, from the waist.

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30,000 Have Moved to  
Toronto Alone—and That's  
Not the Half of It

By David Clark Scott

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**China**

## New crackdown may plans of Western marketers

By JULIE SKUR HILL

The burgeoning consumer marketing business in China was jolted last week after violence erupted in the streets of Beijing. All agencies, marketers and media outlets moved out non-Chinese employees.

June 4, the day the violence started. It has no plan to re-open until "we can ensure the safety of our employees and when a liberal business environment returns," said Richard Detweiler, a KFC spokesman.

The chaotic environment led many ad-

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# NUTMEG WARS

By Clayton Jones



*With products worth their weight in gold, the Spice Islands lured Western powers to battle centuries ago. Today a different kind of turbulence echoes from Indonesia to post-invasion Grenada.*

**T**HE SPICE ISLANDS ARE DIFFICULT TO pinpoint on a globe. Early European mapmakers labeled this area, like so many other mysterious places, *terra incognita* or, sometimes, “where Dragons be.” It lies in the Moluccas, a scattering of a thousand islands that straddle the equator and make up one of 27 provinces in Indonesia.

To possess what grows on these islands, kings and queens risked fortunes, explorers dared, wars were waged.

And all for the pleasure of dazzling the tongue. The craving for other goods from the Orient—gold, tea, teak, Toyotas—came later.

Spices, with their scents of paradise, were the stuff that first beckoned valiant mariners. The cloves, nutmeg, cinnamon, and pepper that had grown for centuries in the islands of Asia were what motivated Europe’s first conquests in this region. The search for shorter routes to the source of spices led Columbus to seek a westward passage, Vasco da Gama to sail around the Horn of Africa, Magellan to try to circumnavigate the globe.

Spices stoked Europe’s bland medieval cooking into culinary virtuosity. They preserved meat across seasons, changing dietary habits, the nature of hunting, and the use of time. So treasured that they merited display, they inspired, yes, the spice rack.

#### THE CASE OF THE SMUGGLED SEEDS

Once discovered, the Spice Islands were the foretaste of Western empires in Asia. Before the first Europeans dropped anchor in Asia, they could obtain spices only at exorbitant prices and from Arabs who brought them overland. Pepper was worth its weight in gold. In England during the Middle Ages cloves served as currency. In Germany, a pound of nutmeg could buy seven oxen. The spice trade supplied much of the wealth that helped bring about the Italian Renaissance. For centuries, spices were a significant force in the global economy.

Sir Francis Drake was astounded to find so many cloves on his visit to the island of Ternate in 1579 that “we furnished our selves of as much as we desired at a very cheap rate.”

But, like a fabled perfume that eventually fades, the Spice Islands, whose presence was once so powerful, have ceased to claim world attention.

After all, it has been more than four centuries since the chemistry of spices first brought East and West together. A long chapter of East-meets-West will end when the Portuguese, the first to sail into Asia, turn over the colony of Macao—the last remnant of early Western colonialism in Asia—to China in 1999. So the next century, which some commen-

tators expect to be the Age of Asia, will dawn with no Western colonial presence.

The Dutch East India Company went bankrupt in 1795, and the Dutch spice monopoly was officially ended in 1873, in large part because of the high cost of posting troops and building and maintaining forts. The knockout blow to the Dutch monopoly came in the mid-1700s when a Frenchman, Pierre Poivre, smuggled a few nutmeg and clove seeds to Mauritius. Until then, it had been assumed that trees and plants could not be grown in places other than where they were found. The 17th-century German botanist Georg Rumpf, for instance, had written that cloves were God-given to these islands “beyond which, by no human industry, can they be propagated or perfectly cultivated.”

Dutch traders’ greed was stemmed by the Frenchman’s smuggled seeds, which propagated spice trees around the globe, leaving Indonesia struggling today to make something of its spices. Only 1%, or about \$200 million, of the country’s exports comes from spices.

But that doesn’t mean spices are not a tempting target for monopoly. Indonesia is the largest exporter of pepper in a weak cartel of world producers. In nutmeg, cacao, vanilla, cinnamon, and other such commodities, it has tried to fix a market share.

Frans Hausjahl explains that his company on Ternate, Sumber Utama, joined up with an Indonesia government campaign in 1986 to create a world monopoly in nutmeg. Mr. Hausjahl bought tons of nutmeg from farmers at high prices when the monopoly succeeded—for about a year—in tripling world prices.

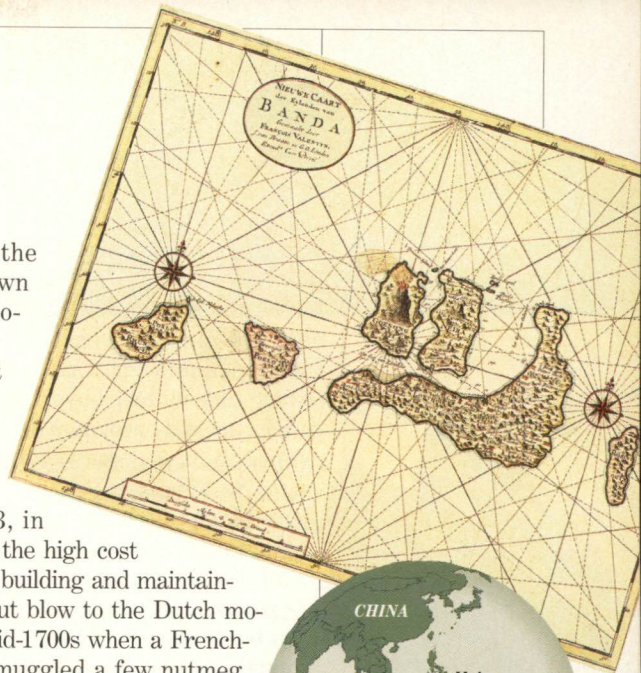
But then the price collapsed. Today he is stuck with debt and piles of the spice. Other nutmeg exporters fell into the same trap.

#### THE GRENADA CONNECTION

Indonesia produces 78% of the world’s nutmeg, with most of the rest grown on Grenada in the West Indies. In 1983, when the US military invaded Grenada, that island’s production was disrupted, briefly raising world prices.

Indonesia, seeing the potential for high profits, asked Grenada to join it in forming a cartel. Indonesia then corralled its nutmeg exporters, almost all of whom are ethnic Chinese, into a group called Aspin, and allocated quotas to each.

“It’s as if the Dutch East India Company had



#### WORTH THE TRIP:

*Old and new maps (above) show islands that throughout history have lured traders in spices such as nutmeg. It comes from the aromatic seed (opposite page) whose red fiber covering produces the even more expensive mace.*

Photo opposite page: Clayton Jones. Map courtesy of Timothy Carney. Globe by Dave Herring

Clayton Jones, Tokyo-based correspondent of The Christian Science Monitor, travels often throughout Southeast Asia.

kers of Europe.” He said their “vast Commerce consists in being supplied from All Parts of the World, that they may supply All the World again.”

With their niche

than as outwards against competing Europeans.

These Western ruins in Asia are footnotes to history. Once manned by helmeted musketeers, the ramparts now are patrolled by nibbling goats. In the modern spice port of Manado, I saw young men toying with an old sextant, aiming it at the midday sun.

The spice trade was built on the notion of exclu-

come back again," said William van der Broeke, a descendant of Dutch settlers who became an Indonesian citizen after the Netherlands gave up its colony in 1949.

But this time the nutmeg sellers' cartel met its match in a nutmeg buyers' cartel. Oddly enough, the buyers were led by a Dutch company, Catz International of Rotterdam, which has been in the

nutmeg. But once Run was one of the world's most valuable pieces of real estate, coveted for that same—then rare—nutmeg. The English, calling themselves "gentlemen adventurers," landed on Run in 1601, sent by Queen Elizabeth I on her country's first commercial venture to the East Indies. In 1667, after a series of sea battles with the Dutch, the English swapped Run for a small

**M**

*alik Hamadje's clove garden lies near a 376-year-old clove tree, planted in the time of Shakespeare and believed to be the oldest in the world.*

sive cultivation within a narrow ecology. Such economic concepts are still widespread in Asia, where the Asian rules of commerce, a form of pre-capitalist mercantilism, do not always accept competition as a necessary way of business life. Chinese, Japanese, Koreans, Thais, and others often spend more energy damaging competitors than expanding their markets. Governments protect local business elites in a silent conspiracy by granting monopoly rights, exclusive licenses, or subsidies. This can create a crony capitalism—which became excessive in the Marcos Philippines—that both concentrates and abuses power.

#### THE CLOVE-LACED CIGARETTE

Ironically, Indonesia—once the world's sole source of cloves—has become an importer of cloves. This coals-to-Newcastle situation came about during this century when Indonesians started to smoke clove-laced cigarettes, or *kreteks*, which crackle and spark, emitting a scent that identifies Indonesians wherever they go in the world. In 1988, they smoked over 100 billion *kreteks*. Despite high domestic demand, many farmers have turned to crops other than cloves. A domestic trading monopoly, led by an ethnic Chinese businessman

and a brother of Indonesia's President Suharto, has helped to keep clove prices to farmers low.

"We're at the mercy of others who set the prices," says Malik Hamadje, a sixth-generation clove farmer on Ternate. He owns 50 trees high up on the island's volcano. Every day he climbs the steep slope to harvest cloves—flower buds which must be picked unopened. He earns about \$1,000 a year. During the peak month for blooms, he lives among the trees to scare away birds.

#### THE SCENTED BREATH OF COURTIERS

The nail-shaped clove, which Indonesians call by a Chinese name, *cengkeh*, was used in China to scent the breath of royal courtiers before they approached the emperor. Romans burned them along roads as incense. Today, they are used to add a musky odor to perfumes, as flavor studs on baked ham, and in pickled fruit, stews, syrups, and chocolate mixes.

"We used to plant a clove tree when a child was born," says Hamadje. "But with low prices, no one does it anymore." His garden lies near a 376-year-old clove tree, planted in the time of Shakespeare and believed to be the oldest in the world.

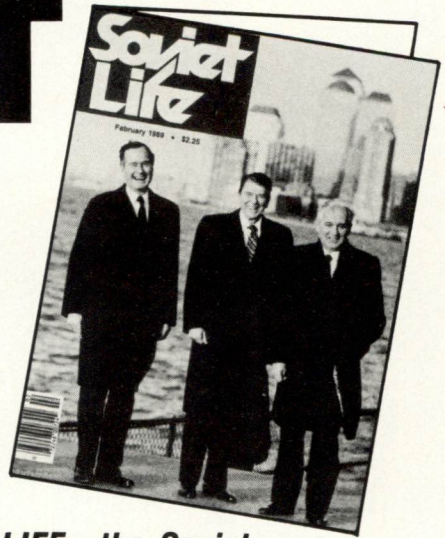
More to the point, the tree was planted after

**CAPTURING THE 'GOLDEN SPICE':** Picker uses long pole with built-on basket to dislodge ripe nutmeg and lower it gently to the ground.



Photo: Clayton Jones

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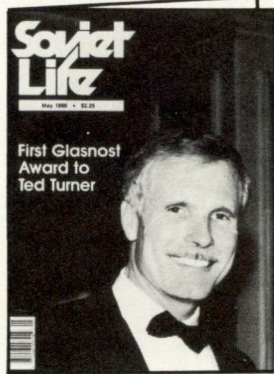
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Photo: Clayton Jones

**THEN AND NOW:**  
*Banana carrier's backdrop is Dutch architecture hinting at former glory in islands that have lost their exclusive claim to spices.*

the Dutch had killed all clove trees on Ternate and other islands in order to concentrate spice production on Ambon and Banda. This old tree was probably the source for that original French seed smuggler. Six feet around, it produces a massive 200 pounds of cloves a year.

### THE SACRED CROWN

When Jesuit St. Francis Xavier visited these islands in 1546, he called them "islands of divine hope." And Somerset Maugham, in his travels as a novelist in colonial Southeast Asia, referred to this area as "the magic islands of the Eastern seas."

On Ternate, a little of that magic and mystery lingers in the sultanate's sacred crown, which is hundreds of years old and made of jewels and human hair.

"People here still believe the crown can give them power," says Effendi Syah, brother of the current sultan.

"People on Ternate need that faith," he says. "They are poor, and the clove trade is influenced by big traders."

Indeed, in the 16th century, the Portuguese killed the sultan of Ternate after he refused to deal with them. At the time, his kingdom spread hun-

dreds of miles over many islands.

The modern spice industry still looks like a big bully to little spice farmers. It has become technologically complex and computerized. One meat-products company in the United States, the country that has become the world's largest spice importer, keeps 40,000 formulas of spice mixes in its computers.

"Spices are no longer a smell and taste industry," says Tom Burns, executive vice-president of the American Spice Trade Association. "We demand more uniformity of flavors, so scientific control is more rigid."

The US Food and Drug Administration (FDA), whose quality standards on imports are difficult for Indonesians to understand, rejects about 10% of the country's spice shipments.

"I've seen nutmegs with neat holes drilled in them by bugs," says FDA official Frank McKeith. "Some are even jumping."

Nutmeg as well as cloves is grown on Ternate these days. Near one ruined fortress stands a nutmeg warehouse that is packed to the ceiling with unsold nutmeg.

As in cloves, nutmeg farmers don't have much incentive to maintain trees. On Banda, which now produces a low share of Indonesia's crop, the number of trees has fallen from more than half a million to fewer than 170,000.

### THE KEY INGREDIENT

The greatest danger to Banda's stock is that farmers have been picking unripe fruit in the past decade to satisfy a rising world demand for nutmeg oil. The oil, which can be extracted only from young nutmeg, is a key ingredient in many perfumes and in preservatives.

High demand for the oil is killing Banda's trees. "The tree's life is cut in half because it overproduces when the young fruit is picked," says Welkie Riupasi, a plantation manager.

Des Alwi, who owns his own nutmeg garden, would like Indonesia to stop the oil production as well as nutmeg exports for a year to allow Banda's trees to recover.

And he wants the government out of the business and the dominance of ethnic Chinese reduced by giving some say in the industry to indigenous Indonesians.

Although nutmeg grows elsewhere now, it rarely has the same richness, productivity, and even round shape as the original Banda variety. "The seed, when taken elsewhere, degenerates," says Alwi.

"The old European wars over Banda—it's the same thing now. All the kings in Europe liked a good cuisine. Today, it's the big companies that want a good preservative from nutmeg oil.

"If we don't act soon, we could lose the mother nutmeg clone on Banda within a hundred years."

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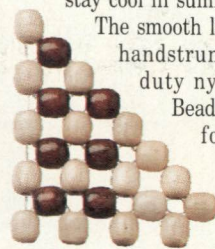
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By Maryann N. Keller

CARS

# The Race for Eastern Europe

— All five main markets are different, as Western automakers are quickly finding out.

**SALVAGEABLE?:** East Germany's out-moded Trabant will get four-stroke VW engine in effort to lure buyers and forestall unemployment among autoworkers in Zwickau until VW can begin producing its own models in East Germany.

Maryann N. Keller is a leading automobile industry analyst who travels frequently to Europe and Japan from her office at the New York securities firm of Furman Selz Mager Dietz & Birney Inc.

**Q**UESTION: WHAT'S THE DIFFERENCE between a Communist economy and the free market?

Answer: A Trabi.

Q: A what?

A: A Trabant, better known as Trabi. You know, that East German car that belches smoke. The little vehicle that first amused then irritated West Germans by sputtering slowly along Berlin streets and the Autobahn after the wall came down.

Q: What's a Trabi got to do with economic systems?

A: Think about it. One month you have a Communist government with a command economy and a wall. So there's a 14-year waiting list to buy a Trabi—even though it's not very safe over 40 m.p.h., it's tiny and tinny, and it emits more smoke than Groucho Marx. The next month the Communists are on the run, ditto the command economy, and the wall looks like a sieve.

Poof!...no waiting list. Everyone wants to buy a used Volkswagen from West Germany instead. In fact, one of the hottest trends in Europe involves entrepreneurs buying up used cars in Western Europe, shipping them to Eastern Europe, and setting up used car dealerships there. The next trend is going to be starting repair and service shops for all these previously unavailable Western brands.

The morality tale of what happened to East Germany's Trabant is exactly the kind of scenario that is driving global automakers to scramble for a

position in Eastern Europe. The Western car industry has been drawn into that region more quickly and completely than any other industry. On the surface the opportunities for carmakers seem incredible—a kind of last frontier of growth compared to the rest of Europe, North America, or Japan where car ownership saturation is approaching as multiple-car households become the norm.

But, as automakers descend on Eastern Europe, they are discovering that each of the seven countries (the six former members of the Soviet bloc plus Yugoslavia) is distinct in terms of its potential to operate and support a modern automotive industry. Differences include the buying power of the populace, ability to generate hard currency, ability to establish cost and quality control, and the evolution

of legislation making it permissible for foreign private companies to invest in domestic businesses or own them outright.

Of the seven countries—East Germany, Czechoslovakia, Hungary, Poland, Yugoslavia, Romania, Bulgaria—only the latter two have failed to attract interest from global carmakers. The industry has gravitated to the countries where business potential

appears largest and most predictable and the economic climate most favorable. West German investments in East Germany (by Volkswagen, Daimler-Benz, and Opel, the West German subsidiary of General Motors) have put East Germany out ahead of its eastern neighbors. Among the rest, Poland and Hungary are in the forefront in seeking to remove legal barriers to investment, with



Photo © Keystone/The Image Works



Photo © Shepard Sherbell/SABA

**ATOP LINE:** *Using 1960s technology, Czechoslovakia's Skoda factory in Bohemia produces the compact Favorit with assistance from Bertone Design and Porsche Engineering. The Favorit meets US emissions standards but is not exported to the United States.*

Czechoslovakia not far behind.

The recent experience of Western automakers in China suggests a need for caution, however. About ten years ago global auto firms were attracted by economic reforms in China. With more than a billion people and almost no private ownership of vehicles, China seemed to provide a staggering potential demand for cars. A decade later many car-building operations in China have shut down or are operating well below their potential. More distressing for profitmaking companies, these investments have proven to be black holes in terms of their ability to suck up capital.

While no auto company wants to be left behind in the European market, it may be that better deals can be struck there after the various economies stabilize. There's really no corporate law to protect outside automakers, to guarantee they can repatriate capital, be protected against confiscation, be safe from arbitrary pricing of utility services or raw materials controlled by government agencies. But for now—euphoria is taking precedence over pragmatism.

And not just for outside carmakers. Government planners and citizens are also beguiled by ideas of producing and owning locally made or assembled cars. Before long the beautiful, empty, clean streets of cities like Prague will be filled with cars—and the noise, pollution, and traffic congestion they generate.

The market for *new* cars would appear to be assured, too. Eastern Europe as a whole has about 38% as many people as Western Europe but only 13%

as many vehicles. Annual sales of automobiles in the East are about 8% of sales in Western Europe.

Poland has about 3.8 million cars on its roads—only 1 car for every 10 people. East Germany has the highest concentration of automobiles in Eastern Europe, with 1 car for every 5 people. Romania has only 1 car for every 50 people.

By contrast, in West Germany there is nearly 1 car for every 2 people and in Austria 1 car for every 3. The United States has 1 car for every 2 people.

Such figures underscore the huge potential of these countries to absorb more than the approximately 1 million automobiles currently purchased each year. Consumer demand—and ability to pay for more expensive new cars—is expected to rise to some 2 million cars a year in the region by 1996.

But Eastern European cars, even those produced under license from a Western automaker, are notoriously unreliable. Most of them are poor in quality, old-fashioned in design, and very small in size. In addition, the assembly factories left behind by the crumbling communist regimes are so outmoded that they have shocked Western automakers.

#### **POLAND**

Poland faces extraordinary hurdles in modernizing its industry. The country's economy is in danger as prices have risen 400% under a new austerity program instituted early this year, and there is a scarcity of hard currency. Poland's enormous external debt was worsened

by the depreciation of the zloty. Result: The government cannot easily find capital to invest in modernization, and consumers are hard-pressed to keep up with inflation and buy new cars.

Fiat has dominated the market since 1960, and the two Polish state-owned car builders, FSO and FSM, assemble a variety of old Fiat models for sale locally. Japan's econo-carmaker, Daihatsu, is evaluating an investment in Poland, but the country's economic problems are likely to discourage investment on the scale seen in Hungary, Czechoslovakia, and East Germany.

#### **EAST GERMANY**

Eastern Europeans' own dissatisfaction with the cars built in the East is evident. Faltering demand for East Germany's Trabant is a case in point. It appears to have a very limited life expectancy as German reunification approaches. When the border between East and West Germany was opened last November, East Germans hungrily bought up the stock of used Volkswagens and Opels. More than 100,000 used VWs were brought back into East Germany in the first two months after the Berlin Wall came down.

When the East German border opened, Volkswagen executives were ready to take advantage of that historic event. VW's Wolfsburg headquarters, only 40 kilometers from the border, was near the easternmost edge of West Germany. Now Volkswagen finds itself in the center of a soon-to-be-reunited country.

Common language, culture, and currency make it easier for the big German firm to invest in East Germany than for most other Western automakers to invest elsewhere in the East. More than 1,000 cooperative deals already have been struck between West German companies and their East German counterparts. Volkswagen has led the way with some of the most ambitious projects.

When Volkswagen executives visited VEB Sachsenring Automobilwerk, the manufacturer of Trabants in Zwickau, they were appalled to find turn-of-the-century machinery still in operation. The factory spews so much pollution into the air that the logical step would seem to be to shut it down. But that would create a crisis in Zwickau—11,305 of the city's 100,000 inhabitants work in the factory.

VW chairman, Carl Hahn, is espe-

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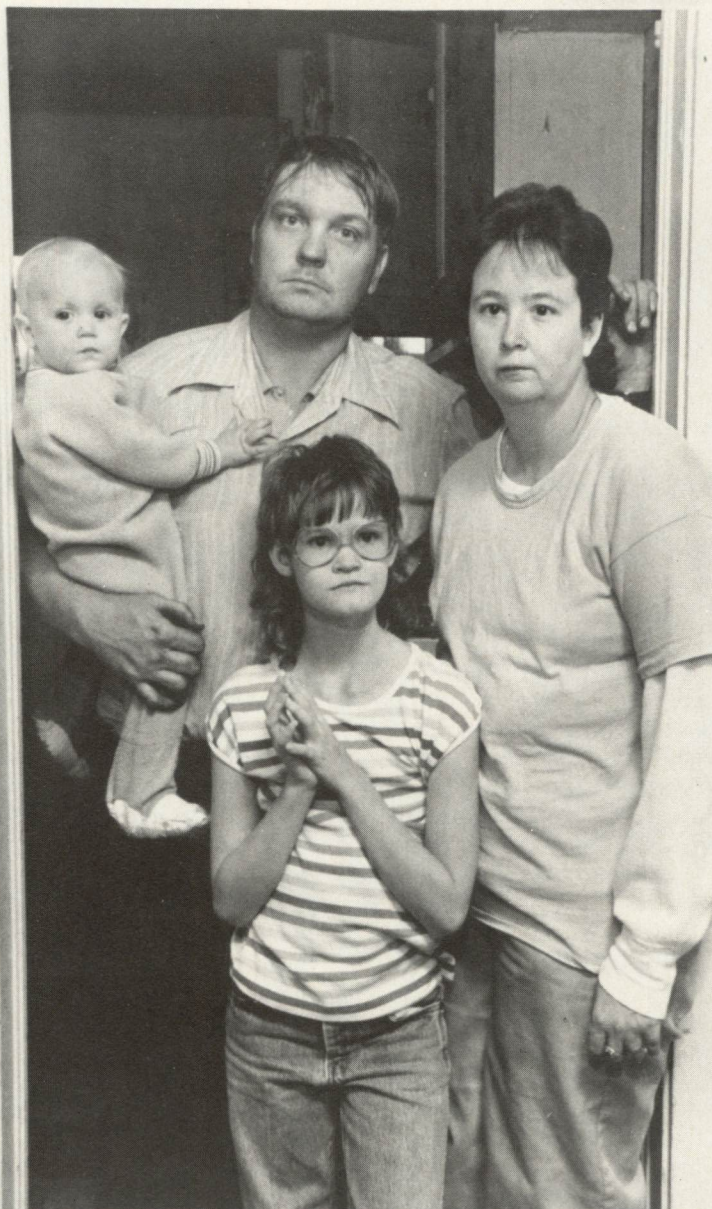
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Photo © Filip Horvat/SABA

**READY TO DEAL:** *Zagreb used car market offers considerable choice to buyers in Yugoslavia, whose own exported Yugo has not fared well in the United States.*

cially sensitive to the dislocations within the auto industry that will be caused by reunification. He argues that advantages and disadvantages will tend to balance out. He maintains, for example, that low wages in East Germany will not stay that way very long, and, because of the decaying infrastructure, East Germany will require huge amounts of capital.

Volkswagen already had ties to the East German auto industry through an engine plant that began shipment of diesel engines to the West in the fall of 1989. In addition, VW was already buying car batteries and headlamps from East Germany. VW plans to invest up to \$3 billion to build 250,000 cars per year by 1995-96. Before that, VW will gradually phase in production of knocked down kits of the small VW Polo to provide work for people displaced by the lack of sales of the old-fashioned Trabant. VW has begun establishing dealers for its Volkswagen, Seat, and Audi models.

Adam Opel, General Motors' German operation, has announced a joint venture with VEB Automobil-Werk in Eisenach, the manufacturer of East Germany's other car, the Wartburg. The venture plans to produce 150,000 Opel Kadetts per year within a few years. Opel has already established 38 dealers in East Germany. Many Europeans don't associate Opel with GM, and its German heritage has given it a significant advantage over Ford, the third-largest producer in West Germany, which is viewed as American.

Ford has established fewer than a dozen dealers so far in East Germany.

Daimler-Benz has established a joint venture with East Germany's IFA to develop, produce, and market light- and medium-weight trucks. Daimler said it will have to abandon existing IFA facilities and start over. The \$600 million price tag scared off other truck manufacturers, who were overwhelmed at the lack of competitiveness of East Germany's truck industry.

The explosion of the car population has strained gasoline supplies and repair facilities. East Germany has no unleaded fuel, so catalytic converters to reduce pollution are useless. Nissan, which is not planning any direct investments in the East at present, sees a long-term opportunity in developing a network of repair shops to fix the used Japanese cars now crossing into Eastern Europe.

#### CZECHOSLOVAKIA

Czechoslovakia faces tremendous economic problems because of its wasteful consumption of energy and a sharply rising fuel bill (thanks to the Soviet Union's reduction of subsidized oil exports). The AZNP plant that produces the Skoda, the best Eastern European car in terms of reliability and design, is woefully outmoded. Built in 1905 and refurbished in 1964, the Skoda plant has seen little investment since then and needs 15,500 people working two shifts to assemble 710 cars a day. This is less than half the productivity of modern assembly complexes.

Although Czechoslovakia has yet to

implement the necessary legislation to permit foreign investment, foreign automakers are optimistic about business prospects there. Volkswagen and Renault are vying to become partners with the state-owned builder of the Skoda Favorit, the only East European car to be exported in meaningful numbers to Western Europe.

Despite Czechoslovakia's shortage of capital for joint ventures, its desire for a partner to upgrade the Skoda cars, and especially their engines, will almost certainly result in an eventual deal. Not to be outdone by AZNP, Czechoslovakia's Bratislavshi Automobilone Zarody is searching for a partner to produce a small van. Renault, Ford, and Toyota are competing for that assignment.

#### YUGOSLAVIA

Yugoslavia has several state-owned automakers that have relied on cooperative relationships with Renault, Peugeot, and Fiat. It is the only Eastern European country to export cars to the United States, the ill-fated Yugo being better known for poor quality than its low price. Although Yugoslavia has a large auto industry by East European standards, it is a grossly inefficient one. Zastava, builder of the Yugo, also faces labor problems.

#### HUNGARY

General Motors dealt with Budapest's hard-currency shortage with a venture that it set up just before the upheaval in Eastern Europe. In conjunction with the state-owned company RABA, GM formed a joint venture in which it will invest \$150 million for a 67% stake. That venture will earn hard currency by producing for export 150,000 4-cylinder engines and assembling from kits 15,000 GM cars for the local market.

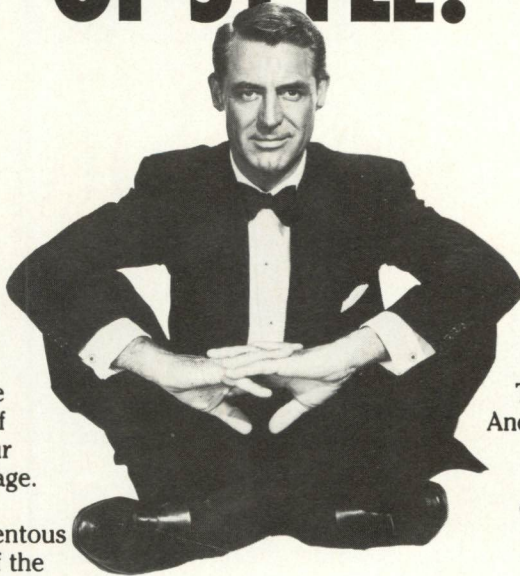
Suzuki is the first Japanese automaker to sign a deal in Eastern Europe. By 1992 it expects to produce 15,000 minivans a year in Hungary, with an ultimate goal of 50,000 vehicles.

What's obvious from this tour of Eastern Europe is that global automakers find the numbers enticing when it comes to low wages and pent-up consumer demand. But not so enticing when it comes to potential inflation, local partners' lack of hard currency, and local consumers' lack of disposable income for buying cars.

Many automakers got burned in China. They don't want to risk a repeat in Eastern Europe.



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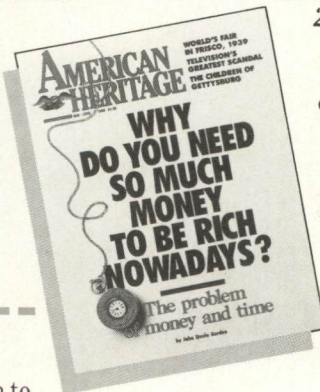
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By Megumi Oka

TRAVEL

# The Time to Go to Guadeloupe

— Caribbean history comes alive in the sunbathed festival of 'Cuisinières,' whose jewelry, clothing—and food—bring together Europe, India, Africa, and points west.

**FUTURE COOK?:** Young girl at *fête* wears *Cuisinières'* distinctive madras costume, including *tête créole* head-dress and gold beads.

Megumi Oka writes about her travels from the experience of living on three continents. WM has had her words from Austria, Denmark, and Martinique. In Paris she studied cooking and cooked professionally. In New York she imports books for Kitchen Arts & Letters Inc. This spring she revisited Japan.

THE WOMEN WERE CLUSTERED IN THE shade, their dresses exuberantly colored—a profusion of red, blue, and yellow flowers flounced over ample white petticoats—their heads wrapped in bright madras turbans. They wore heavy gold chains about their necks and wrists, and delicate earrings that glinted in the sun. Some were sedately fanning themselves, their fans a vivid swirl of color, as others preened and tucked up their skirts, revealing the white lace below. Others arrived bearing elaborate platters of food: flaming red giant crayfish, arched backs decorated with lemon slices; grilled red snapper bathed in herbs and vinaigrette; a glistening roast duck surrounded by carved oranges.

The women carried baskets overflowing with bananas, custard apples, pineapples, and other local fruits. The baskets were ornamented with doll-sized cooking utensils that jangled as the women moved, and with red anthuriums whose long stalks waved. These were the women cooks of Guadeloupe—as they readied themselves for the *Fête des Cuisinières* (Festival of Women Cooks), quite impervious to the heat, the honking cars, and the scrappy group of townspeople, tourists, and journalists who were gawking at them in the broiling sun. The women looked proud, and serious, as they kissed each other with gracefully inclined heads.

The *Fête des Cuisinières* is an annual festival in the city of Pointe-à-Pitre, taking place in August and celebrating the feast day of St. Laurent, the patron saint of the *Cuistot Mutuel* (Organization of Women Cooks). It launches six months of smaller

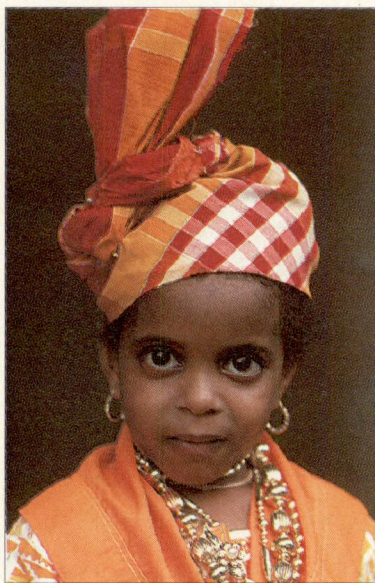
celebrations elsewhere in Guadeloupe.

August is the traditional vacation month of the French, when Paris residents leave the city to American tourists. Guadeloupe is popular as a vacation destination for the French, the *fête* itself is covered on French mainland television, and hotel rooms can be hard to find. Few Americans, however, have discovered the attraction of Guadeloupe in August.

I was unable to resist the invitation to attend the big event last summer, particularly as it meant a chance to visit Guadeloupe, a Caribbean island group that is still a part of France, a *département d'outre mer* (overseas department). I had been quite captivated by neighboring Martinique and was curious to compare these two vestiges of French colonial power. Furthermore, as far as I was concerned, any island that celebrated its cooks—and its women cooks, at that—had much to commend it.

The *Fête des Cuisinières* is a joyous celebration, but the complicated history of Guadeloupe's relationship with slavery remains in the air. Many Caribbean societies, including Guadeloupe, are matriarchies. During the days of slavery, children obtained their legal status from their mother and belonged to the owners of the mother, not the father.

Women are honored and respected as the repositories of culture, a tradition that has its roots in Africa. Many are the effective heads of their households. They work and contribute to the financial support of their children, and are responsible for most major family decisions. They often make life easier by creating support groups of extended family or networks of friends.



All photos © Suzanne Murphy



The Cuiست Mutuel was founded in 1916, during the hardships of World War I, to provide members with some form of insurance coverage for medical and funeral expenses. This was before Guadeloupe had become a full *département* of France with all the attendant social security rights for its citizens.

Over the years the organization has provided moral support as members have moved from cooking privately—for their families or employers—to cooking professionally and often owning their own restaurants. In Guadeloupe it is the women cooks who are talked about, it is their restaurants one frequents—Prudence's, Violetta's, or Jeanne's; not, as in mainland France, Paul's, Alain's, or Marc's.

Guadeloupe's history is reflected in the cooks' sumptuous gold jewelry: strings of beads, some bigger than marbles (and known as *collier choux* or *graines d'or*), of a kind that originated in the days when a master gave his favorite slaves one bead at a time on special occasions. Eventually the beads were strung together, and the necklace became a public affirmation of one's good standing. Heavier gold chain necklaces, known as *chaines de forcat*, and thick handcuff bracelets symbolize the actual chains that were used to bind the slaves. After slavery was abolished, such jewelry was still greatly prized, and one Cuisinière described how

her mother carefully saved money for each bead, determined to make a sound investment for her daughter's future.

Most of the women assembling for the festival were draped in gold, with a dozen or more chains, bracelets up both arms, and large dangling earrings in the shapes of grape clusters or heartlike custard apples. I was quickly put in my place when I wondered aloud if the ornaments were real gold: Each piece, I was told, was handcrafted by local master craftsmen of 18 carat gold from French Guiana.

The brilliant dresses and starched, rustling petticoats are copies of those worn by the cooks in the great plantation homes. The style seems to have evolved from the European dress that the colonists brought—transformed by the African and Indian heritage of the Caribbean. Colors are vibrant, dominated by the yellows and oranges of the madras turbans.

The bodices of the dresses are 19th-century European in style, with a foulard (scarf) worn over the shoulders like a shawl and secured with a gold brooch. The striking difference is the puffy folds caused by picking the skirts up above the hem and tucking them into the waistband at several points, creating wonderful drapes. This custom may have evolved from the voluminous boubous worn in parts of Africa, and seen in 18th-century litho-

**TURBANS, FOULARDS, AND LOCAL FOODS:**  
*Top-knotted head-dresses and costumes reminiscent of plantation days identify Cuisinières, bringing baskets of fresh local ingredients to festival in Pointe-à-Pitre.*

# Bringing a Taste of the Islands Home

## COCONUT ICE CREAM

Overlooking the rocks at Pointe des Châteaux, which juts into the Atlantic Ocean, a young man was scooping fresh coconut ice cream from a well-worn handranked churn. It was a race against the sun—and the hordes of children clamoring for more—but the slurpy scoop I tried was so luscious, pure coconut, refreshingly cold, smooth and creamy, with a delicate after-taste of nutmeg, that I rushed back for more. But the sun was victorious, and he was packing to go home. He did, however, share his recipe:

1 1/2 lb. grated coconut  
2 1/2 cups milk  
1 tin sweetened condensed milk  
1/2 cup sugar  
grated nutmeg

Bring milk and sweetened condensed milk to a boil, add sugar and coconut, and mix well. Remove from heat and leave to cool. Pass through cheesecloth and squeeze out as much juice as possible from grated coconut. Freeze mixture.

## CRABS

The land crabs of Guadeloupe have been a favored delicacy for centuries. Père Labat, a French Dominican priest who arrived in 1693, praised them as the best part



**EGGS WITH A DIFFERENCE:** *The addition of curry and land crabs to the filling gives stuffed eggs the piquant flavor of Guadeloupe.*

about the island food. They are less plentiful now, but still delicious. Their preparation is time consuming, as they need to be purged of impurities for several weeks before cooking. Lafcadio Hearn writes:

“It is customary here to keep live crabs in barrels and fatten them,—feeding them with maize, mangoes, and above all, green peppers. Nobody likes to cook crab as soon as caught; for they may have been eating manchineel apples (poisonous fruit) at the river-mouths.”

## CRAB FARCIE

12 crabs  
parsley  
thyme  
hot pepper  
3 cloves  
1 bay leaf  
1/2 loaf stale French bread (baguette)

6 chopped scallions  
4 cloves finely chopped garlic  
lemon juice to taste  
salt and pepper  
1/2 cup dried bread crumbs

As it is easier to find sea crabs in the United States, they can be substituted. The Guadeloupéan crabs are about the size of a small hand. Cook crabs in boiling water with parsley, thyme, hot pepper, cloves, and bay leaf. It should take about 10-15 minutes. Leave them to cool in their cooking liquid. Crack shells (but try to keep backs whole, as they will be used later) and remove meat from crabs and their claws.

Soak bread in some of crabs' cooking liquid, and process in food processor. Fry chopped garlic in oil until soft. Add crab meat, then scallions, chopped pars-

ley, and some thyme. Then add bread mixture and stir well. Season with salt, pepper, and lemon juice.

Wash crab shells and dry them. Place filling in mound on top of shells. Sprinkle with dried bread crumbs and broil for 1 minute.

**CHIQUETAILLE DE MORUE** (adapted from “Delices de la Cuisine Creole,” edited by Francis Delage, formerly of Guadeloupe, who has a restaurant, La Plantation, in Paris).

In Guadeloupe this can be served at all meals, including breakfast.

1 lb. salt cod  
10 scallions  
1 hot pepper, chopped  
thyme  
parsley, chopped  
juice of 2 limes  
6 cloves garlic, chopped  
1 onion, chopped  
1/4 cup oil

Place salt cod on a grill or close to broiler and let it get black. Then soak it in cold water and let it swell for 30 minutes or so. Remove skin and bones. Combine flesh with chopped herbs, garlic, and onion. Add lime juice and let sit for another 30 minutes. Add oil at the last minute.—**M.O.**

graphs of Guadeloupe women wearing boubous in the marketplace.

The madras turbans, however, are a legacy of the Indians who came to work the sugar fields of Guadeloupe after slavery was abolished in 1848. Many of them came from Pondicherry, just south of Madras on the eastern coast of India. After their arrival, the madras patterns and colors were imitated in Guadeloupe, although whether the custom of wearing a turban, and the turban's particular shape, is Indian or African in origin is unclear.

By the time US writer Lafcadio Hearn visited the French West Indies in the late 1880s, madras was enough a local fashion for him to include a wonderful description of a *calendeuse*, or woman who makes the turban and colors it.

“When purchased the Madras is simply a great oblong handkerchief, having a pale green or pale pink ground, and checkered or plaided by intersecting bands of dark blue, purple, crimson, or maroon. The *calendeuse* lays the Madras upon a broad board

placed across her knees, then, taking a camel's-hair brush, she begins to fill in the spaces between the bands with a sulfur-yellow paint.... It requires a sure eye, very steady fingers, and long experience to do this well....”

Unfortunately, that practice has completely disappeared. Today, only the Cuisinières wear the turbans, which identify them as members of the Cuistot Mutuel.

The religious significance of the festival was brought out by a mass in honor of St. Laurent in the cavernous

Cathedral of St. Pierre and St. Paul in downtown Pointe-à-Pitre. The steps leading to the altar were carpeted with the baskets and platters of food, the Cuisinières filling the pews with bright splashes of color. The food was blessed, and many references made to the nurturing spirit of love and the unselfish desire to give pleasure that must accompany good cooking.

Afterwards came dancing to the throbbing beat of the beguine—and endless feasting. Our appetites had been heightened through hours of staring longingly at the platters. Earlier, I had succumbed to temptation and was caught pilfering a few pastry turnovers with a delicious salted fish stuffing.

Our lunch began with a *chiquetaille de morue* (salt cod salad), spicy flakes of grilled salt cod fragrant with thyme, chives, and lemony vinaigrette. Then, a *matete de crabes*, the sweet gray-blue land crabs of Guadeloupe, cooked with rice that was swollen with their concentrated essence. I picked each crab apart, determined to extract every speck of flesh from the spindly legs and suck up any remaining juice.

One Cuisinière told me that this dish, which resembles paella, is a vestige of the Spanish influence; another traced it to a West African dish made from land crabs. Both said this is a dish for special occasions: It is traditionally served on Good Friday.

The meal ended with a colombo—a mild chicken curry, pale green in color, its spices releasing a tantalizing aroma of onions and turmeric.

That night, in search of more Guadeloupéan cuisine, I went to Chez Prudence, a small restaurant perched on a

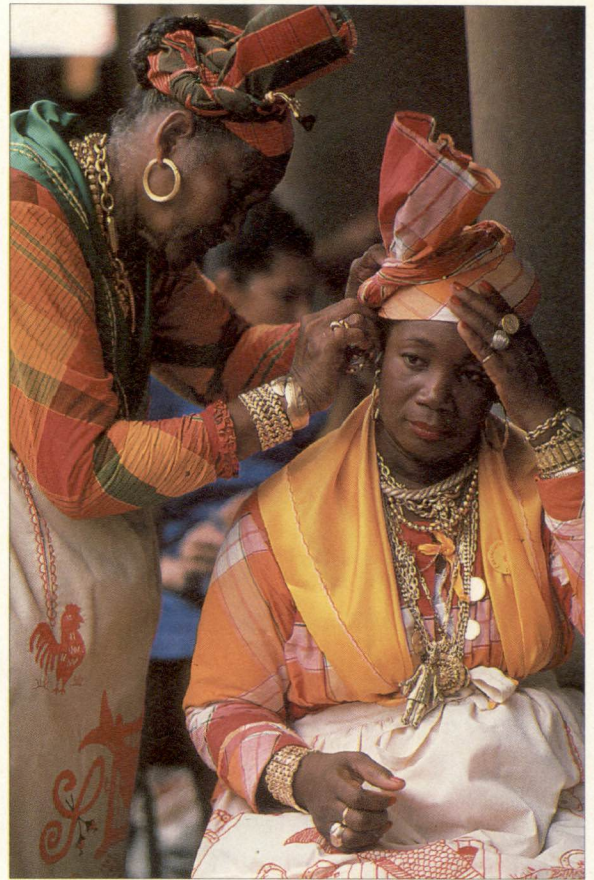
cliff overlooking the Caribbean Sea. Prudence was still wearing her madras turban and gold jewelry, although the flounced skirt and white petticoats had given way to a cool, dark blue robe, a perfect backdrop for her magnificent chains. She had been up since 4 a.m. preparing for the Fête des Cuisinières but showed no signs of fatigue. She was warm and gracious as she spoke of Guadeloupe's creole food with great pride.

She described some Guadeloupéan specialties—the *bebele*, a rich, spicy stew of green bananas, beans, *dombres* (dumplings), tripe, and pickled pigs' tails from the island of Marie-Galante. Apparently the dumplings evolved from the *knefle* of the Dutch Jews who settled there in the 17th century, after fleeing Brazil.

Calalou soup is another specialty, made from the spinach-like leaves of the dasheen plant, pickled pigs' tails, and the savory land crabs. The soup is thick and full of the best local ingredients. She serves it with the traditional accompaniment, the *chiquetaille de morue*, which she feels intensifies the flavors.

By this point I was ravenous once again. I proceeded to regale myself with more crab. This time it was *crab farcie*—two hollowed crab shells with a mound of gratinéed stuffing, a tasty blend of sweet crab meat and fragrant spices.

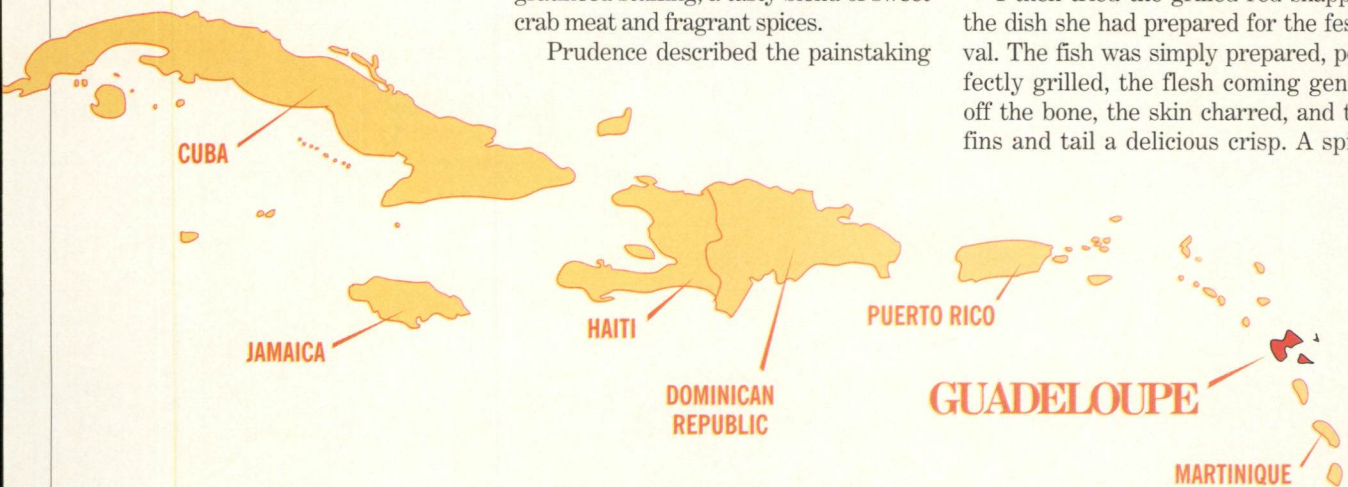
Prudence described the painstaking



**MUTUAL SUPPORT:** Members of Cuistot Mutuel help each other, with small things like turbans and larger issues such as setting up a restaurant of one's own.

labor that goes into this dish: The crabs, which are quite small, have to be shelled, and the meat picked clean. She will sit down before a vat of freshly boiled and cooled crabs and pick away, leaving the telephone unanswered and all other business on hold, until there is not a spot of meat left on the shells, or a sliver of shell mixed in with the meat. In her mind it is that love and attention to detail that makes true cooking.

I then tried the grilled red snapper, the dish she had prepared for the festival. The fish was simply prepared, perfectly grilled, the flesh coming gently off the bone, the skin charred, and the fins and tail a delicious crisp. A spicy



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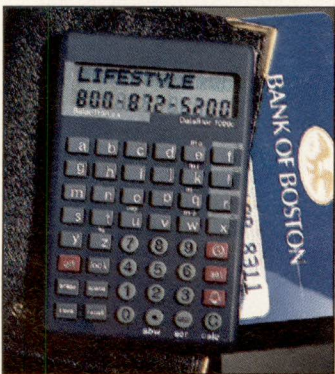
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**SUN AND SEA, TOO:** Windsurfing, swimming, or simply enjoying a shaded chair by the sea provides a respite from the feasts cooked up by the women chefs of Guadeloupe.

vinaigrette, made with hot peppers and *graines of bois d'Inde*, a fragrant local peppercorn, was poured on top, adding just enough spice to let the flavor of the fish come through. I soaked up the remaining sauce with the accompanying starchy boiled yams.

These were memorable taste sensa-

tions from this island of proud women cooks who have risen from the small, dark kitchens of the great plantation houses to their own establishments, where they continue to transform the local bounty into delicious meals, secure in their acknowledged positions as professionals. **WM**

## Places to Stay, Places to Eat

All tourists on Guadeloupe are invited to the Fête des Cuisinières banquet, which is held in the Lycée Amédée Fingarol at the corner of Rue Schoelcher and Rue Barbès in Pointe-à-Pitre. Tickets can be obtained from the Tourist Office, telephone (590) 82-09-30, or from your hotel.

This year the fete is scheduled for Aug. 11. The cooks usually begin gathering in the shady square behind the Cathedral of St. Pierre and St. Paul at 9:30 a.m. The mass itself begins at 10, followed by a parade through the streets, and several hours of feasting and dancing at the Lycée.

### Hotels

*Auberge de la Vieille Tour*  
Gosier  
Telephone: (590) 84-23-23

Built in an old sugar mill, this is one of the oldest hotels in Guadeloupe. It was renovated after Hurricane Hugo hit the islands. Approx. \$116-\$142 for a double.

*Gîtes de France*  
Office de Tourisme  
5 Square de la Banque  
Pointe-à-Pitre, 97110  
Telephone: (590) 82-09-30

Lists comfortable villas, apartments,

and private rooms in modest homes. Information available from the Tourist Office.

*Toubana*  
Sainte Anne  
Telephone: (590) 88-25-78

Small hotel, perched on a cliff above La Caravelle, with bungalows. Approx. \$104-\$123 for a double.

### Restaurants

*Chez Prudence*  
Anse Bertrand  
Telephone: (590) 22-11-17

Overlooks the ocean, traditional Creole cooking. Bungalows for rent.

*La Langouste*  
Anse à la Gourde  
Pointe des Châteaux  
Telephone: (590) 84-40-61

On the beach, specializes in grilled lobster.

*La Canne à Sucre*  
Pointe-à-Pitre  
Telephone: (590) 82-10-19

A traditional Creole home, nouvelle Creole cooking, i.e., nouvelle cuisine using local produce.—*M.O.*

# WORLD MONITOR PREVIEW

Coming up in future issues of  
*WORLD MONITOR*:

- **THE MAN WHO HOLDS BACK THE DESERT.** Allan Savory learned on the grasslands of Africa how the hoofs of animals could help rather than hurt the land. Now based in the US, he uses his specific methods and his larger environmental concepts to rescue productive acres in many countries.  
*By Sam Bingham*

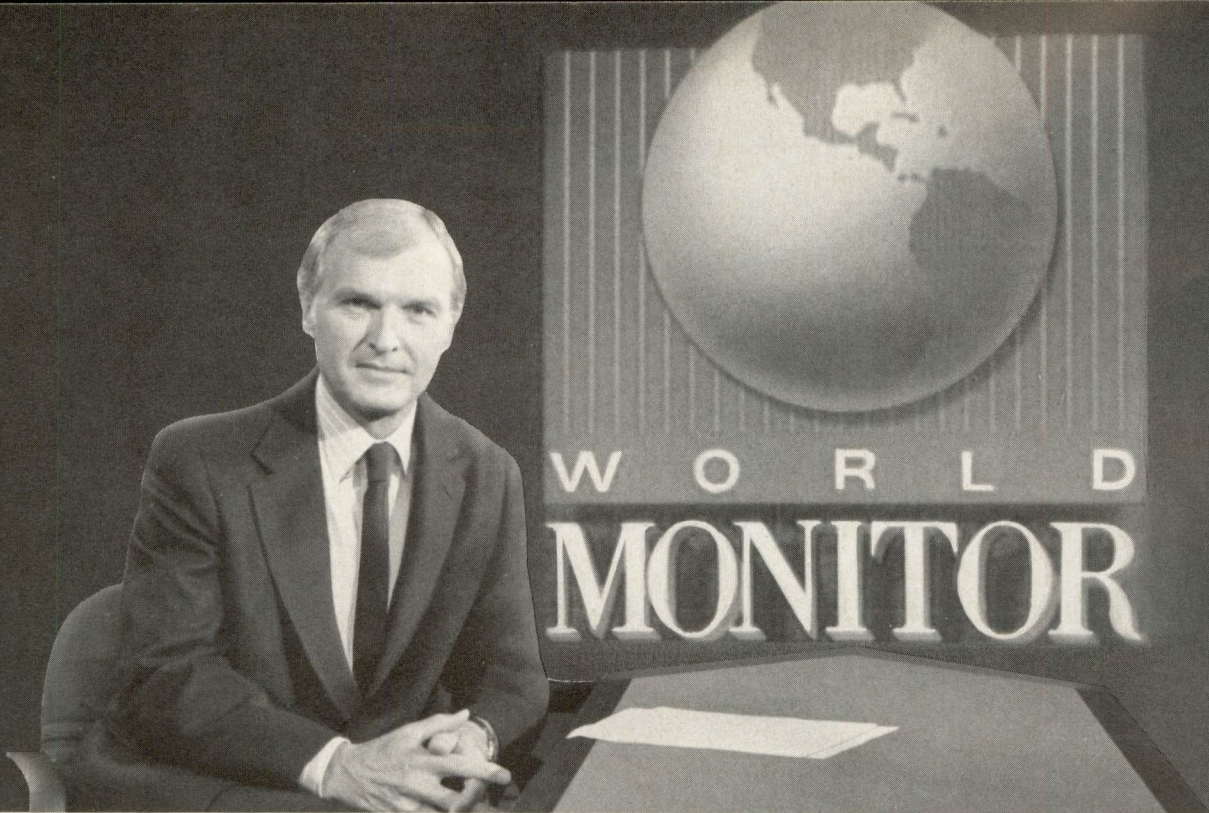
- **MIDEAST STRATEGY.** Fresh from the stunning events in Eastern Europe and South Africa, the BBC's television news editor goes to the Gulf and finds some urgent matters not to be overlooked while most eyes are elsewhere.  
*By John Simpson*

- **TEMPLETON'S TENETS II.** The global investing wizard is back with more rock-bottom advice on how to keep an even keel as world stock markets bounce and flutter.  
*By Sir John Templeton*

- **GETTING AHEAD OF HISTORY.** Heard the pundits say events in the Soviet bloc caught even the experts by surprise? Well, they're wrong, say the world's leading proponents of thinking ahead. Through some fascinating detective work, the authors of "Future Shock" uncover some analysts who painted the correct scenario well before the drama of Gorbachev and the Berlin wall unfolded. They also look at other forecasters who anticipated history earlier in this century.  
*By Alvin and Heidi Toffler*

## PLUS

- **Marlene Nadle** on Eastern Europe —as a travel destination
- **Alan Lightman** on the romance going out of science
- **WM Gallery:** Australia's amazing aboriginal art



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*L.A. TIMES*

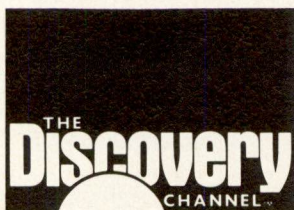
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# Destiny

**W**ORLD MONITOR: THE CHRISTIAN SCIENCE MONITOR MONTHLY is a beneficiary of the pioneering journalistic spirit of Mary Baker Eddy, who established the Monitor in 1908 as an international daily newspaper. Her basic mandate for the Monitor was, in keeping with the Christian Science religion she founded, to "injure no man, but to bless all mankind." Each month this space provides a commentary related to that mandate.

For college graduates seeking their first serious employment this summer, long-term goals may not be the first thought that comes to mind. Starting pay, vacation policy, other benefits, yes; and perhaps some notion of what one's expectations should be three to five years down the road.

Down the road, yes. But what road? The road to where?

Is the road one we choose for ourselves?

The nature of an individual's destiny is, by one definition, not entirely decided by oneself. Destiny usually implies a final end that we believe is set either by divine will, or fate, or universal laws that we did not make ourselves. We can best fulfill ourselves in serving this destiny. But what can we know about individual destiny?

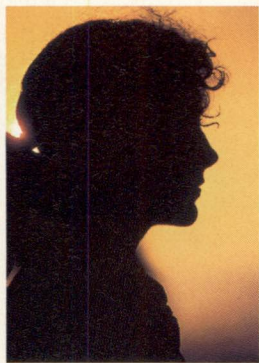


Photo © John P. Kelly/Image Bank

During one of my first years in college, I read a book new at that time, "Human Destiny," by a French scientist, Pierre Lecomte du Noüy. The author argued that the physical evolution of man was largely complete, but that a further stage of moral and spiritual evolution awaited him.

Whether one agreed with the entire thesis of the book or not, there was a convincing argument that moral and spiritual development were part of a divine plan for the universe. They were not an incidental "add-on" conjured up by civilized society. They were, in fact, an integral part of human destiny. It remained for each individual to choose whether or not to join in to fulfill this plan.

The Discoverer of Christian Science, Mary Baker Eddy, wrote at the end of a short book ("No and Yes") answering questions about Christian Science: "Man has a noble destiny; and the full-orbed significance of this destiny has dawned on the sick-bound and sin-enslaved. For the unfolding of this upward tendency to health, greatness, and goodness, I shall

continue to labor and wait." As a religious leader, Mrs. Eddy fulfilled her individual destiny by unstintingly nurturing the new expression of Christianity she had discovered.

So what of our own "noble" destinies? What can one say about them in general? In looking back at Lecomte du Noüy a generation later, I find that he was asking us to extend our horizons, to think of the goal one's entire life could be serving. Thinking of the tinkering going on with the world's military at the start of the Cold War years, he wrote: "Can we not find, amongst those whose voice is heard, a few men capable of looking beyond the term of their activity...and anxious to shape the future by preparing clear-sighted coming generations, imbued with self-respect and free from the superstitions which impede the flight of integral progress?"

The job one chooses depends in part on what kind of preparation one has had, on one's temperamental inclinations, and of course on what is available at the time. Yet, if one "buys into" the concept that humanity's moral and spiritual development are what life is ultimately about, then every job, every decision made, should contain at least an element of consideration as to how it contributes to an unselfish end, an end that will move oneself and humanity in a positive direction.

When men and women are young, they may be egotists on the surface. Scratch the surface, and the young egotists are apt to be cynical about the importance of their life to humanity. Yet much of the usefulness one can have two or three decades out depends on the preparation one continues to make even in those first few job choices.

That usefulness, in terms of contributing to humanity's total development, may extend long beyond one's own career, too. Wrote Lecomte du Noüy: "We cannot but be struck by the disproportion between the duration of a man's life and the duration of his influence on future generations. Every one of us leaves a trail either modest or brilliant, and this conviction should make itself felt in all the acts of our lives...Every man can, if he wishes, leave a more or less brilliant trace behind him..."

If the '80s were in fact a "me" generation more than some others, the '90s have arrived, folks. Let's see if our choices help fulfill not only our own but humanity's destiny.

—Richard A. Nenneman  
Contributing Editor

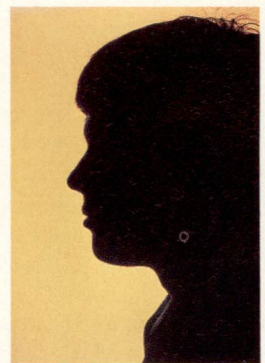


Photo © Al Satterwhite/Image Bank

By Melvin Maddocks

# Reinventing Men

**T**HE PROPER STUDY OF MANKIND is man," wrote Alexander Pope in his "Essay on Man," thus qualifying as the father of men's studies, the latest novelty among the social sciences.

About 200 American colleges offer classes with descriptions like "The Psychology of Men" or "Sociology of the Male Experience." There is a Men's Studies Association. There is a Men's Studies Review. Last year the first annual Men's Studies Conference assembled, providing the physical presence without which no new academic tribe can be quite positive it exists.

Why is "male liberation"—a term first applied 20 years ago—experiencing a moderate revival, on campus and off? To casual observers (men included) men would hardly appear to be a fragile special-interest group, desperate for a support system. More accurately they might be characterized as the entitled gender that runs the world, and always has. Yet in certain men's studies texts the underdog language of an oppressed minority is used to describe in all seriousness the alleged misfortune of being born a white, middle-class male. "Burden" is the word one writer employs to sum up the curse of masculinity.

From a less sympathetic point of view, men's studies could be defined as a monopoly laying an unnecessary claim to equal time. As a woman remarked on being introduced to men's studies, "Hasn't all history been about men?" The authors of men's studies respond with reasoned if not entirely convincing counterarguments.

A professor, leafing through the indexes of American history textbooks, was overwhelmed by the references under W as in women. "But look under M," he reported in sorrow, "and you find nothing between Manifest Destiny and Mexican War."

Who, one might ask, was propounding Manifest Destiny and fighting the

Mexican War? But no matter. Man, men's studies have rather proudly discovered, is the weaker sex. More Jimmy Stewart than John Wayne, he is shy and vulnerable, burned out by competition with the other boys, confused by women's insistence on intimacy. What a terrifying idea that is!—enough to make a chap run for the nearest locker room.

Nevertheless, men's studies are at pains to avoid the Adam game—blaming

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*"I love myself"—  
the words that pass  
these days as the  
equivalent of  
"I am saved."*

---

men's grief on women—though a reader may grow just a bit suspicious when those baritone voices insist they are pursuing their investigations for the equal benefit of women. Dad—second only to Eve on men's traditional blame list—is still fair game. The poet Robert Bly, organizing seminars of male self-scrutiny, seems to be pointing toward an ideal the opposite of Dear Old Dad—stern, aloof, incapable of expressing affection. "Mythopoetic man" Bly and his colleagues call the enlightened and caring Dear New Dad—a stereotype of hugs and honest tears, almost as off-putting, it must be admitted, as Dear Old Dad.

At their emotive worst, men's studies demand plenty of reading between the whines. Nor are they a lot better at literary criticism, analyzing masterpieces so narrowly that the subtleties of Captain Ahab and Huck Finn get reduced to a couple of Joes muddled about their manhood. Men's studies are at their best when they stick to history, providing documentation that the perplexed male

is not just a modern phenomenon.

A pioneer of men's studies, Harry Brod, writes: "Men's history lays decisive emphasis on dispelling the commonly held belief that the contemporary period is uniquely tumultuous and troubling for beleaguered male egos." There was a "crisis of masculinity" in the United States in the 1890s and a "gender crisis" in early 18th-century England, and so on.

The male, it seems, is and always has been an international case of self-destruction. Horror stories can be told from the Eskimos to the Japanese, not excluding the Islamic man. And what about those Arunta males in Australia who come of age by lying down on green boughs over an open fire and having their heads bitten by other males?

Through contemplating all this, preferably in "sensitizing" groups, men's studies scholars assume they are inventing a New Man, a sweet, rational creature who can at last say, "I love myself"—the words that pass these days as the equivalent of "I am saved." It seems ironic that men in groups should be trying to reform men in groups—the tribal rap session interrupting the tribal war dance to sell the old warriors on a change in "attitude" and "life style."

Whatever became of change of heart?—the profound, lonely, silent shaking of a man's (or woman's) soul to its very center. The question may be embarrassing at a time when one has to join a group even to diet. Yet if men's studies are to be more than a pleasantly chummy episode of self-dramatization, the New Boys club should remind themselves that Prometheus bound to his rock and Jacob wrestling with his angel—and Herman Melville struggling with Captain Ahab—did not arrive at their terrible and glorious visions of what a man can be through sessions of group therapy. WM

WM columnist Melvin Maddocks writes each month.

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**THE POTENTIAL EFFECTS OF GLOBAL CLIMATE CHANGE  
ON THE UNITED STATES**

**DRAFT**

**REPORT TO CONGRESS**

**EXECUTIVE SUMMARY**

United States Environmental Protection Agency

Office of Policy, Planning, and Evaluation

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June 1989

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# EXECUTIVE SUMMARY

Scientific theory suggests that the addition of greenhouse gases to the atmosphere will alter global climate, increasing temperatures and changing rainfall and other weather patterns. In 1979 the National Academy of Sciences estimated that a doubling of carbon dioxide concentrations over preindustrial levels would cause global temperatures to rise 1.5 to 4.5°C. In 1985, the World Meteorological Organization (WMO), the United Nations Environment Programme (UNEP), and the International Council of Scientific Unions (ICSU) reaffirmed these estimates. Such a climate change could have significant implications for man and the environment. Among other effects, it could raise sea level, alter patterns of water availability, and affect agriculture and global ecosystems.

Although there is consensus that increased greenhouse gas concentrations will change global climate, the rate and magnitude of change is not certain (see box on "Climate Change"). Uncertainties about climate feedbacks from clouds, vegetation, and other factors make it difficult to predict the exact amount of warming that a given level of greenhouse gases such as a doubling of carbon dioxide (CO<sub>2</sub>) concentrations would cause. How quickly climate may change is also not known, because scientists are uncertain both about how rapidly heat will be taken up by the oceans and about some climate feedback processes. Generally, scientists assume that current trends in emissions will continue and that climate will change gradually over the next century, although at a much faster pace than historically. At this rate, the full effect of the equivalent doubling of CO<sub>2</sub> concentrations probably would not be experienced until after 2050. It is possible, however, that sudden changes in ocean circulation could cause abrupt changes in global climate. Indeed, if climate changed more rapidly than estimated, the effects

would be more difficult and more costly to adapt to. Furthermore, continued emissions of greenhouse gases could raise atmospheric concentrations beyond doubled CO<sub>2</sub> causing greater and more rapid climate changes, and larger effects.

To explore the implications of climate change and ways to control it, Congress asked the U.S. Environmental Protection Agency (EPA) to undertake two studies on the greenhouse effect: the first to address, "The potential health and environmental effects of climate change including, but not be limited to, the potential impacts on agricultural, forests, wetlands, human health, rivers, lakes, estuaries as well as societal impacts;" and the second to examine "policy options that if implemented would stabilize current levels of greenhouse gas concentrations." The second study, "Policy Options for Stabilizing Global Climate", is a companion report to this document.

EPA responded to this request by first holding workshops with atmospheric scientists to discuss the use of global climate change models for impact analyses and then meeting with ecologists, hydrologists, geographers, and forestry and agricultural specialists to identify topics for this study. A major purpose was to bridge the gap in our ability to relate a rise in average annual surface temperatures to regional climate changes. Based on these and other discussions, EPA decided to use common scenarios of climate change to analyze the sensitivities of coastal resources, water resources, agriculture, forests, biodiversity, health, air pollution, and electricity demand to climate change on regional and national scales (see Figure 1). These systems were chosen for analysis because they are sensitive to climate and significantly affect our quality of life. EPA decided to conduct regional analyses for the Southeast, the

Great Plains, California, and the Great Lakes, because of their climatological, ecological, hydrological, and economic diversity. Leading academic and government scientists in the relevant fields used published models to estimate the impacts on both the regional and national scales. As a common base for conducting these analyses, they used the scenarios specified by EPA.

After consulting with scientific experts, EPA developed scenarios for use in effects analysis. Regional data from atmospheric models known as General Circulation Models (GCMs) were used as a basis for climate change scenarios (see box on "Scenarios and Methodology"). The GCMs are large models of the ocean-atmosphere system that simulate the fundamental physical relationships in the system. GCMs provide the best scientific estimates of the impacts of increased greenhouse gas concentrations on climate. Yet, they use relatively simple models of oceans and clouds, both of which will be very critical in influencing climate change. The GCMs generally agree concerning global and latitudinal

increases in temperature, but they disagree and are less reliable concerning other areas, such as regional changes in rainfall and soil moisture. The GCM data were compared to historic meteorologic data. In addition, the decade of the 1930s was used as an analog for global warming.

In Figure 2, the temperature changes from the three GCMs used to create scenarios are shown for both the United States and four regions of the United States for a doubling of carbon dioxide levels. The GCMs agree on the direction of temperature changes, but differ in the magnitude. Estimates of precipitation changes are shown in Figure 3. The GCMs agree that annual rainfall would increase across the country, but disagree about the direction of regional and seasonal changes. All models show increased evaporation.

The GCM results should not be considered as predictions, but as plausible scenarios of future climate change. Because the regional estimates of climate change by GCMs vary considerably, the

### CLIMATE CHANGE

A panel of experts convened by the National Academy of Scientists (National Research Council, 1987) recently gave the following estimates of scientific confidence in predictions of the climate response to increased greenhouse gas concentrations. This table is a summary of their conclusions only about "the possible climate responses to increased greenhouse gases." The full report should be consulted for the details:

**Large Stratospheric Cooling** (virtually certain). The combination of increased cooling by additional CO<sub>2</sub> and other trace gases, and reduced heating by reduced ozone "will lead to a major lowering of temperatures in the upper stratosphere."

**Global-Mean Surface Warming** (very probable). For an equivalent doubling of CO<sub>2</sub>, "the long-term global-mean surface warming is expected to be in the range 1.5 to 4.5°C."

**Global-Mean Precipitation Increase** (very probable). "Increased heating of the [earth's] surface will lead

to increased evaporation and, therefore, to greater global mean precipitation. Despite this increase in global average precipitation, some individual regions might well experience decreases in rainfall."

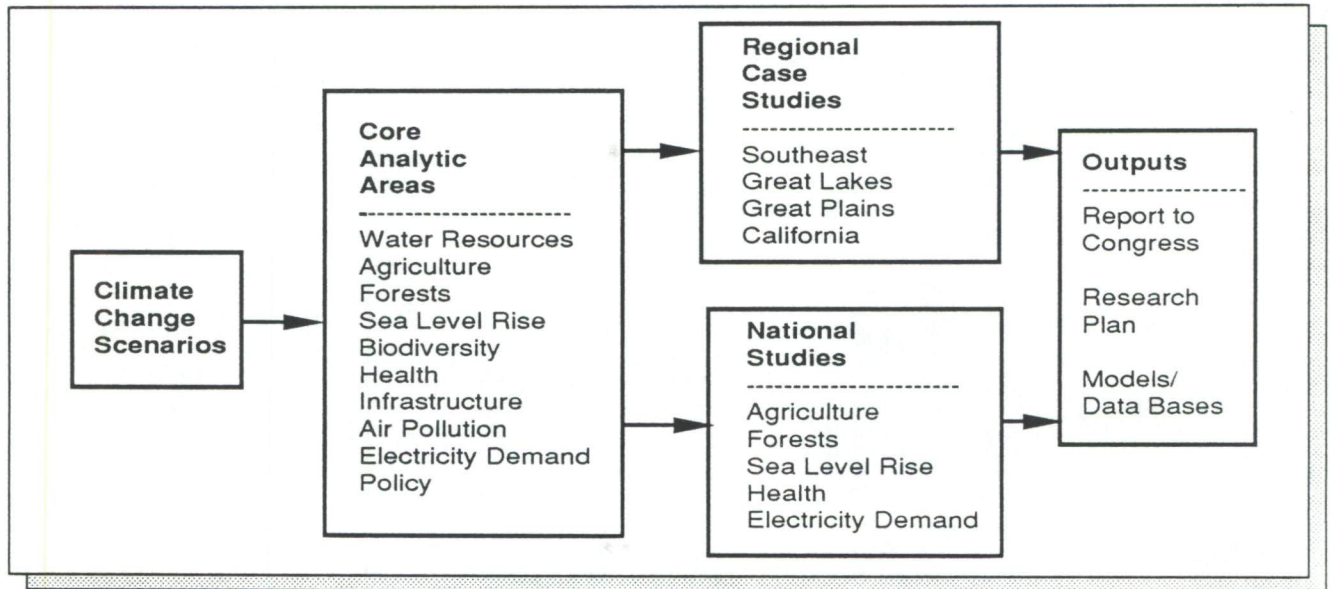
**Reduction of Sea Ice** (very probable). This will be due to melting as the climate warms.

**Polar Winter Surface Warming** (very probable). Due to the sea ice reduction, polar surface air may warm by as much as 3 times the global average.

**Summer Continental Dryness/Warming** (likely in the long term). Found in several, but not all, studies, it is mainly caused by earlier termination of winter storms. "Of course, these simulations of long-term equilibrium conditions may not offer a reliable guide to trends over the next few decades of changing atmospheric composition and changing climate."

**Rise in Global Mean Sea Level** (probable). This will be due to thermal expansion of sea water and melting or calving of land ice.

FIGURE 1. ELEMENTS OF THE EFFECTS REPORT



scenarios provide a range of possible changes in climate for use in identifying the relative sensitivities of systems to higher temperatures and sea level rise. There are two major limitations in the GCM scenarios. First, the scenarios assume that climate variability does not change from recent decades. Second, the scenarios did not change the frequency of events, such as heat waves, storms, hurricanes, and droughts in various regions which would affect the results presented in this report (see "Limitations" box). Changes in variability as estimated by GCMs were examined for this report. We found that no firm conclusions can be drawn about how global warming could affect variability.

The methods used to estimate impacts (for example, how forests might change) also have limitations. We have no experience with the rapid warming of 1.5 to 4.5°C projected to occur during the next century. Many of the effects are estimated based on knowledge of the response of systems to known climate conditions. We cannot be certain that a forest would be able to migrate, how higher atmospheric concentrations of CO<sub>2</sub> would affect vegetation, whether fish would find new habitats, how agricultural pests would proliferate, or how impacts would combine to create or reduce stress.

With some exceptions, we did not generally examine responses and adaptations to effects of climate change. The report was intended to examine sensitivities and potential vulnerabilities of current systems to climate change. Many other changes will also take place in the world at the same time that global climate is changing. We cannot anticipate how changing technology, scientific advances, urban growth, and changing demographics will affect the world of the next century. These changes and many others may singularly, or in combination, exacerbate or ameliorate the impacts of global climate change on society.

The results are also inherently limited by our imaginations. Until a severe event occurs, such as the drought of 1988, we fail to recognize the close links between our society, the environment, and climate. For example, in this report we did not analyze the reductions in barge shipments on the Mississippi River due to lower river levels, the increases in forest fires due to dry conditions, or the impacts of disappearing prairie potholes on ducks; all these impacts were made vivid during the past year. The drought reminded us of our vulnerability as a nation, but it cannot be viewed as a prediction of things to come.

FIGURE 2. TEMPERATURE SCENARIOS

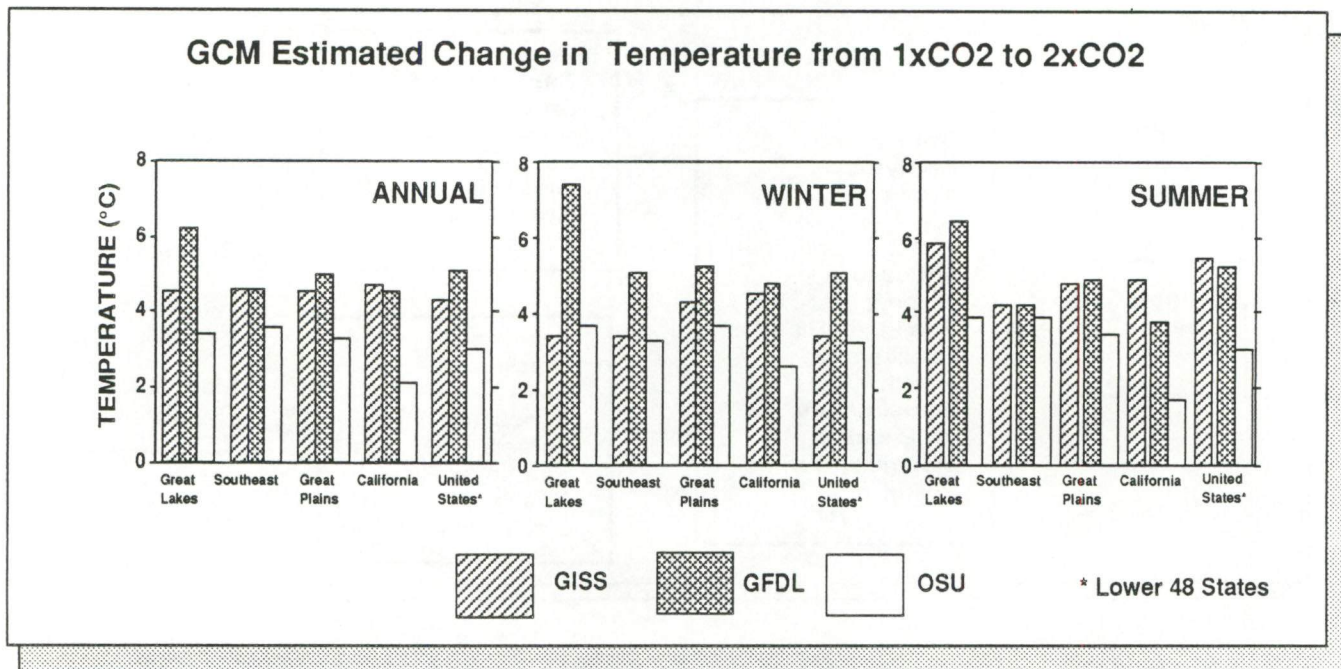
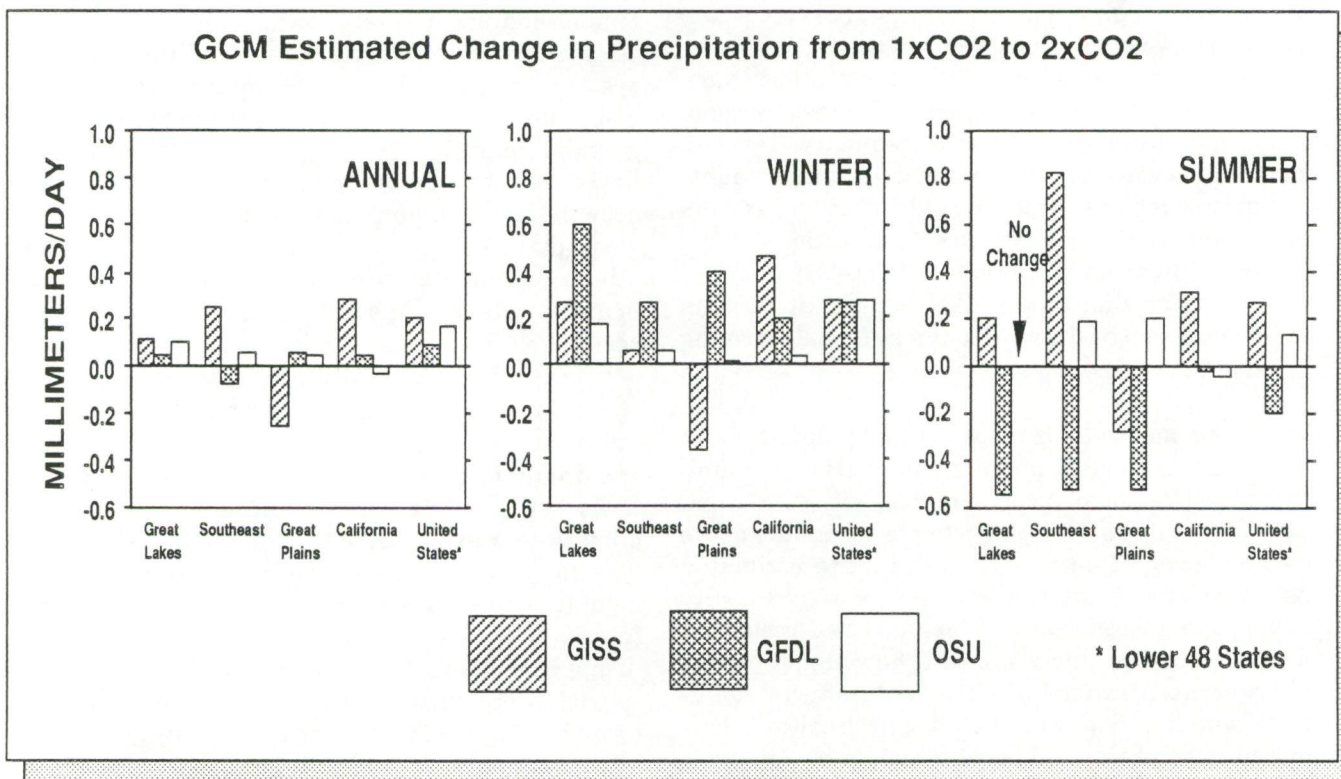


FIGURE 3. PRECIPITATION SCENARIOS



## MAJOR FINDINGS

The findings collectively suggest a world that is different from the world that exists today. Global climate change would have significant implications for natural ecosystems; for where and how we farm; for the availability of water to irrigate crops, produce power, and support shipping; for how we live in our cities; for the wetlands that spawn our fish; for the beaches we use for recreation; and for all levels of government and industry.

The rate of global warming may be the most important factor affecting both natural and managed systems. The faster the warming, the harder it will be to adapt. The ability of natural ecosystems (forests, wetlands, barrier islands, national parks) to adapt to a rapidly warming climate is limited. Rates of natural migration and adaptation could be much slower than climate change. Populations of many species and inhabited ranges could decrease, and many may face extinction. The ultimate effects could last for centuries and would be virtually irreversible. Whether human intervention could mitigate these effects was not studied.

Managed systems may show more resilience. For example, although sea level rise may put additional stresses on coastal cities and although changes in temperature and rainfall patterns may require new strategies for managing water resources and agriculture, we could adapt to changing climate

relatively quickly, if we have enough financial resources. We would expect that basic requirements for food and water could be met in the United States (as crops are shifted and water management systems are modified), and that developed areas with high economic value could be protected against sea level rise (as bulkheads and levees are built). The total cost of adapting to global climate change is beyond the scope of this report. It appears it could be expensive, but affordable, for a highly industrialized country like the United States to adapt managed systems in response to gradual global warming. If change comes more quickly, adaptation by managed systems will be more difficult and expensive.

In many cases, the results of our analysis appear to be consistent across scenarios, because either increasing temperatures or higher sea levels dominate the systems that were studied. For example, higher temperatures would cause earlier snowmelt, a northward migration of forests, and a northward shift in crops, and higher sea levels could inundate wetlands and low-lying areas. In other cases, however, only a range of values can be presented because uncertainties in an important variable, such as precipitation, make the direction of change highly uncertain.

The main findings and policy implications of this report are presented in national and regional chapters. They are summarized in the following pages, but the reader is urged to explore the full report to understand the complete context of these results.

## SCENARIOS AND METHODOLOGY

A number of scenarios were specified by EPA to help identify the sensitivities of natural and manmade systems to climate change. Scenarios were used as inputs with models of natural resources. Most researchers used GCM-based scenarios. Some used analog scenarios or expert judgment.

Regional output from three General Circulation Models (GCMs) were used: the Goddard Institute for Space Studies (GISS); the Geophysical Fluid Dynamics Laboratory (GFDL); and Oregon State University (OSU). All of these models estimate climate change caused by a doubling of CO<sub>2</sub> concentrations in the atmosphere. The regional estimates of doubled CO<sub>2</sub> changes were combined with 1951-80 climate observations to create doubled CO<sub>2</sub> scenarios. This GISS model has been used to estimate how climate may change between now and the middle of the next century. This is called a transient run, the outputs of which were used to create a transient scenario.

Other approaches were used to supplement the GCMs. Weather observations from the 1930s were used as an analog for global warming, although greenhouse warming may raise temperatures much higher than they were in that decade. In some cases, paleoclimatic warmings were studied to provide evidence of how species respond to climate change. In addition, the use of scenarios was supplemented by expert judgment (gathered through literature reviews and workshops with scientific experts) to provide the best opinions on potential effects.

Since we cannot predict the exact nature of climate change, we cannot predict impacts. All of these analytic approaches help us determine the potential sensitivities and vulnerabilities of systems to climate change.

## LIMITATIONS

- Climate Scenarios
  - Differences Between Scenarios. The GCM and other scenarios do not provide consistent estimates of climate change.
  - Variability. The scenarios assume no change in variability.
  - Major Climate Events. The scenarios assume no changes in hurricanes, droughts, etc.
- Societal Changes Most studies did not consider changes in population, technology and other areas. There was only limited consideration of responses and adaptation measures, which could mitigate some of the results presented here.
- Linkages Many indirect effects (e.g., effect of increased irrigation demand on water resources) were not quantitatively analyzed.
- Limited Effects Analyses Many impacts and regions in the United States were not analyzed. In addition, this report did not analyze the impacts of climate change on other countries. Compared to the United States, it may be much more difficult for poorer and less mobile societies to respond to climate change. It is not unreasonable to assume that climate change could have important geopolitical consequences, which could have subsequent impacts on the United States.
- Effects Models These models were calibrated for historic climate conditions and may not accurately estimate future response to climate change.

## NATIONAL FINDINGS

### Natural Systems

The location and composition of various plants and animals in the natural environment depend, to a great extent, on climate. Trees grow in certain areas and fish exist in streams and lakes because the local climate and other conditions are conducive to reproduction and growth. A major focus of this report was to identify what may happen to plants and animals, as a result of climate change — whether they would survive in their current locations or be able to migrate to new habitats, and how soon these ecosystems could be affected.

#### Natural Systems May Be Unable to Adapt Quickly to a Rapid Warming

If current trends continue, climate may change too quickly for many natural systems to adapt. In the past, plants and animals adapted to historic climate changes over many centuries. For example, since the last ice age 18,000 years ago, oak trees migrated northward from the southeastern United States as the ice sheet receded. Temperatures warmed about 5°C (9°F) over thousands of years, but they rose slowly enough for forests to migrate at the same rate as climate change. In the future, the greenhouse effect may lead to similar changes in the magnitude of warming, but the changes may take place within a century. Climate zones may shift hundreds of miles northward, and animals and especially plants may have difficulty migrating northward that quickly.

### Forests

Forests occupy one-third of the land area of the United States. Temperature and precipitation ranges are among the determinants of forest distributions. Forests are also sensitive to soils, light intensity, air pollution, pests and pathogens, disturbances such as fires and wind, and management practices.

Several approaches were used to examine geographic shifts in forests. Potential ranges of forests were estimated for eastern North America using temperature and precipitation correlations from pollen data. Changes in composition and abundance of particular forests were estimated for particular sites in the Great Lakes and Southeast using

site-specific models. These regions were chosen to represent a diversity of forest types and uses. Finally, the ability of trees to migrate to new habitats was analyzed using shifts in climate zones from GCMs and historic rates of tree migration. This study focused on several species that are widely dispersed across the northeastern United States. The direct effects of CO<sub>2</sub>, which could change water-use efficiency, pest interactions, and the competitive balance among plants, were not modeled; nor were reforestation or the suitability of soils and sunlight considered. It is not clear how these results would have been affected, had such factors been included.

#### The Range of Trees May Be Reduced

Figure 4 shows the potential shifts in forest ranges in response to climate change. The scenarios assume that climate change could move the southern boundary northward by 600-700 km (approximately 400 miles), while the northern boundary would only move as fast as the rate of migration of forests. Assuming a migration rate of 100 km (60 miles) per century or double the known historic rate, the inhabited ranges of forests could be significantly reduced because the southern boundary may advance more quickly than the northern boundary. Even if climate stabilizes, it could take centuries for migration to reverse this effect. If climate continues to warm, migration would continue to lag behind shifts in climate zones. If elevated CO<sub>2</sub> concentrations increase the water-use efficiency of tree species and pest infestations do not worsen, the declines of the southern ranges could be partly alleviated. Reforestation could help speed the migration of forests into new areas.

#### Changes in Forest Composition Are Likely

Climate change may significantly alter forest composition and reduce the land area of healthy forests. Higher temperatures may lead to drier soils in many parts of the country. Trees that need wetter soils may die, and their seedlings could have difficulty surviving these conditions. A study of forests in northern Mississippi and northern Georgia indicated that seedlings currently in such areas would not grow because of high temperatures and dry soil conditions. In central Michigan, forests now dominated by sugar maple and oak may be replaced by grasslands, with some sparse oak trees surviving. These analyses did not consider the introduction of

species from areas south of these regions. In northern Minnesota, the mixed boreal and northern hardwood forest could become entirely northern hardwoods. Some areas might experience a decline in productivity, while others (currently saturated soils) might have an increase. The process of changes in species composition would most likely continue for centuries.

Changes May Begin in 30 to 80 Years

Forest change may be visible in a few decades from now. This would involve a faster rate of mortality among mature trees and a decline in seedlings and growth of new species. The studies of forests in the Southeast and Great Lakes indicate that these forests could begin to die back in 30 to 80 years. Figure 5 displays possible reductions in balsam fir trees in northern Minnesota and forests in Mississippi in response to two different scenarios of warming. At the same time in Minnesota, for example,

sugar maple could become more abundant. These forests appear to be very sensitive to small changes in climate, because dieback starts to become noticeable after an approximate 1 to 1.5°C warming. Once this process starts, major dieback may occur rapidly. The timing of a decline is sensitive to the rate of climate change, a warming slower than that assumed in the scenarios would delay the dieback.

Other Factors Will Influence Forest Health

The health of forests will not be determined by climate change alone. The drier soils expected to accompany climate change could lead to more frequent fires, warmer climates may cause changes in forest pests and pathogens, and changes in air pollution levels could reduce the resilience of forests. Continued depletion of stratospheric ozone would also further stress forests. None of these outcomes was considered by the forest studies in this report, although they could speed forest declines.

**FIGURE 4. SHIFTS IN RANGE OF HEMLOCK AND SUGAR MAPLE UNDER ALTERNATIVE CLIMATE SCENARIOS**

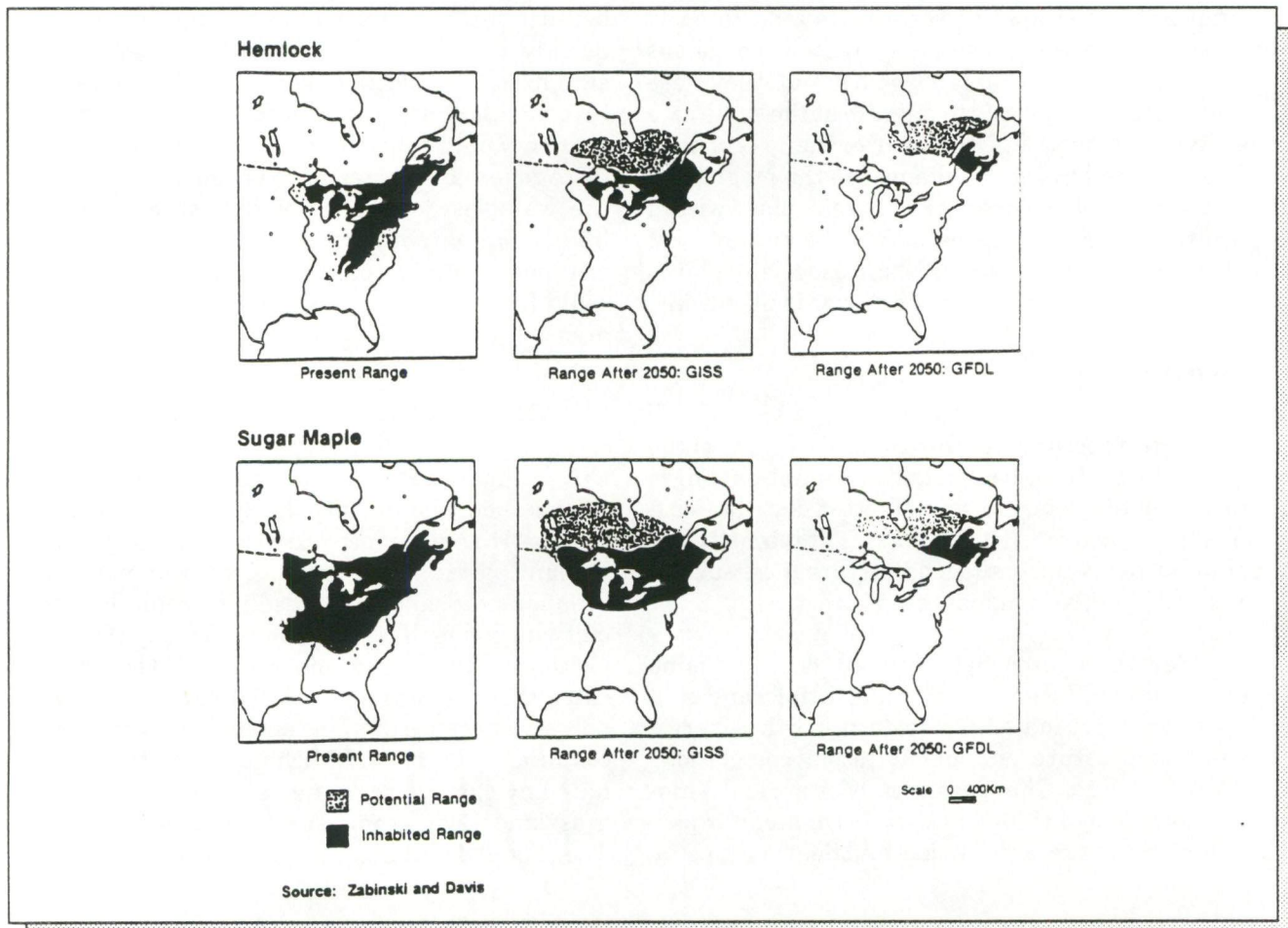
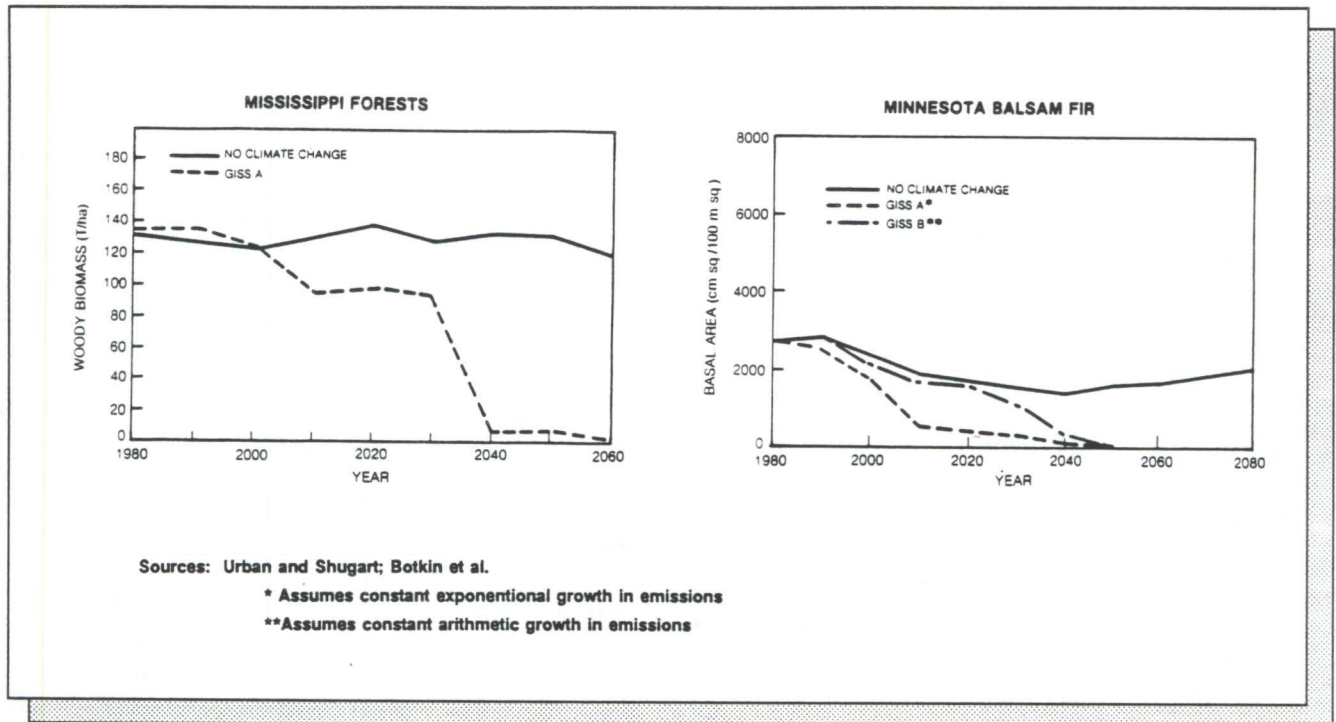


FIGURE 5. FOREST DECLINES DUE TO TEMPERATURE INCREASES



## Biodiversity

Biological diversity can be defined as the variety of species in ecosystems, and the genetic variability within each species and the variety of ecosystems around the world. Over 400 species of mammals, 460 reptiles, 660 freshwater fishes, and tens of thousands of invertebrate species can be found in this country, in addition to some 22,000 plant species. About 650 species of birds reside in or pass through the United States annually. Biological diversity is needed to provide food, medicine, shelter, and other important products.

This report examined the impacts of climate change on specific plants and animals by using climate change scenarios and models of particular species or systems within a region. Analyses have been performed for impacts on finfish and shellfish in the Apalachicola Bay in the Florida panhandle, fish in the Great Lakes, and marine species in San

Francisco Bay. Additional information on potential impacts on biodiversity was gathered from the published literature.

### Extinction of Species Could Increase

Historic climate changes, such as the ice ages, have led to extinction of many species. More recently, man's activities, such as deforestation, have greatly accelerated the rate of species extinction. The faster rate of climate warming due to the greenhouse effect, absent an active program to preserve species, would most likely lead to an even greater loss of species. The uncertainties surrounding the rate of warming, the response of individual species, and interspecies dynamics make it difficult to assess the probable impacts, although natural ecosystems are likely to be destabilized in unpredictable ways.

As with trees, other plants and animals may have difficulty migrating at the same rate as a

rapidly changing climate, and many species may become extinct or may be reduced in population. The presence of urban areas, agricultural lands, and roads would restrict habitats and block many migratory pathways. These obstacles may make it harder for plants and wildlife to survive future climate changes. On the other hand, some species may benefit from climate change due to increases in habitat size or reduction in population of competitors. The extent to which society can mitigate negative impacts through such efforts as habitat restoration is not clear.

### Impacts on Fisheries Would Vary

Freshwater fish populations may grow in some areas and decline in others. Fish in such large water bodies as the Great Lakes may grow faster and may be able to migrate to new habitats. Increased amounts of plankton could provide more forage for fish. However, higher temperatures may lead to more aquatic growth, such as algal blooms, and decreased mixing of lakes (longer stratification), which would deplete oxygen levels in shallow areas of the Great Lakes such as Lake Erie and make them less habitable for fish. Fish in small lakes and streams may be unable to escape temperatures beyond their tolerances, or their habitats may simply disappear.

Warmer temperatures could also exceed the thermal tolerance of many marine finfish and shellfish in some southern locations, although some marine species could benefit. The full impacts on marine species are not known at this time. The loss of coastal wetlands could further reduce fish populations, especially shellfish. And while increased salinity in estuaries could reduce the abundance of freshwater species, it could increase the presence of marine species. Whether finfish and shellfish could migrate to new areas and the effectiveness of restocking were not studied.

### Effects on Migratory Birds Would Depend on Impacts on Habitats

Migratory birds are likely to experience mixed effects from climate change, with some arctic-nesting herbivores benefiting, and continental nesters and shorebirds suffering. Some winter habitats could experience increased productivity. On the other hand, the loss of wintering grounds resulting from sea level rise and changing climate could harm many species as would the loss of inland prairie potholes resulting from potentially increased mid-continental dryness.

## Sea Level Rise

A rise in sea level is one of the most certain impacts of climate change. Higher global temperatures will most likely thermally expand the oceans and melt glaciers. Global sea level is currently rising at a rate of 12 cm (5 inches) per century, and along the U.S. coastline, relative sea level rise (which includes land subsidence) averages 30 cm (1 foot) per century. Published estimates of sea level rise due to global warming generally range from 0.5 to 2.0 meters (1.5 to 7 feet) by 2100, although some estimates are higher.

The studies estimate the potential nationwide loss of wetlands, and the cost of defending currently developed areas from a rising sea, for three scenarios (50, 100, and 200 cm) of sea level rise by the year 2100. Wetland loss estimates were based on remote-sensing data and topographic maps for a sample of sites along the U.S. coast. The cost of holding back the sea was based on (1) the quantity of sand necessary to elevate beaches and coastal barrier islands as sea level rises; (2) rebuilding roads and elevating structures; and (3) constructing levees and bulkheads to protect developed lowlands along sheltered waters.

### Protecting Developed Areas May Be Expensive

Given the high property values of developed coastlines in the United States, it is likely that measures would be taken to hold back the sea along most developed shores. Preliminary estimates suggest that the cumulative capital cost (including response to current sea level rise) of protecting currently developed areas would be \$73 to 111 billion (in 1988 dollars) through 2100 for a 1-meter global rise (compared to \$4 to 6 billion to protect developed areas from current trends in sea level rise). A 1-meter sea level rise would lead to a cumulative inundation of 7,000 square miles of dryland — an area the size of Massachusetts (see Table 1). If the oceans continue to rise at current rates, approximately 3,000 square miles of dryland would be lost.

### Most Coastal Wetlands Would Be Lost

Historically, wetlands have kept pace with a slow rate of sea level rise. However, in the future, sea level will probably rise too fast for marshes and swamps to keep pace. Although some wetlands can survive by migrating inland, a study on coastal wetlands estimated that for a 1-meter rise, 26 to 66% of

TABLE 1. NATIONWIDE IMPACTS OF SEA LEVEL RISE

	Baseline*	Sea Level Rise by 2100		
		50 cm	100 cm	200 cm
If Densely Developed Areas Are Protected				
Shore protection costs (\$billions)	4-6	32-43	73-111	169-309
Dryland lost (mi <sup>2</sup> )	1,500-4,700	2,200-6,100	4,100-9,200	6,400-13,500
Wetlands lost (%)	9-25	20-45	29-69	33-80
If No Shores Are Protected				
Dryland lost (mi <sup>2</sup> )	N.C.	3,300-7,300	5,100-10,300	8,200-15,400
Wetlands lost (%)	N.C.	17-43	26-66	29-76
If All Shores Are Protected				
Wetlands lost (%)	N.C.	38-61	50-82	66-90
N.C. = Not Calculated				
*Baseline assumes current global sea level rise trend of 12 cm per century. Given coastal subsidence trends, this implies about a 1-foot rise in relative sea level along most of the U.S. coast.				
Source: Assembled by Titus and Greene.				

wetlands would be lost, even if wetland migration were not blocked. A majority of these losses would be in the South (see Table 2). Efforts to protect coastal development would increase wetland losses, because bulkheads and levees would prevent new wetlands from forming inland. If all shorelines are protected, 50 to 82% of wetlands would be lost. The different amounts of dryland lost for different regions and scenarios are shown in Figure 6.

The loss of wetland area would have adverse ecological impacts, with the ability of ecosystems to survive a rising sea level depending greatly on how shorelines are managed. For many fish and shellfish species, the fraction of shorelines along which wetlands can be found is more important than the total area of wetlands. This fraction could remain at

approximately present levels if people do not erect additional bulkheads and levees. In Louisiana, with 40% of U.S. coastal wetlands, large areas of wetlands are already being lost from relative sea level rise, and most could be lost by 2030 if current trends continue.

#### Estuaries May Enlarge and Become More Saline

Although future riverflows into estuaries are uncertain, a rise in sea level would increase the size and salinity of estuaries and would increase the salinity of coastal aquifers. For example, sea level rise may result in a more saline and enlarged Sacramento-San Joaquin Delta, and Miami, New York, and other coastal communities would have to step-up current efforts to combat salinity increases in surface water and groundwater supplies.

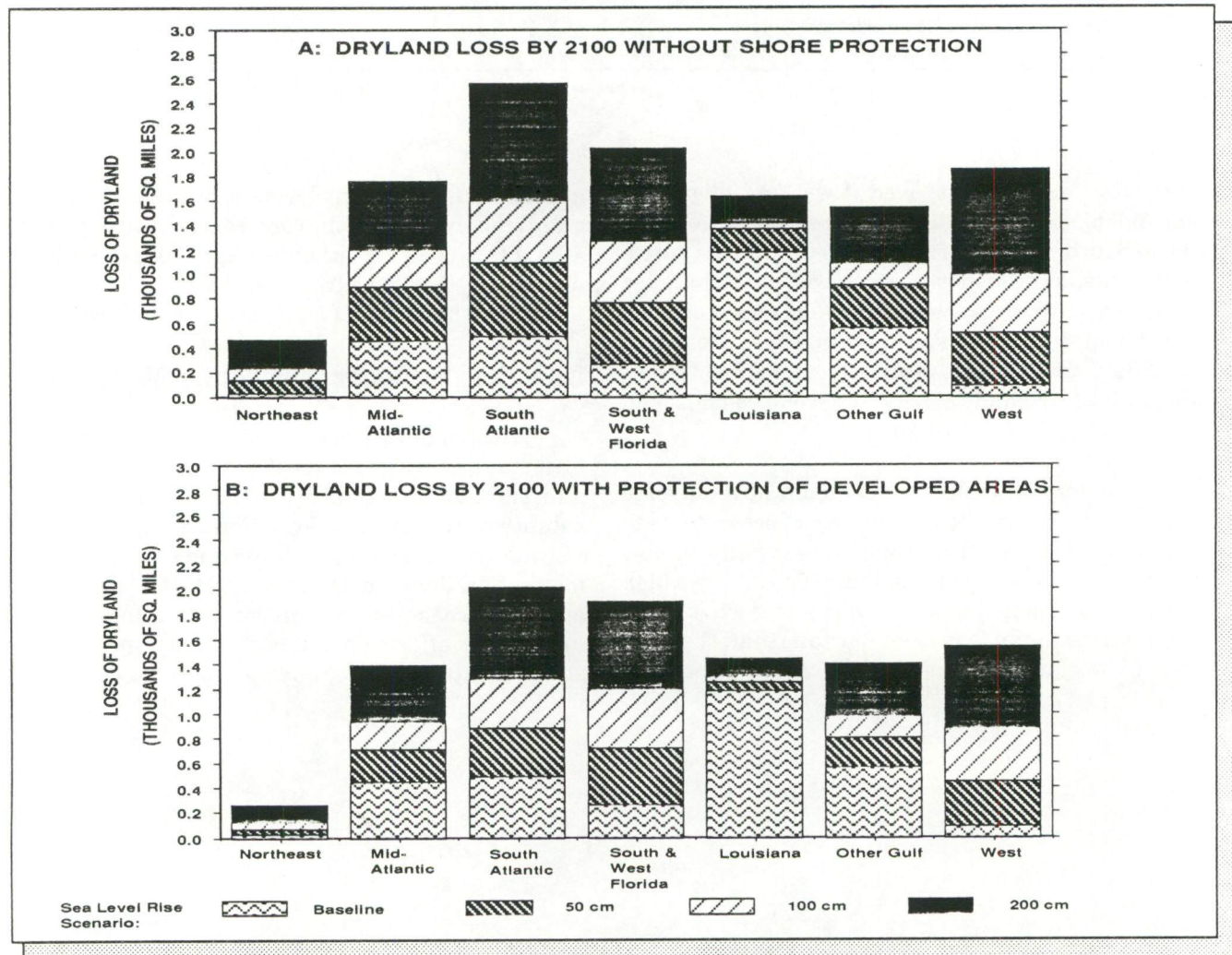
**TABLE 2. LOSS OF WETLANDS FROM A ONE-METER RISE IN SEA LEVEL**

Region	Current Wetlands Area (mi <sup>2</sup> )	All Dryland Protected (% Loss)	Current Development Protected (% Loss)	No Protection (% Loss)
Northeast	600	16	10	2
Mid-Atlantic	746	70	46	38
South Atlantic	3,813	64	44	39
S/W Florida	1,869	44	8	7
Louisiana*	4,835	77	77	77
Other Gulf	1,218	85	76	75
West	64	56	gain**	gain**
USA	13,145	50-82	29-69	26-66

\*Louisiana projections do not consider potential benefits of restoring flow of sediment and freshwater.  
 \*\*Potential gain in wetland acreage not shown because principal author suggested that no confidence could be attributed to those estimates. West Coast sites constituted less than 0.5% of wetlands in study sample.

Source: Adapted from Park et al.

**FIGURE 6. DRYLAND LOSS BY 2100**



## Agriculture

The temperate climate and rich soils in the United States, especially in the Midwest, have helped make this country the world's leading agricultural producer. Agriculture, a critical component of the U.S. economy, contributed 17.5% of the gross national product in 1985, with farm assets totaling \$771 billion.

Crop production is sensitive to climate, soils, management methods, and many other factors. During the Dust Bowl years of the 1930s, wheat and corn yields dropped by up to 50%, and during the drought of 1988, corn yields declined about 40%.

The agriculture analyses in this report examined potential impacts on crop yields and productivity from changes in climate and direct effects of CO<sub>2</sub>. (Higher CO<sub>2</sub> concentrations may increase plant growth and water use efficiency.) The studies used high estimates of the beneficial effects of CO<sub>2</sub> on crops. Changes in dryland and irrigated corn, wheat, and soybean yields and in irrigation demand were estimated for the Southeast, Great Plains, and Great Lakes regions using widely validated crop growth models. Crop yield changes were estimated for California using a simple agroclimatic index. The studies did not examine effects on yields of introduction of crops, such as citrus into new areas; changes in weed growth caused by higher CO<sub>2</sub> concentrations; or such new technologies as biotechnology. Some of these changes could enhance the ability of agriculture to adapt to global warming.

The estimated yield changes from the crop modeling studies and runoff changes from the GCMs were used in a nationwide agricultural economic model to estimate regional and national changes in crop production, land use, and demand for irrigation. The economic model did not consider the introduction of new crops, changes in government policies on agriculture, change in demand for water for non-agriculture uses, and global agriculture changes. Both a modeling study and a literature review were used to estimate changes in plant-pest interactions. An agricultural runoff and leaching model was used to estimate potential changes in water quality in the Great Plains. Some farm-level adjustments, including the effects of changed planting dates and use of different varieties were investigated in various studies and the potential national implications on livestock were analyzed using modeling studies and a literature review.

### Yields Could Be Reduced. Although the Combined Effects of Climate and CO<sub>2</sub> Would Depend on the Severity of Climate Change

In most regions of the country, climate change alone could reduce dryland yields of corn, wheat, and soybeans, with site-to-site losses ranging from negligible amounts to 80%. These decreases would be primarily the result of higher temperatures, which would shorten a crop's life cycle. In very northern areas, such as Minnesota, dryland yields of corn and soybeans could increase as warmer temperatures extend the frost-free growing season. The combined effects of climate change and CO<sub>2</sub> may result in net increases in yields in some cases, especially in northern areas or in areas where rainfall is abundant. In southern areas, however, where heat stress is already a problem, and in areas where rainfall is reduced, crop yields could decline.

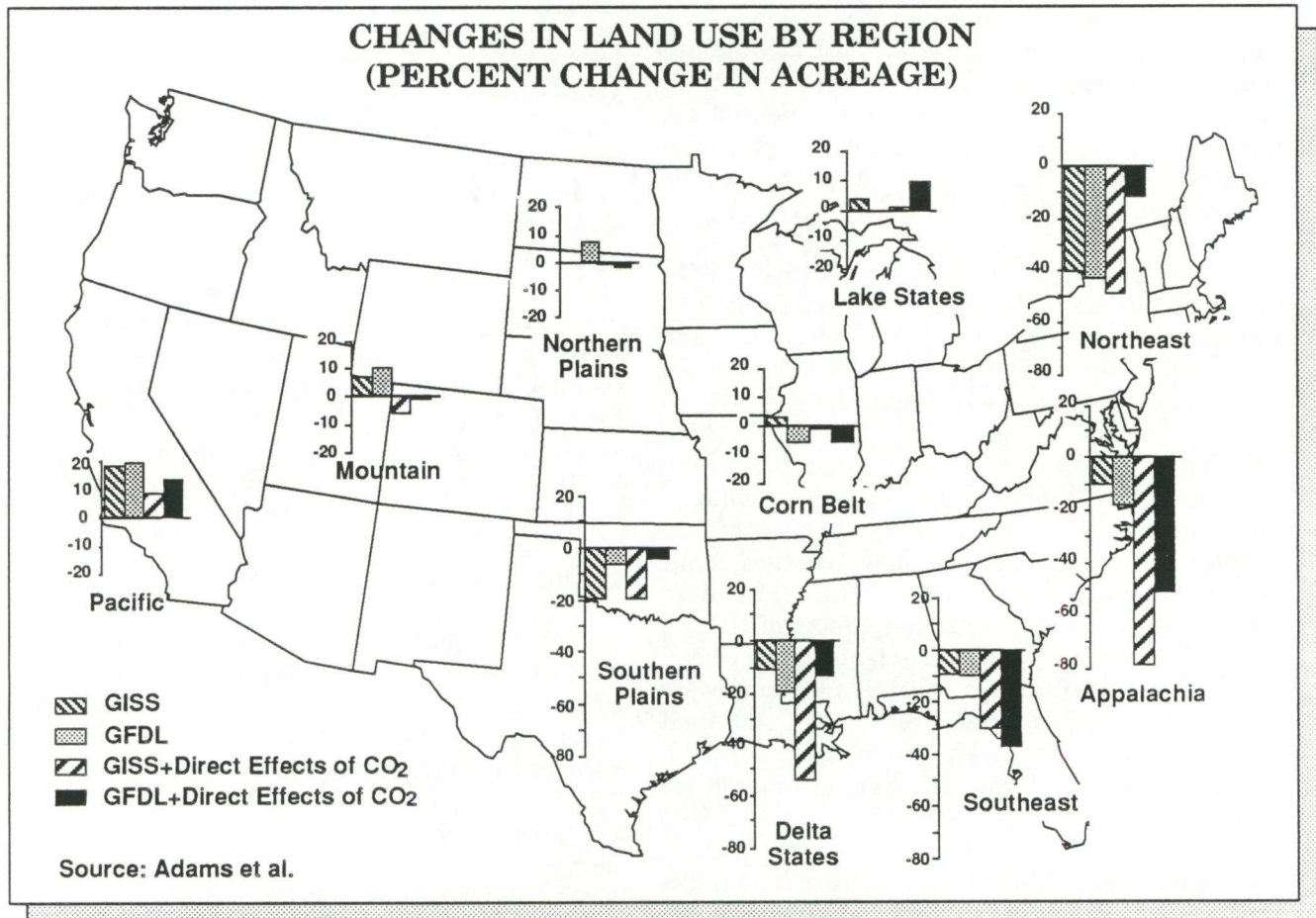
### Productivity May Shift Northward

Under all of the scenarios (with and without the direct effects of CO<sub>2</sub>), the relative productivity of northern areas for the crops studied was estimated to rise in comparison with that of southern areas. In response to the shift in relative yields, grain crop acreage in Appalachia, the Southeast, and the southern Great Plains could decrease, and acreage in the northern Great Lakes States, the northern Great Plains, and the Pacific Northwest could increase (see Figure 7). A change in agriculture would affect not only the livelihood of farmers, but also agricultural infrastructure and other support services. The sustainability of crop production in northern areas was not studied. Changes in foreign demand for U.S. crops, which would likely be altered as a result of global warming and could significantly alter the magnitude of the results, were not considered in this analysis.

### The National Supply of Agricultural Commodities May Be Sufficient to Meet Domestic Needs, But Exports May Be Reduced

Even under the more extreme climate change scenarios, the production capacity of U.S. agriculture was estimated to be adequate to meet domestic needs. Only small to moderate economic losses were estimated when climate change scenarios were modeled without the beneficial effects of CO<sub>2</sub> on crop yields. When the combined effects of climate and CO<sub>2</sub> were considered, results were positive with a relatively wetter climate change scenario and negative

**FIGURE 7. PERCENT CHANGE IN REGIONAL AGRICULTURAL ACREAGE**



with the hotter, drier climate change scenario. Thus, the severity of the economic consequences could depend on the type of climate change that occurs and the ability of the direct effects of CO<sub>2</sub> to enhance yields. A decline in crop production would reduce exports, which could have serious implications for food-importing nations. If climate change is severe, continued and substantial improvements in crop yields would be needed to fully offset the negative effects. Technological improvements, such as improved crop varieties from bioengineering, could be helpful in keeping up with climate change. These results could be affected by global changes in agriculture, which were not considered in the analysis.

Farmers Would Likely Change Many of Their Practices

Farm practices would likely change in response to different climate conditions. Most significantly, in many regions, the demand for irrigation is likely to increase due to higher temperatures. If national productivity declines, crop prices may rise, making irrigation more economical and increasing the use of it (see Figure 8). Irrigation equipment may be installed in many areas that are currently dryland farms, and farmers already irrigating may extract more water from surface and groundwater sources. Changes in competing demands for water by municipi-

pal and industrial users, which could raise the cost of irrigation, were not considered. Farmers may also switch to more heat- and drought-resistant crop varieties, plant two crops during a growing season, and plant and harvest earlier. Whether these adjustments would compensate for climate change depends on a number of factors, including the severity of the climate change. Under extreme climate change conditions, some farms could be abandoned.

Ranges of Agricultural Pests May Extend Northward

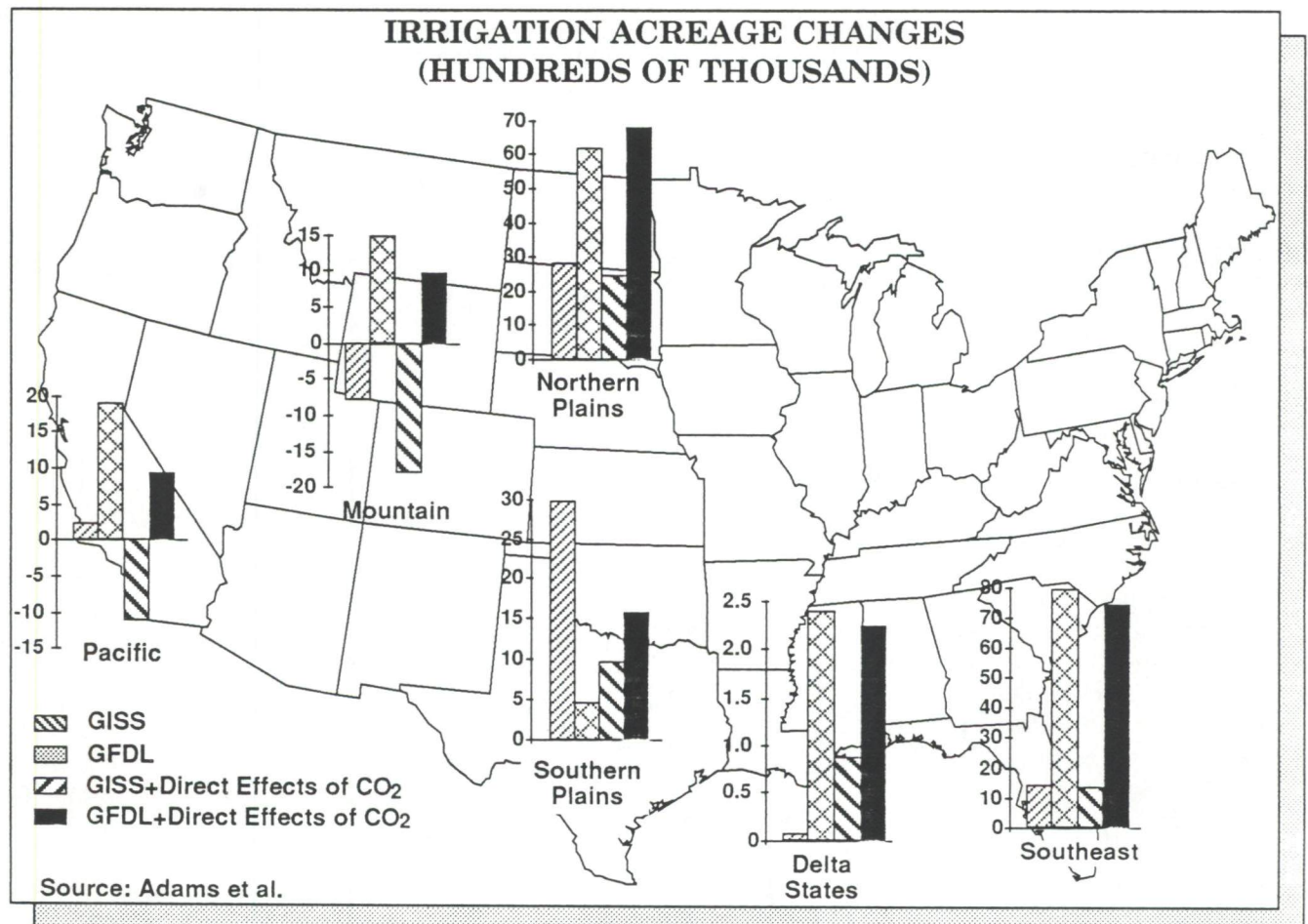
Warmer temperatures may result in the northward extension of the range of diseases and pests that now afflict livestock in the South, and could make conditions more favorable for the introduction of new livestock diseases into the southern United

States. This extension could reduce crop yields and affect livestock.

Shifts in Agriculture May Harm the Environment in Some Areas

Expansion of irrigation and shifts in regional production patterns imply more competition for water resources, greater potential for surface water and groundwater pollution, loss of some wildlife habitats, and increased soil erosion. A northward migration of agriculture would increase the use of irrigation and fertilizers on sandy soils, thus endangering the quality of underlying groundwater. Chemical pesticide usage may change to control different crop and livestock pests. Thus, climate change could exacerbate environmental pollution and resource use from agriculture in some areas.

FIGURE 8. CHANGE IN REGIONAL IRRIGATION ACREAGE



### Water Resources

The United States is endowed with a bountiful supply of water, but the water is not always in the right place at the right time or of the right quality. In some regions, such as the Great Basin and the Colorado River Basin, the gap between demand and supply of water is narrow. In these basins, such offshore uses as irrigation and domestic consumption often conflict with each other and with other needs, such as maintaining flow to preserve environmental quality.

Although global precipitation is likely to increase, it is not known how regional rainfall patterns will be affected. Some regions may have more rainfall, while others may have less. Furthermore, higher temperatures would most likely increase evaporation. These changes would likely create new stresses for many water management systems.

To discuss the potential impacts of climate change on water resources, this report studied water resources in California, the Great Lakes, and the Southeast, estimated the demand for irrigation in the Great Plains, and drew on information from the literature. These studies focused on changes in runoff, and in California and the Southeast, considered management responses. The studies examined the water management systems as they are currently configured and did not examine new construction. Among other factors not considered were changes in demand for water resources (which would most likely lead to greater changes in water management systems) and changes in vegetation due to climate change and CO<sub>2</sub> which could affect runoff.

#### The Direction of Change in Some Water Bodies Can Be Estimated, but Total Impacts in the United States Cannot Be Determined

Results of hydrology studies in some regions indicate that it is possible to identify the direction of change in water supplies and quality due to global warming. For example, in California, higher temperatures would reduce the snowpack and cause earlier melting. Earlier runoff from mountains could increase winter flooding and reduce deliveries to users. In the Great Lakes, reduced snowpack combined with potentially higher evaporation would most likely lower lake levels (although certain combinations of conditions could lead to higher levels). In other areas, such as the South, little snowcover

currently exists, so riverflow and lake levels depend more on rainfall patterns. Without better rainfall estimates, we cannot determine whether riverflow and lake levels in the South would rise or fall.

#### Water Quality in Many Basins Could Change

Changes in water supply could significantly affect water quality. Where riverflow and lake levels decline, such as in the Great Lakes, there would be less water to dilute pollutants. On the other hand, where there is more water, water quality may improve. Higher temperatures may enhance thermal stratification in some lakes and increase algal production, degrading water quality. Changes in runoff and leaching from farms and potential increases in the use of irrigation for agriculture could affect surface and groundwater quality in many areas.

#### Water Use Conflicts May Increase

In some regions, decreased water availability and increased demand for water, such as for irrigation and powerplant cooling, may intensify conflicts among offshore uses. Conflicts between these offshore uses and instream uses such as flood control and wildlife habitat also may be intensified.

### Electricity Demand

The demand for electricity is influenced by economic growth, by changes in industrial and residential/commercial technologies, and by climate. The principal climate-sensitive electricity end uses are space heating and cooling and, to a lesser degree, water heating and refrigeration. These uses of electricity may account for up to a third of total sales for some utilities and may contribute an even larger portion of seasonal and daily peak demands.

This report analyzed potential changes in the national demand for electricity in 2010 and 2055, using the relationship between demand and climate for several major utility systems. The study estimated changes in demand due to nonclimate factors, such as increases in population and GNP. The impacts of climate change are expressed as an increase over non-climate growth, and results are given on nationwide and regional bases. The study did not consider changes in technology and improvements in energy efficiency; the impacts of higher temperatures on the demand for natural gas and oil for home heating, which will most likely decrease;

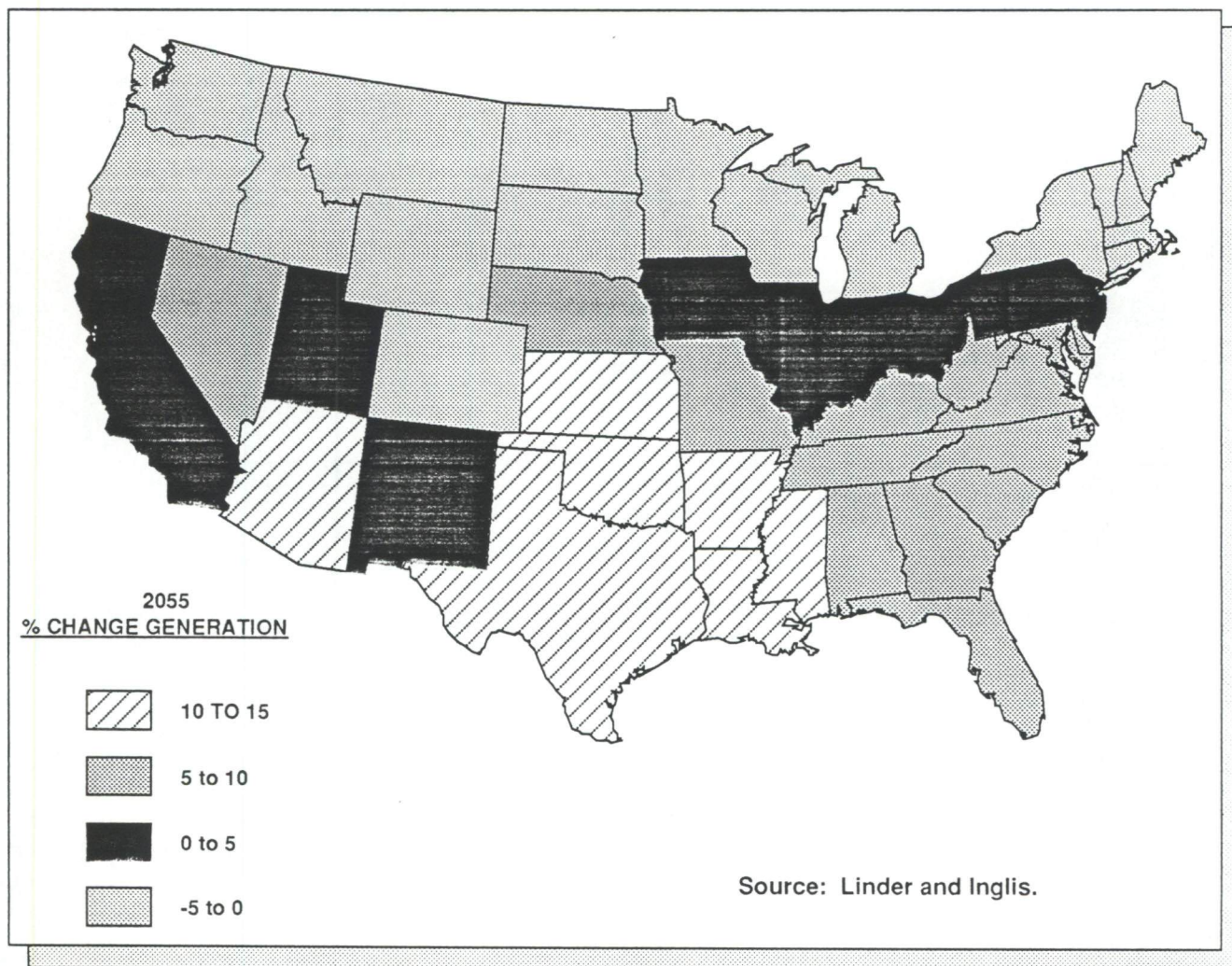
changes in electricity supplies, such as hydropower; or changes in demand for electricity for such uses as irrigation.

National Electricity Demand Would Rise

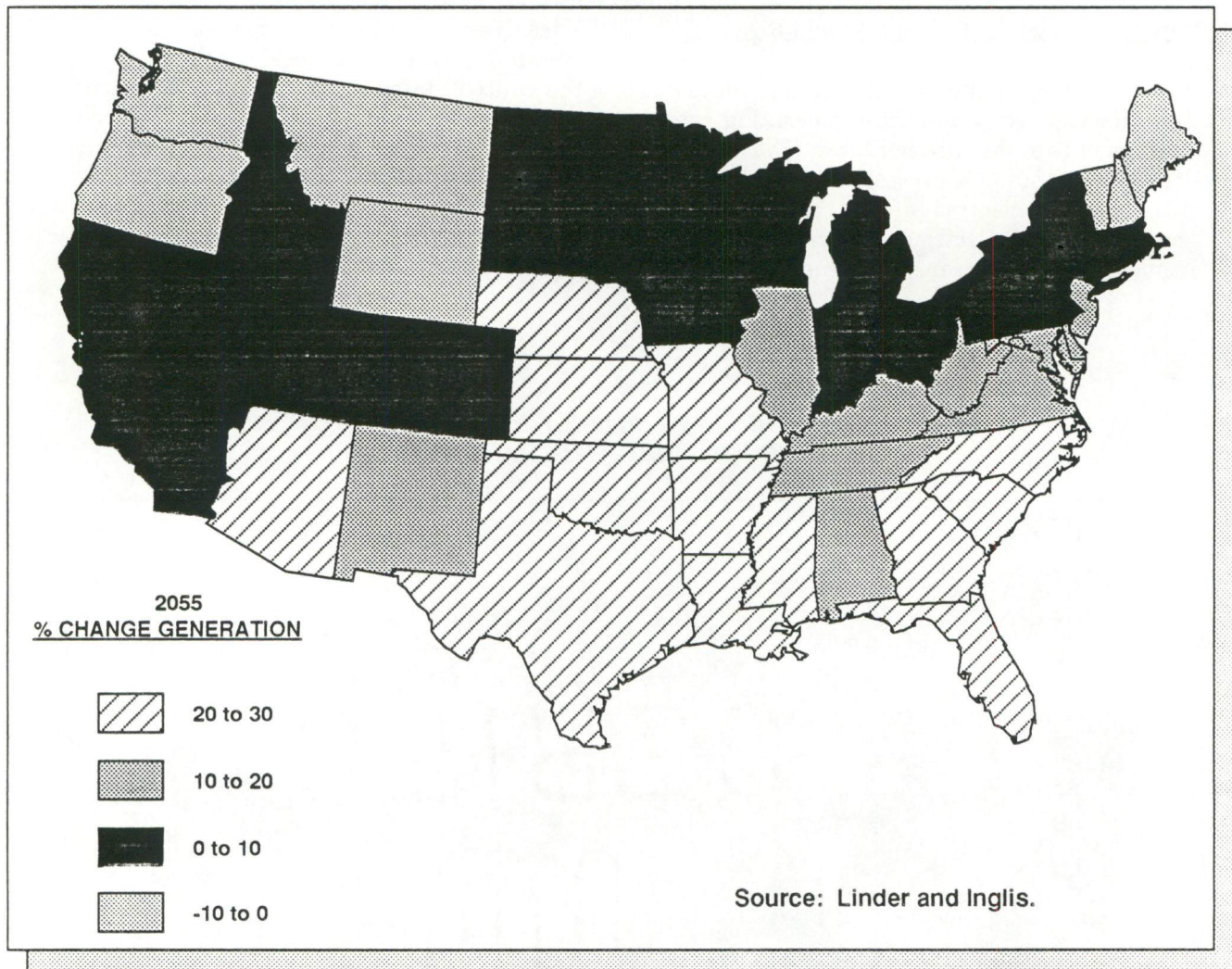
Global warming would increase annual demand for electricity and total generating capacity requirements in the United States. The demand for electricity for summer cooling would increase, and the demand for electricity for winter heating would decrease. Annual electricity generation in 2055 was estimated under the transient scenarios to be 4 to 6%

greater than without climate change. The annual costs of meeting the increase due to global warming, assuming no change in technology or efficiency, was estimated to be \$33-73 billion (in 1986 dollars). These results differ on a regional basis and are shown in Figure 9. States along the northern tier of the United States could have net reductions in annual demand of up to 5%, because decreased heating demand would exceed increased demand for air-conditioning. In the South, where heating needs are already low, net demand was estimated to rise by 7 to 11% by 2055.

**FIGURE 9. CHANGES IN ELECTRICITY GENERATION BY STATE INDUCED BY CLIMATE CHANGE IN 2055**



**FIGURE 10. CHANGES IN ELECTRICITY CAPACITY ADDITIONS BY STATE INDUCED BY CLIMATE CHANGE IN 2055**



Generating capacity requirements are determined largely by peak demand, which occurs in the summer in all but the far northern areas of the country. By 2010, generating requirements to meet increased demand could rise by 25 to 55 gigawatts (GW), or by 9 to 19% above new capacity requirements, assuming no climate change. By 2055, generating requirements could be up by 200 to 400 GW, or 14 to 23% above non-climate-related growth. The cumulative cost of such an increase in capacity, assuming no change in technology or improvements in energy efficiency, was estimated to be between

\$175 and 325 billion (in 1988 dollars). The South would have a greater need than the North for additional capacity, as shown in Figure 10. Additional capacity requirements could range from 0 to 10% in the North, to 20 to 30% in the South and Southwest. U.S. emissions of such greenhouse gases as CO<sub>2</sub> could increase substantially if additional powerplants are built to meet these capacity requirements, especially if they burn coal. Improvement in the efficiency of energy production and use would reduce these emissions.

## Air Quality

Air pollution caused by emissions from industrial and transportation sources is a subject of concern in the United States. Over the last two decades, considerable progress has been made in improving air quality by reducing emissions. Yet high temperatures in the summer of 1988 helped raise tropospheric ozone levels to all-time highs in many U.S. cities. But air quality is also directly affected by other weather variables, such as windspeed and direction, precipitation patterns, cloud cover, atmospheric water vapor, and global circulation patterns.

A literature review of the relationship between climate and air pollution was conducted for this report. In addition, air quality models were used for a preliminary analysis of the changes in ozone levels in several regions. The latter analysis did not consider reduction in emissions of air pollutants due to enforcement of the Clean Air Act.

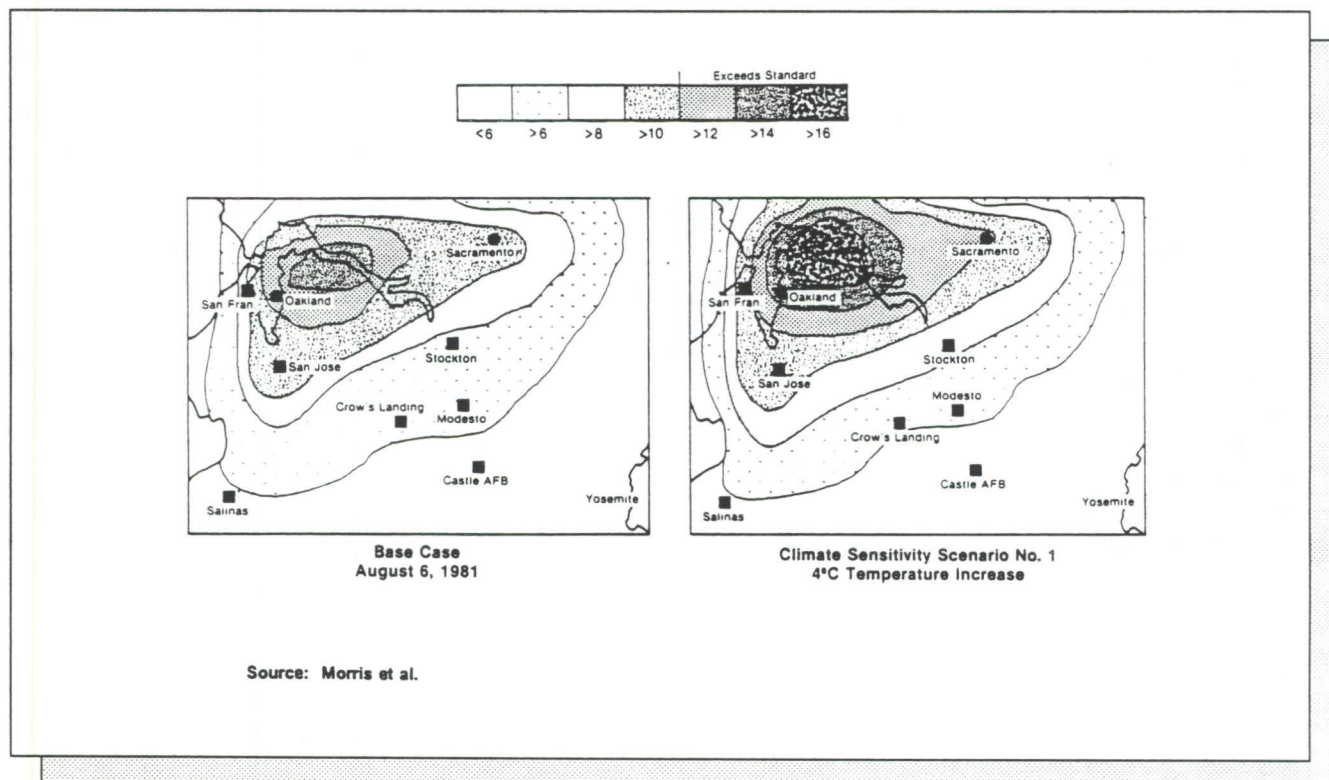
### Climate Changes Could Increase Air Pollution, Especially Smog

A rise in global temperatures would increase manmade and natural emissions of hydrocarbons and manmade emissions of sulfur and nitrogen ox-

ides over what they would be without climate change. Natural emissions of sulfur would also change, but the direction is uncertain. Although the potential magnitude of the impacts of the increased emissions on air quality is uncertain, higher temperatures would speed the reaction rates among chemicals in the atmosphere, causing higher ozone pollution in many urban areas than would occur otherwise. They would also increase the length of the summer season, usually a time of high air pollution levels. As shown in Figure 11, preliminary analyses of a 4°C temperature increase in the San Francisco Bay area (with no changes in other meteorologic variables, such as mixing heights), assuming no change in emissions from current levels, suggest that maximum ozone concentrations would increase by 20%, and that the area exceeding the National Ambient Air Quality Standards would almost double. Studies of the Southeast also show expansion of the areas violating the standards, but they show smaller changes in levels.

Although the impacts of higher temperatures on acid rain were not analyzed, it is likely that sulfur and nitrogen would oxidize more rapidly under higher temperatures. The ultimate effect on acid deposition is difficult to assess because changes in clouds, winds, and precipitation patterns are uncertain.

**FIGURE 11. CHANGES IN MAXIMUM DAILY OZONE CONCENTRATIONS**



### Health Effects

Human illness and mortality are linked in many ways to weather patterns. Weather affects contagious diseases such as influenza and pneumonia, and allergic diseases such as asthma. Mortality rates, particularly for the elderly and the very ill, are influenced by the frequency and severity of extreme temperatures. The life cycles of disease-carrying insects, such as mosquitoes and ticks, are affected by changes in temperature and rainfall, as well as by habitat, which is itself sensitive to climate. Finally, increased air pollution, which is related to weather patterns, can heighten the incidence and severity of such respiratory diseases as emphysema and asthma.

Both expert judgment and modeling were used to study the potential impacts of climate change on human health. A literature review and workshop were conducted to identify potential changes in vector-borne diseases caused by ticks, fleas, and mosquitoes (such as dengue and malaria). Models were used to estimate potential geographic shifts in the prevalence of Rocky Mountain spotted fever and malaria. Potential changes in mortality from heat and cold stress were quantitatively estimated, although such estimates did not consider changes in air pollution levels. The total impacts of climate change on human health are difficult to assess; these analyses only looked at a limited number of potential effects and are only indicative of possible changes in mortality and morbidity.

#### Summer Mortality Could Increase, While Winter Mortality Could Decrease

Global warming may lead to changes in morbidity and increases in mortality, particularly for the elderly during the summer. There may be decreases in morbidity and mortality because of milder winters, although net mortality may increase. If the frequency or intensity of climate extremes increases, mortality is likely to rise. If people acclimatize by using air-conditioning, changing their workplace habits, and altering the construction of their homes and cities, the impact on summer mortality rates may be substantially reduced.

#### Regional Morbidity Patterns Could Change

Changes in climate as well as in habitat may alter the regional prevalence of vector-borne diseases. For example, some forests may become grasslands, thereby modifying the incidence of vector-borne diseases. Changes in summer rainfall could alter the amount of ragweed growing on cultivated land, and changes in humidity may affect the incidence and severity of skin infections and infestations, such as ringworm, candidiasis, and scabies. Increases in the persistence and level of air pollution episodes associated with climate change will have other harmful health effects.

### Urban Infrastructure

The value of municipal infrastructure in the United States, excluding buildings and electric power production, probably approaches one trillion dollars. The majority of the nation's investments are in water supply, wastewater transport and treatment facilities, drainage, roadways, airports, and mass transit facilities. Like the regions studied for this report, urban areas would feel a variety of impacts from climate change. This report examined the potential impacts of climate change on Cleveland, New York City, and Miami. These areas encompass a diversity of climates and uses of natural resources.

Much of the current inventory in urban infrastructure will most likely turn over in the next 35 to 50 years. A warmer global climate would require changes in the capital investment patterns of cities for water supplies, peak electric generating capacity, and storm sewer capacity. Urbanized coastal areas might have to invest additional billions of dollars into coastal protection to defend developed areas from a rising sea. In Miami, for example, this would imply an increase of 1 to 2% in the city's capital spending over the next 100 years. Generally, northern cities such as Cleveland may fare better, since reductions in the operating and maintenance costs associated with heating public buildings, snow removal, and road maintenance should offset increasing costs for air-conditioning and port dredging (see Table 3).

**TABLE 3. ESTIMATED IMPACTS OF A DOUBLING OF CO<sub>2</sub> ON CLEVELAND'S ANNUAL INFRASTRUCTURE COSTS (MILLIONS OF 1987 DOLLARS)**

<b>Cost Category</b>	<b>Annual Operating Costs</b>
Heating	-\$2.3
Air-conditioning	+\$6.6-9.3
Snow and ice control	-\$4.5
Frost damage to roads	-\$0.7
Road maintenance	-\$0.5
Road reconstruction	-\$0.2
Mass transit	summer increase offsets winter savings
River dredging	less than \$0.5
Water supply	negligible
Stormwater system	negligible
<b>Total</b>	<b>-\$1.6 to +\$1.1</b>

Source: Walker et al.

## REGIONAL IMPACTS

Studying the national impacts of climate change may disguise important differences in regional effects across the country. Shifting demands for economic and natural resources may cause stresses that cannot be seen at a national level. Furthermore, changes in one system, such as water supply, may affect other systems such as irrigation for agriculture. These combined effects may be most evident on a regional scale. The designs of the regional studies on agriculture, forests, and electricity were described above.

The studies discussed below only considered some of the potential regional impacts. Many potential impacts were not analyzed — for example, demographic shifts into or out of the Southeast, recreational impacts in the Great Lakes, direct effects on such aquifers as the Ogallala in the Great Plains, and impacts on many specialty crops in California. The discussion that follows should not be viewed as comprehensive, but rather as examples of important issues for each region.

### California

California contains a highly managed water resource system and one of the most productive agricultural regions in the world. The state produces 14% of the nation's cash receipts for agriculture. California's water resources are poorly distributed in relation to its needs. Precipitation is abundant in the north, with the highest levels in the winter, while water is needed in the south for agriculture and domestic consumption. The Central Valley Project (CVP) and State Water Project (SWP) were built basically to capture runoff from the north and deliver it to uses in the south. These projects also provide flood protection, hydroelectric power, and freshwater flows to repel salinity (known as carriage water) in the Sacramento-San Joaquin River Delta. Islands in the delta are highly productive farmlands and are protected by levees.

The California case study focused on the Central Valley. First, changes in runoff in the valley were estimated. These results were then used to estimate changes in deliveries from the CVP and SWP and in agricultural water use. These results

were combined with sea level rise estimates and used to model how the salinity and shape of the San Francisco Bay estuary may change and how the demand for carriage water may be affected. The estimated changes in salinity and sea level rise were used to examine impacts on the ecology of the bay. Yield changes for a number of crops grown in the state were estimated as were changes in ozone levels in central California and changes in electricity demand (see Figure 12).

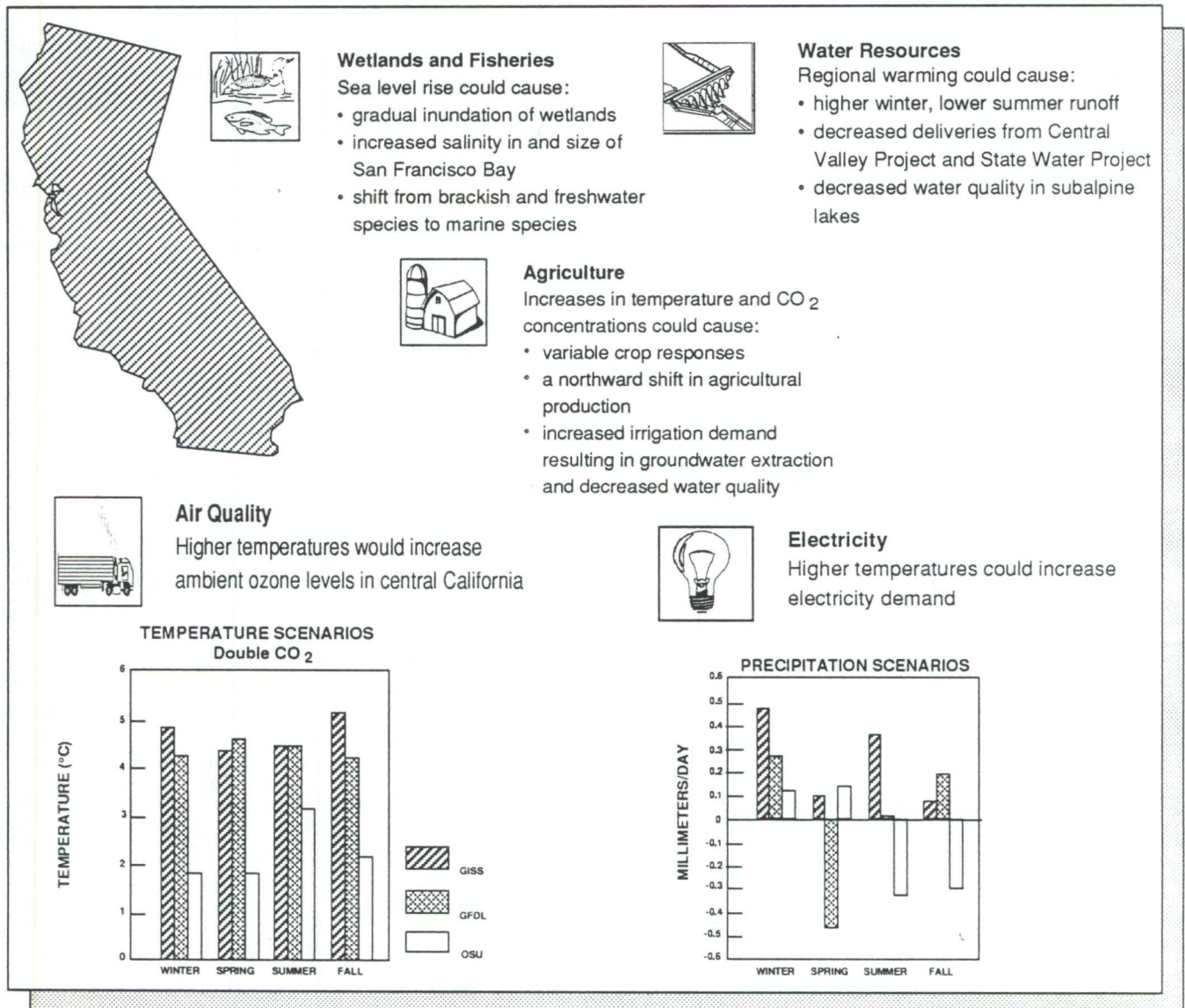
### California's Water Management System Would Have To Be Modified

Warmer temperatures would change the seasonality of runoff from the mountains surrounding the Central Valley. Runoff would be higher in the winter months due to less snowpack and more precipitation in the form of rain. Consequently, runoff would be lower in the late spring and summer. Under these conditions, the current reservoir system in the Central Valley would not have the capacity to provide adequate flood protection in the winter and store enough water to meet deliveries in the summer. Thus, much of the earlier winter runoff would have to be released. This would leave less water in the system for late spring and summer deliveries, when runoff would be lower. Under the three GCM scenarios, annual water deliveries from the SWP were estimated to decrease by 200,000 to 400,000 acre feet (7 to 16% of supply). In contrast, the increase in statewide demand for water from the SWP due to non-climate factors such as population growth, may total 1.4 million acre feet by 2010. Reduced snowpack and earlier runoff are likely to happen throughout the West, exacerbating water management problems in a region that is currently short of water.

### Climate Change Is Likely to Increase Water Demand

On the whole, California's water demand could increase with a warmer climate. Twice as much carriage water may be needed to repel higher salinity levels resulting from a 1-meter sea level rise. In addition, consumptive uses may also increase. Irrigation, which may come from groundwater, may increase in some parts of the state. If new powerplants are built, they would need water for cooling; which could come from surface water supplies, depending on the location. Although it was not studied, municipal demand for water may also rise.

FIGURE 12. CALIFORNIA



Sea Level Rise Would Affect the Size and Environment of San Francisco Bay

A sea level rise would increase the salt concentrations of San Francisco Bay. It is estimated that a 1-meter rise could cause the salt front in the Sacramento-San Joaquin River Delta to migrate upstream 4 to 10 km (2.5 to 6 miles). Sea level rise would also make it harder to maintain the Sacramento-San Joaquin Delta islands. If the levees around the delta islands are strengthened and raised, a 1-meter rise could increase the volume of the San Francisco Bay estuary by 15% and the area by 30%. If the levees are not maintained and the islands are flooded, there would be a doubling and tripling, respectively, of the volume and area of the bay. As a result of these changes, some wetlands would be lost, marine aquatic

species would become relatively more abundant, and freshwater species would decline.

Climate Change Could Degrade Air Quality in California

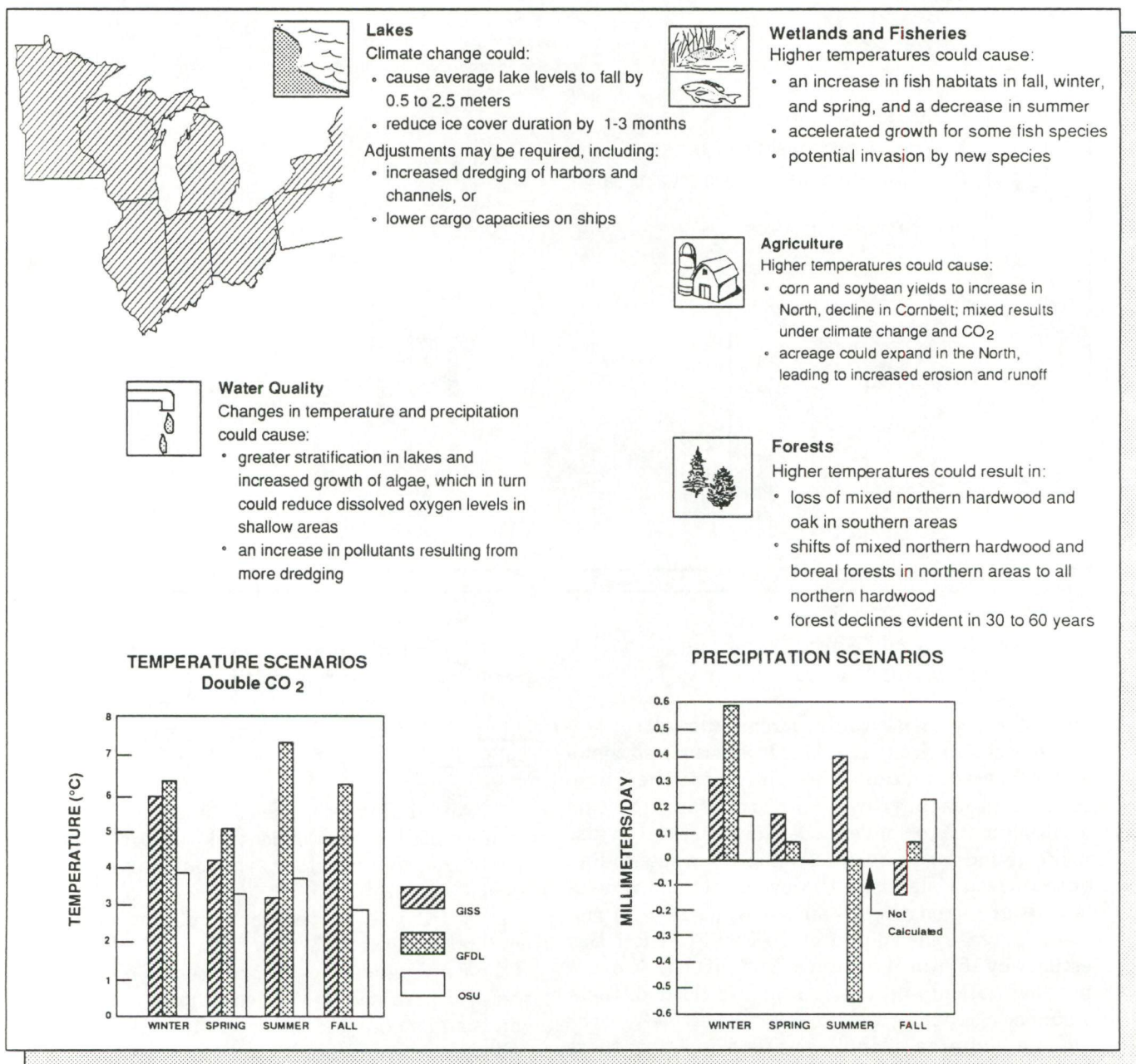
Air quality is currently a major concern in California. The area of central California in violation of ozone quality standards could increase due to higher temperatures. Under one climate scenario, with a 4°C rise and current emission levels, the maximum size of the area with ozone levels in excess of the EPA standard of 0.12 ppm could double. This scenario assumed that such climate variables as winds and mixing height (the volume of air in which pollutants were diluted) would not change.

### Great Lakes

The Great Lakes contain 18% of the world's supply and 95% of the U.S. supply of surface freshwater, and are an important source of commerce and recreation for the region. In recent years, reductions in pollutant loadings have significantly improved the quality of such water bodies as Lake Erie. The Great Lakes states produce 59% of the country's corn and 40% of its soybeans, and their forests have important commercial, recreational, and conservation uses.

Models were used to estimate the potential impacts of climate change on lake levels and ice cover. Results from these studies were used to analyze impacts on navigation and shorelines. Changes in the thermal structure of the Central Basin of Lake Erie and southern Lake Michigan were estimated. Output from these studies was used along with scenario temperatures to analyze potential impacts on fishes in the lakes. Changes in crop yields were estimated for corn and soybean and changes in forest composition were analyzed for Michigan and Minnesota (see Figure 13).

FIGURE 13. GREAT LAKES



Lake Levels Are Likely to Drop and Ice Cover Duration Would Decrease

Higher temperatures would most likely reduce snowpack and increase evaporation, which would lower lake levels. The level of Lake Superior was estimated to be reduced by 0.4 to 0.5 meters (1.2 to 1.5 feet), and that of Lake Michigan by 0.9 to 2.5 meters (3 to 8 feet). Diversions out of the lakes for irrigation or to supply other basins would further lower lake levels, although these were not analyzed. These results are very sensitive to assumptions made about evaporation and under an unlikely combination of circumstances, lake levels could rise.

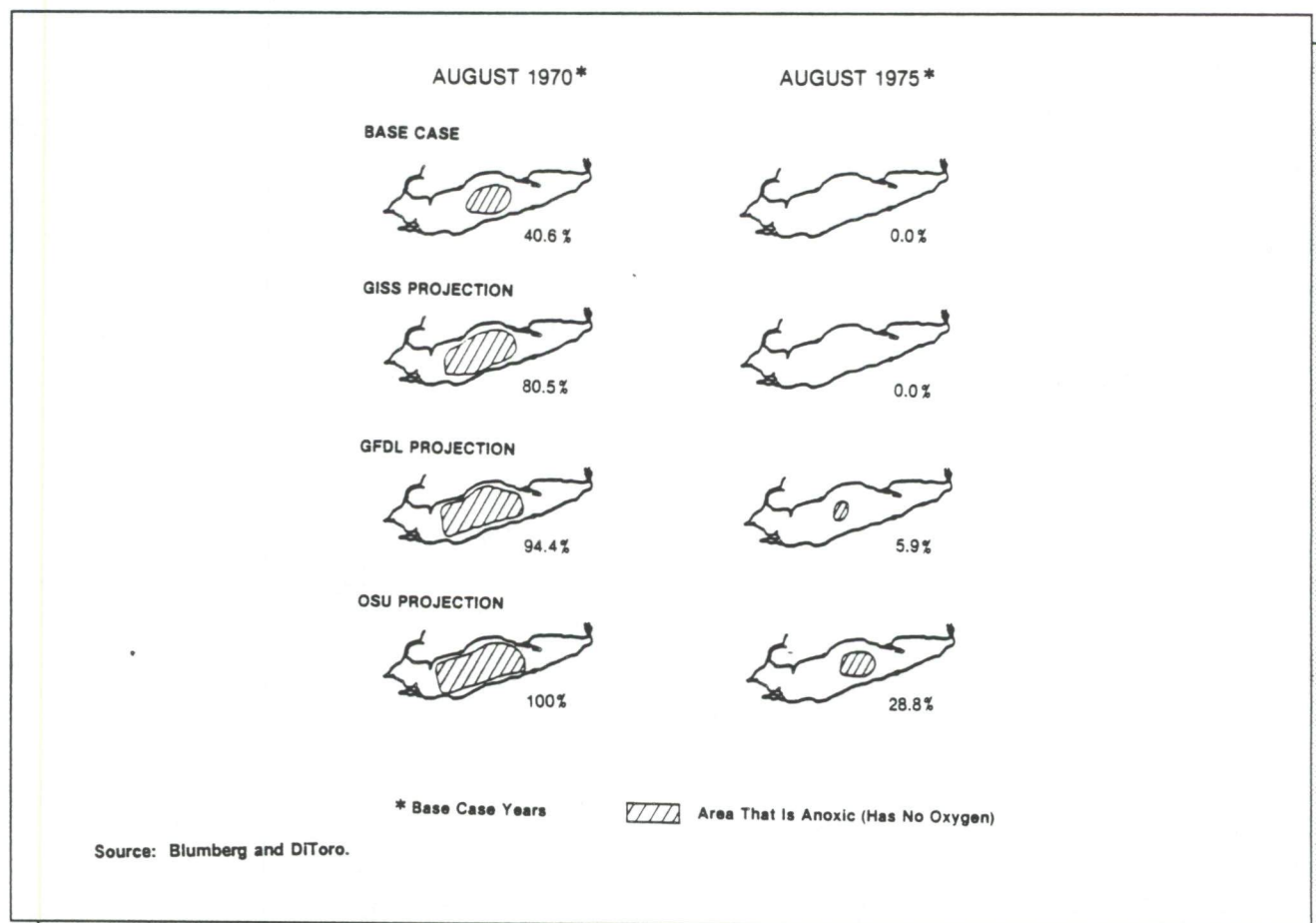
Higher temperatures would also reduce ice cover on the lakes. Specifically, they could cut ice duration by 1 to 3 months on Lake Superior and by 2 to 3 months on Lake Erie, although ice would still form on both lakes. Changes in windspeed would affect the reduction in duration of ice cover.

In response to lower lake levels, either ships would have to sail with reduced cargoes or ports and channels would have to be dredged. On the other hand, a shorter ice season would allow for a longer shipping season.

Water Quality May Be Degraded in Some Areas

Higher temperatures could lengthen stratification of the lakes (where summer temperatures warm the upper part of lakes and isolate the cooler lower layers of lakes). Analysis of the Central Basin of Lake Erie showed that longer stratification, combined with increased algal productivity, would most likely reduce dissolved oxygen levels in the lower layers of the lake (see Figure 14). Reducing pollutant loadings in the lake would likely result in less severe impacts. One study raised the possibility that the annual mixing of a lake such as Lake Michigan may be disrupted. If winds and storms increase, such outcomes would be less likely. Disposal of contaminated dredge soils could increase water pollution.

**FIGURE 14. AREA OF CENTRAL BASIN OF LAKE ERIE THAT BECOMES ANOXIC UNDER DOUBLED CO<sub>2</sub> SCENARIOS**



Fish Productivity In Open Areas May Increase

The average annual thermal habitat would increase with a warmer climate (see Figure 15). If sufficient oxygen is present, growth rates and productivity for such fish as bass and lake trout in open areas of large lakes may increase, provided that the forage base also increases. However, reduced ice cover and decreased water quality could harm some species in shallow basins of the Great Lakes. The effects of increased species interaction, changes in spawning areas, and possible invasion of exotic species were not analyzed.

Northern Agriculture May Benefit

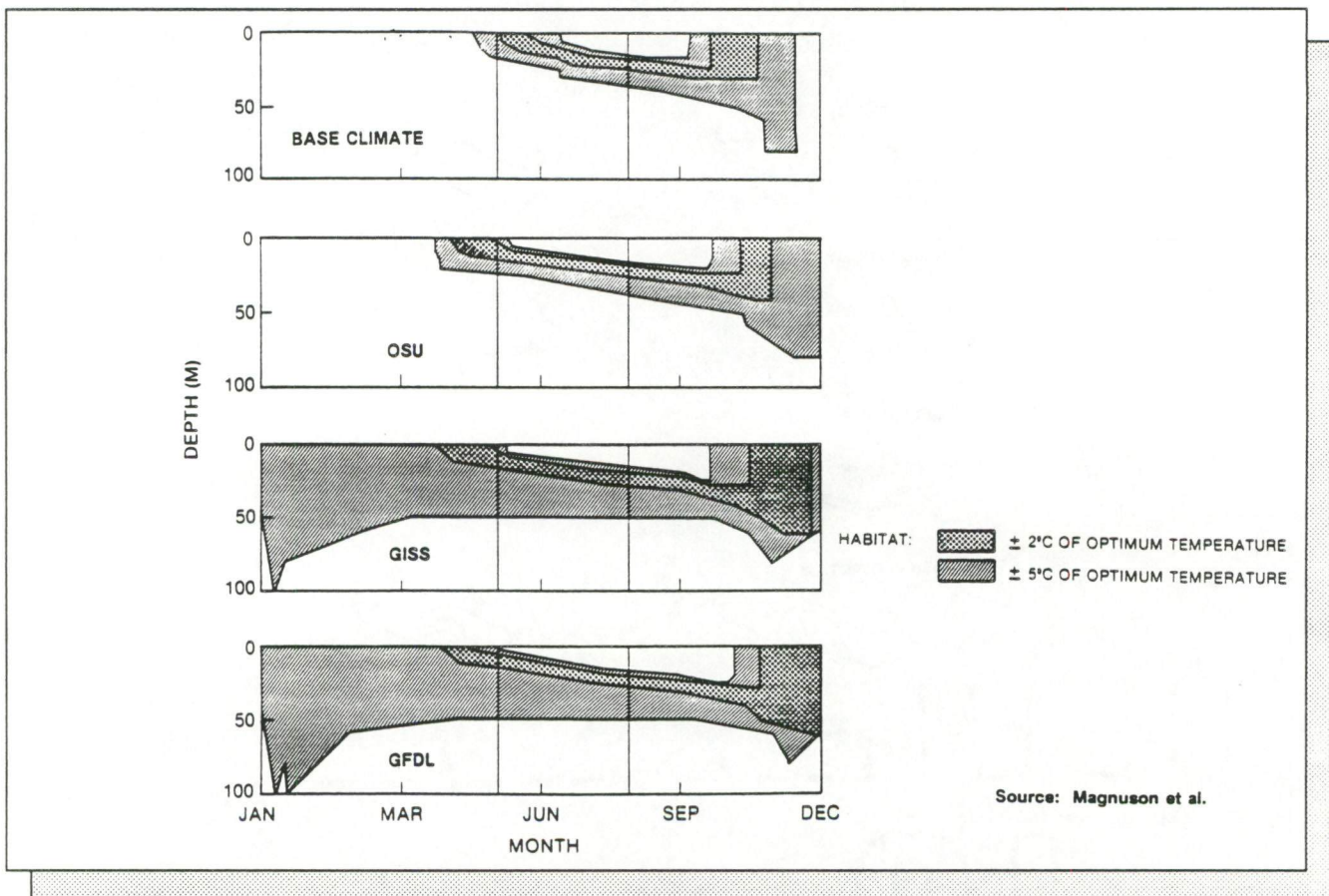
Due to the relative increase in northern agricultural productivity, agriculture could be enhanced in Minnesota, Wisconsin, and northern Michigan with additional opportunities for the agriculture support sector. The presence of relatively poor soils,

however, could limit agricultural expansion. Increased cultivation in northern areas could increase erosion and runoff, with negative impacts on surface and groundwater quality.

Forests Could Change in Abundance and Composition

Northern hardwood forests in dry sites in Michigan would die back and could become oak savannas or grasslands. In northern Minnesota, mixed boreal and northern hardwood forests may become completely northern hardwoods. Productivity in some wet sites in Michigan could improve. Commercially important softwood species could be replaced by hardwoods used for different purposes. Changes in forests could be evident in 30 to 60 years. Whether reforestation with southern species not currently in the region and CO<sub>2</sub> fertilization would mitigate these impacts was not studied.

**FIGURE 15. INCREASES IN THERMAL HABITAT FOR LAKE TROUT IN SOUTHERN LAKE MICHIGAN UNDER ALTERNATIVE CLIMATE SCENARIOS**



Source: Magnuson et al.

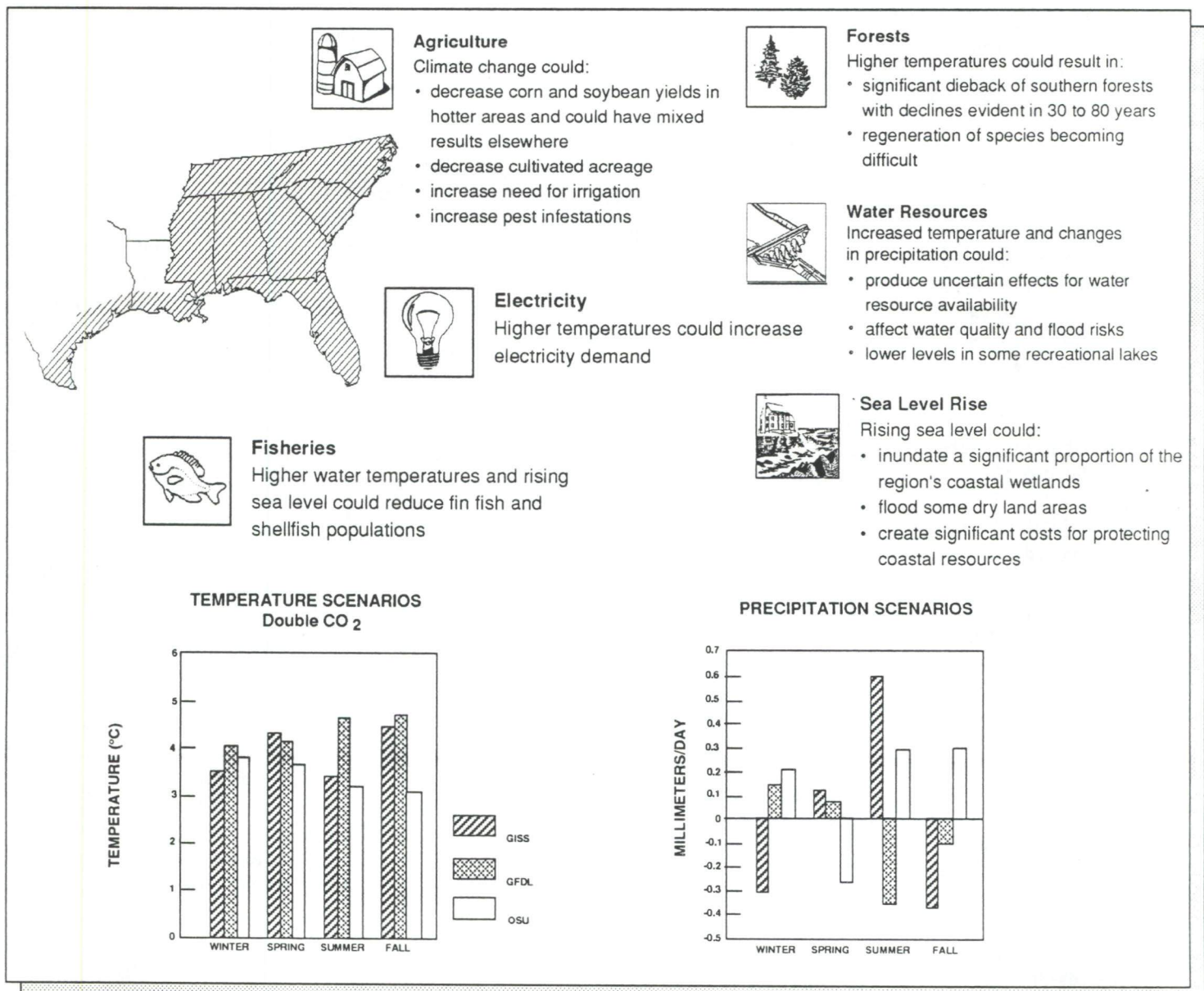
## Southeast

The Southeast is distinguished from the other regions in this study by its warm temperatures, abundant rainfall, large coastal plain, and productive marine fisheries. The region supplies about half of the nation's softwood and hardwood timber, and tobacco, corn, and soybeans are among its major crops. Over 85% of the nation's coastal wetlands are in the Southeast, and over 43% of the finfish and 70% of the shellfish harvested in the United States are caught in the region.

This report focused on two regions within the Southeast: the Tennessee Valley and the Chattahoochee and Apalachicola Rivers. The Tennessee

Valley Authority examined the potential vulnerability of its water management system to high and low riverflow scenarios (based on runoff estimates from GCMs). Flow in the Chattahoochee River Basin was estimated using hydrologic analysis to study impacts on the management of Lake Lanier, which supplies water to Atlanta. The estimates of outflow from the lake, along with estimates of the flow in the Apalachicola River, were combined with potential wetland losses attributable to sea level rise to identify impacts on finfish and shellfish in Apalachicola Bay. Sea level rise impacts for the entire Southeast were derived from the national studies. Crop yields were estimated for corn and soybeans, and changes in forest composition were analyzed at several sites across the region (see Figure 16).

FIGURE 16. SOUTHEAST



### Adverse Impacts on Agriculture and Forests Could Hurt the Region

Decreases in the relative productivity of southeastern agriculture were estimated to lead to the abandonment of 10 to 50% of the agricultural acreage in the region. The studies did not consider introduction of new crops, such as citrus, or the use of new technologies, such as biotechnology.

Most forests in the Southeast were estimated to have difficulty surviving climate change. Dieback of existing forests in such areas as Georgia and Mississippi may be particularly large. These changes could be evident in 30 to 80 years. The forest studies did not consider whether more southern species could be transplanted and survive in the region, not did they account for higher CO<sub>2</sub> concentrations, which could mitigate some losses. The combined effects of reduced agriculture and forestry could lead to significant economic losses in the Southeast.

### Many Coastal Fish Species Would Be Harmed

Sea level rise could inundate most of the coastal wetlands and raise salinity levels, which could reduce the populations of Gulf Coast fisheries. In addition, higher temperatures may exceed the thermal tolerances of many species of shellfish in Gulf Coast estuaries, further reducing fish populations. Whether these species would be able to migrate to cooler water was not considered. Some species, however, could increase in abundance, while others may migrate into the region.

### The Studies Were Unable To Determine Region-wide Impacts on Water Resources

The Southeast currently has little winter snowcover. Therefore, seasonal runoff depends much more on changes in rainfall than on changes in temperature which affect the size of snowpack. Analysis of the rivers managed by the Tennessee Valley Authority showed that increased runoff could lead to higher riverflow and higher flood probabilities, while less runoff could reduce flood probabilities, but could lead to lower riverflow problems maintaining adequate supplies for industrial use, powerplants, and dilution of effluent. Use of climate change scenarios produced inconclusive results concerning the potential change in flow in the Chattahoochee River. A study of the management of Lake Lanier concluded that changes in operating rules would be sufficient to handle higher or lower flows estimated in the scenarios, although some uses would be restricted.

## The Great Plains

Agriculture is one of the main sources of income in the Great Plains. The states of Kansas, Nebraska, Oklahoma, and Texas produced 80% of the nation's sorghum and 30% of the wheat crop in 1982. In recent years, increased use of water from the Ogallala Aquifer has reduced groundwater levels in the region, with potential long-term consequences for agriculture and the economy.

The studies in this report focused on Nebraska, Kansas, Oklahoma, and Texas and concentrated mainly on agriculture-related impacts. They estimated changes in corn, wheat, and soybean yields and in the demand for irrigation. Changes in runoff and leaching of chemicals from farms were also examined (see Figure 17).

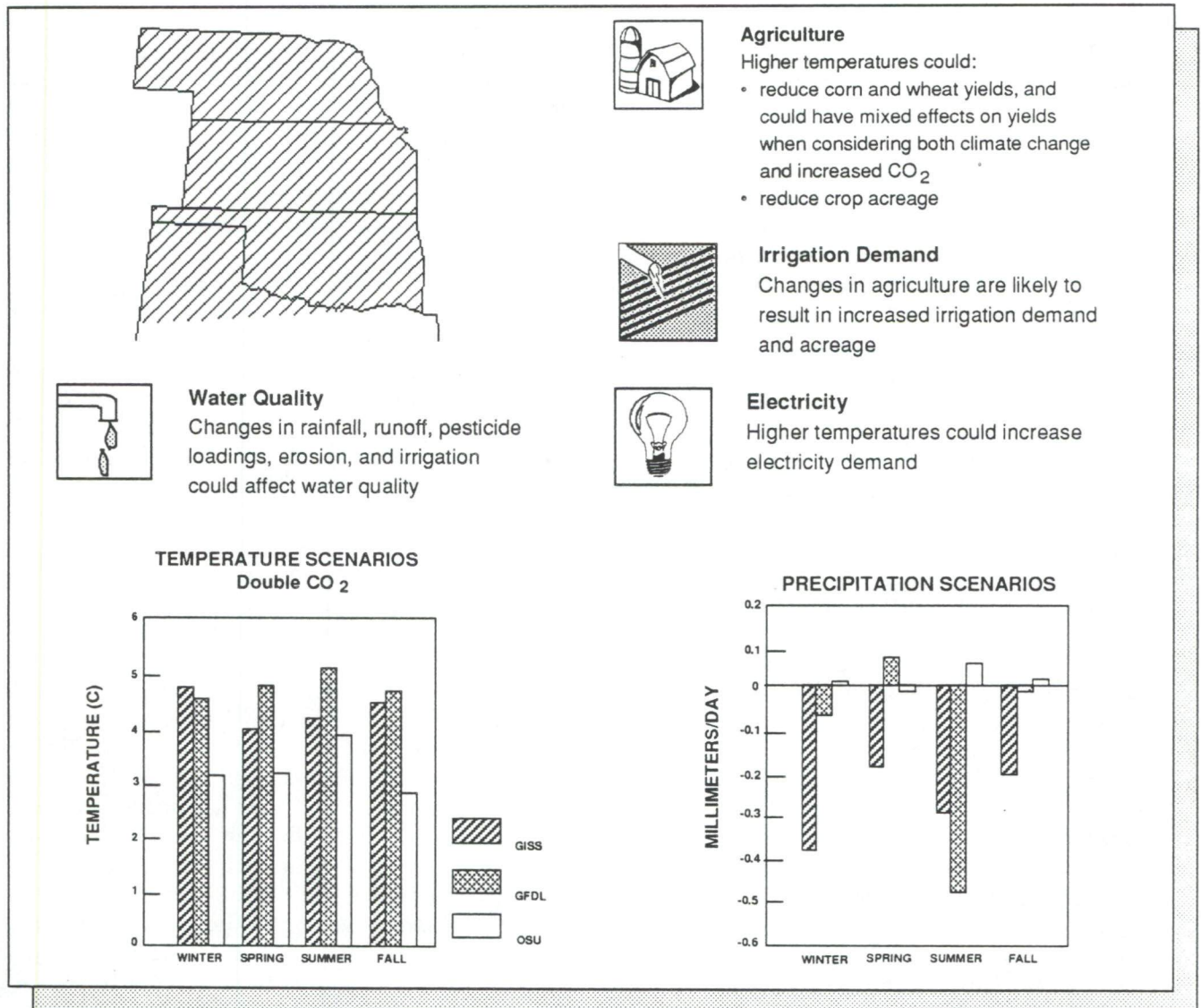
### Crop Acreage Could Decline

The crop yield and economic adjustment studies indicate that grain crop acreage could diminish in the region. The direction of changes in wheat and corn yields depends on the direct effects of CO<sub>2</sub> on crop growth and the severity of climate change. If climate becomes hotter and relatively drier, yields could decrease. Whatever the climate change, relative productivity may decline, compared to northern areas. As a result, crop acreage was estimated to drop by 4 to 22%. Such a reduction in agriculture could adversely affect the economy of the region. These studies did not consider use of new technologies or introduction of new crops.

### Demand for Irrigated Acreage Would Increase

The demand for irrigation on the farms that continue to grow grain crop could increase. Irrigated acreage, which currently makes up about 10% of the total acreage and is growing, could increase by 5 to 30%. This report did not examine how this demand would be satisfied, although the Ogallala Aquifer could be a candidate. Other impacts of global warming could change ground and surface water supplies and, possibly, surface water quality. Changes in precipitation could affect the leaching of pesticides into groundwater and runoff to surface waters in some cases, although the direction of change can not be determined because runoff and leaching of pesticides and soils are very sensitive to rainfall variability.

FIGURE 17. THE GREAT PLAINS



## FINAL THOUGHTS AND POLICY IMPLICATIONS

Because this is the most comprehensive study to address the issue of the environmental effects of climate change in the United States, we expect that a sizable debate will follow its publication. Considerable additional research and analyses are likely to amplify, improve, and challenge these findings. We expect further research to develop new insights into the role of climate, but precise forecasts must await more advanced climate models, which may require many years to develop. For some time to come, our ability to provide national and local officials with guidance may be limited to effects driven primarily by temperature and sea level changes.

Apart from strategies to limit emissions of greenhouse gases (discussed in the companion report), policymakers should consider policy options for adapting to global warming. Consideration of these options is complicated by the uncertainties identified in this report by delays in the onset of climate change, and by the pressure to solve today's problems. Many adaptations would undoubtedly occur as climate changes, but some decisions being made today have a long enough lifetime and sufficient risk to support consideration of the impacts of the greenhouse effect. These decisions should be made if they make economic and environmental sense for today's conditions and are sufficiently flexible to handle changing climate. Given the uncertainty about the timing, magnitude, and regional scope of climate change, we cannot plan for specific climate conditions in the future, but can strive to be ready to respond to significantly changed climate conditions in the future.

Conversely, natural resource management should not assume that climate will not change. All managers of natural resources that are sensitive to climate should consider the vulnerabilities of their systems to climate change and whether anticipatory steps are prudent. In some cases, no anticipatory action would be needed — the systems can be adjusted and adapted as climate changes. In other areas, where long-term decisions on sensitive systems may result in irreversible impacts, anticipatory actions to mitigate these potential effects may be required. It may make sense in some instances to change the rules under which long-term planning is done, such as zoning laws, to allow for consideration of climate change in private-sector decisions.

Finally, research and education are needed in many areas to improve our ability to respond to these changes. In any case, managers should reexamine their systems to consider ways to improve the flexibility and resiliency of the systems to handle these and other changes. The criteria to guide decisions should include consideration of the following factors:

- the uncertainties in the magnitude and timing of effects;
- whether the lifetime of the plan, project, or policy is long enough to be affected by climate change;
- whether effects of climate change are irreversible;
- whether the policy or project will increase flexibility and resilience or restrict future options;
- whether a policy or action makes economic or environmental sense, even without climate change;
- the uniqueness of the ecosystems or man-made structures that may need protection; and
- whether the impacts would be greater if no anticipatory action were taken.

The U.S. government is strongly supporting the Intergovernmental Panel on Climate Change (IPCC) under the auspices of the United Nations Environment Programme and the World Meteorological Organization. The IPCC has established a process for governments to follow when reviewing scientific information and policy options. The federal government is conducting other activities on global climate change. The Global Climate Protection Act of 1987 calls for a scientific assessment of climate change which is to be completed by 1989. This work will be sponsored by EPA and other federal agencies such as the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, and the National Science Foundation, and coordinated through the IPCC. Also, the Department of Energy and EPA have been asked to report to Congress on policy options for reducing CO<sub>2</sub> emissions in the United States. In addition, various federal agencies conduct significant research programs on climate. These research efforts on climate change are coordinated by the National Climate Program Office and the Committee on Earth Sciences. The latter has produced a plan called *Our Changing Planet: A United States Strategy for Global Change Research*, which outlines federal research activities.

The federal government can also take the lead in pursuing prudent policies in anticipation of climate change, and many agencies can play a role in preparing the country for the impacts. These include the departments of the Interior, Energy, Health and Human Services, and Agriculture; the U.S. Environmental Protection Agency; and the U.S. Army Corps of Engineers (see box on "Federal Activities"). However, adaptation should not occur just at the federal level, for there will likely be a need to involve

other nations, state and local governments, industry, and even individuals. The regional studies in this report demonstrate that climate change cuts across manmade and natural systems, geographic boundaries, and government agencies. Research, technical guidance, planning, and creative approaches to resource management will be needed in the future to prepare for the impacts of climate change on the United States.

### FEDERAL ACTIVITIES THAT SHOULD CONSIDER CLIMATE CHANGE

Sample questions relating to climate change impacts that federal agencies should consider:

Agencies	Policy Questions
U.S. Environmental Protection Agency	How should current wetland protection programs be modified to accommodate future sea level rise and precipitation changes?
U.S. Department of the Interior	Should regulatory approaches to air pollution be supplemented with incentive systems, new chemicals, or relocation policies?
U.S. Department of the Interior	Should national parks and wildlife refuges purchase land to accommodate migration necessitated by climate change? Should additional parks and refuges be created?
U.S. Department of the Interior	Are current activities increasing the vulnerability of species that might be threatened by climate change?
U.S. Department of the Interior	Should the U.S. Geological Survey produce maps with finer contour intervals in coastal areas? How will climate change alter projected ground water levels?
U.S. Department of the Interior	Will current water policies in the West prove to have been ill-advised if the climate changes?
U.S. Department of Agriculture	Do price support programs help or hinder the adjustments that climate change may necessitate?
U.S. Department of Agriculture	To what extent could irrigation be increased on a sustainable basis if climate becomes drier?
U.S. Department of Agriculture	What actions would be necessary to maintain national forests as the climate changes?
U.S. Army Corps of Engineers	How does a consideration of future climate change alter the relative merits of alternative approaches to coastal protection, flood control, and navigation?
U.S. Army Corps of Engineers	Will climate change affect the success of wetland protection efforts in Louisiana as administered under Section 404 of the Clean Water Act?
Federal Emergency Management Agency	Would current rate caps on premiums enable the National Flood Insurance Program to remain solvent if climate changes?
U.S. Department of Health and Human Services	Are current programs adequate to address potential changes in mortality and shifts in diseases resulting from climate change?



U.S. Department of Justice  
Land and Natural Resources Division

Office of the Assistant Attorney General

Washington, D.C. 20530

June 21, 1990

Hon. John A. Knauss  
Undersecretary,  
National Oceanic & Atmospheric Administration  
Department of Commerce  
14th and Constitution Ave., N.W.  
Washington, D.C. 20230

Dear Dr. Knauss:

This letter responds to your request that each agency participating in the CEES Mitigation and Adaptation Research Strategies (MARS) Working Group submit proposals for work to be done under the MARS FY 92 program and beyond.

As you know, under the auspices of the DPC Working Group on Global Change, we have been asked to lead a task force developing the practical underpinnings of the "comprehensive" and "emissions trading" approaches in preparation for international discussions on potential climate change policy. Our task force met June 19 to discuss the two main research components of the comprehensive approach: measuring and monitoring net emissions of greenhouse gases, and developing an index of the comparative impacts of the various gases. We were briefed by Dr. Dan Albritton of NOAA on the current science and the needs for further research. Our group, which included attendees from DOE, DOI, DOJ, EPA, NOAA, NSF, OSTP, USDA, and White House Counsel, considered how best to organize this research. The strong consensus was that the CEES Working Groups, in particular the MARS group (in light of its areas of expertise, and the emphasis of its Charter on supporting U.S. international negotiating positions), could play a key role in furthering this work, which includes the following:

1. Developing an accounting of net emissions of greenhouse gases. The MARS Working Group's Charter makes clear its intent to encompass all greenhouse gases, their sources and sinks. Much work is underway in many nations on the emissions of carbon dioxide from energy consumption practices. Additional work is needed on global, national and sectoral accountings of:

- Sinks of CO<sub>2</sub>, including the role of oceans, oceanic life, and ocean sequestration; roles of forests, grasses, and other plants; above-ground and below-ground sequestration; and chemical reactions in the atmosphere;
- Emissions sources and sinks of the other important trace gases, including both point and non-point sources (e.g. agricultural emissions of N<sub>2</sub>O and CH<sub>4</sub>).

Without such research, policy proposals will likely focus only on limiting CO<sub>2</sub> emissions from industry, excluding the use of sinks and limits on other gases from a variety of sources. Such a narrow focus on CO<sub>2</sub> would be less environmentally effective (given the radiative importance of other gases), less economically efficient and less equitable than a comprehensive approach.

The 16 gas-by-sector analyses currently being developed by the Mitigation Subcommittee of the MARS group are a promising beginning on such research. Sinks for CO<sub>2</sub>, under items 6, 15 and 16, are especially in need of research, as are the sources and sinks of N<sub>2</sub>O and CH<sub>4</sub>. We suggest adding halons, HCFCs and other related substances to item 11. Under item 14, the sources and sinks, including atmospheric sinks, of tropospheric ozone and its precursors should be analyzed. The MARS FY 92 research plan should contain explicit and detailed proposals to advance the accounting of sources and sinks of all greenhouse gases.

2. Developing practical means of monitoring or otherwise calculating actual emissions from sources and uptakes by sinks. Where practicable, means to directly monitor net emissions rates should be developed. In addition to direct monitoring, it will be necessary to develop surrogates or proxies for calculating net emissions that are not directly measurable. This task also includes devising means of monitoring and calculation that are sensitive to changes in net emissions resulting from changes in the ratio of resource inputs to greenhouse gas outputs, e.g. changes in fuel combustion techniques, animal diets, fertilizers, genetically engineered organisms, etc.

This monitoring or calculating capability is essential if claimed accomplishments and compliance with international and national policy instruments are to be objectively verifiable. In addition, careful monitoring or calculation of actual net emissions will enable better forecasts of future atmospheric concentrations of relevant trace gases.

Both CEES Working Groups appear to have expertise in this area. The need to understand the activities, technologies and practices that lead to emissions (and the careful choice of surrogates to monitor certain emissions) suggest a prominent role for MARS. Perhaps a joint group would be best.

3. Developing an understanding of the comparative environmental impacts of greenhouse gases, building on the current work on an "index" of "global warming potentials." (See the GWP index developed by Working Group I of the IPCC, and the ODPs used in the Montreal Protocol.) This task is central to the development of the comprehensive approach. Considerable work has already been done on the instantaneous radiative forcing of the different gases, and this factor is in general quite well understood (though additional work could be done to relate forcings to the ambient concentration of the gas and other relevant factors). The key items for the MARS research plan to pursue further work on include:

(a) Residence times and chemical behavior of different greenhouse gases, especially the residence time of CO<sub>2</sub>, which is still subject to important uncertainties. Determining the residence time of CO<sub>2</sub> will, in turn, require better understanding of its sinks. Better estimates of residence times of CH<sub>4</sub> and other gases with important atmospheric chemical sinks are also needed; this in turn implies better understanding of such factors as the hydroxyl population and its behavior in the atmosphere.

(b) Incorporating discount rates or time horizons. The choice of time values will rest on scientific, environmental and socioeconomic factors.

(c) Incorporating the flexibility to respond to new research results about residence times and other factors.

(d) Constructing an overall environmental impacts index, beginning with the relative warming potentials, incorporating the items just mentioned, and incorporating evidence of the non-warming impacts of different gases, e.g. benefits to agriculture from CO<sub>2</sub>'s impacts on plant photosynthesis and water use efficiency, CFCs' impacts on

ozone depletion and hence on agriculture and other life, and other gases' toxicity. Incorporation of these non-warming impacts will likely require a multidisciplinary effort, and is very important if policy measures are to avoid providing incentives that lead to environmentally deleterious results.

Both of the CEES Working Groups will probably need to work on these tasks. Given the importance of these tasks for international policy discussions and their reliance on both policy choices and scientific information, the MARS might be the more appropriate group to lead the effort, working in concert with the relevant sections of the CEES Global Change Working Group. Within MARS, as appropriate, either the Mitigation subgroup or the Implementation Strategies subgroup could be designated to be the lead.

4. Economic and institutional analysis. Such analysis includes:


(a) Researching market-based tools for mitigation and adaptation. This includes the work the MARS group is organizing to analyze the changes in technologies and practices which might be used to mitigate or adapt to climate change, in all sectors of socioeconomic activity. But it also means understanding the institutional systems at work -- markets, government policy, etc. -- that affect the likelihood of such changes being invented, disseminated, and adopted. This research will be invaluable to policy makers, in order to present them with means to provide incentives for least-cost, innovative, diverse and flexible responses by decentralized market actors, rather than simply generating a list of practices and technologies from which government would select.

(b) Assessing the economic, social and environmental costs and benefits of various policy options, including both options proposed by the U.S. and options proposed by other nations, for use in both domestic and international discussions.

This work is already being discussed under the MARS' Economics Subcommittee, and should be further pursued by its Implementation Strategies subgroup and its Economics Subcommittee.

We hope these suggestions will be incorporated in the appropriate places in the MARS research plan and the FY 92 proposals. They are intended in large part to reflect the research needs for sound development of any international policy regarding potential global climate change, as suggested by the Charter of the MARS Working Group.

Sincerely,

A handwritten signature in cursive script, appearing to read "Richard B. Stewart".

Richard B. Stewart  
Assistant Attorney General

cc: D. Allan Bromley  
Relevant CEES-MARS subgroups  
Members of Comprehensive/Trading Task Force

## FIRE AND WATER

WHERE THERE'S  
SMOKE...

*"We believe that global environmental change may well be the most pressing international issue of the next century."*

P. 63

**T**his sentiment comes not from some small environmental sect, but from the presidents of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The problem is simply stated, if profound: Human activity is altering the Earth's atmosphere in ways that could trigger climatic changes as dramatic as those associated with an ice age. Moreover, these changes could come far more swiftly than any natural climatic shift, altering the destiny of nations, causing human hardship, and wreaking ecological destruction.

## CAUSES

The causes are in part ancient—human use of fire, clearing of forests for crops, and tending of beasts for food—but magnified by the scale of modern industrial civilization and its insatiable appetite for energy—and by human population growth. Energy use—our modern fire—has grown tenfold since 1900, and we have relied primarily on coal, oil, or natural gas. When burned, these fossil fuels release carbon dioxide, which can trap heat and thus warm the atmosphere. Additional carbon dioxide comes from the clearing and burning of huge tracts of the world's tropical forests.

Methane—from natural gas leaks, from fermentation in rice paddies and the stomachs of farm animals, and from burning of forests and grasslands—is another heat-trapping gas, 20 to 30 times more potent than carbon dioxide. Methane levels in the atmosphere have

nearly doubled this century, pushed by growth in energy use and population.

Added to these scaled-up sources of naturally occurring gases is a modern, completely artificial agent: chlorofluorocarbons. CFCs, which in the stratosphere destroy Earth's ozone layer, in the lower atmosphere act as a heat-trapping gas more than 10,000 times as effective as carbon dioxide, molecule for molecule. Atmospheric CFC levels are rising 5% per year.

Altogether, the world added the equivalent of 6.5 billion tons of carbon—in the form of carbon dioxide or other heat-trapping gases—to the atmosphere in 1987, the latest year for which complete figures are available.<sup>1</sup> That amounts to about 1.25 tons of carbon for every man, woman, and child on the planet.

Not every citizen or every country of planet Earth contributed equally, however. Industrial countries, those undergoing significant deforestation, and those with abundant rice paddies or farm animals contributed more. A new "Greenhouse

Index"<sup>2</sup> that ranks countries based on emissions of heat-trapping gases finds the United States at the top of the list, followed by the Soviet Union, Brazil, China, India, Japan, and Germany. Overall, industrial countries contributed 55% of the increase in the atmosphere's warming potential, but developing countries had a significant share. It is, in other words, a truly global problem.

## CONSEQUENCES

Higher temperatures can be a blessing or a curse, depending on where you live. To a dweller in an already sweltering sunbelt city, the prospect of two or three times as many 100-degree days is

not a blessing. To a Canadian wheat farmer, however, a longer growing season and milder winters might be welcome. If global warming comes, however, temperature will be but one of the consequences. Water shortages in some areas could be another.

A shift to a warmer climate would bring major—but unpredictable—shifts in rainfall patterns, snowfall accumulation, and soil moisture. Overall, rainfall might increase as much as 10% with even modest global warming, but the distribution would be highly unequal, with more precipitation in high and low latitudes in continental regions of the Northern Hemisphere, and less in the middle latitudes. Unfortunately, the middle latitudes are where the most intensive agriculture takes place. The result could be summer conditions reminiscent of the Dust Bowl years in sections of the U.S. Great Plains and in parts of the Soviet Union and Central Europe, with much heavier rain and river flooding in other regions.

Duke University botany professor William Schlesinger says that the degree of global warming projected for the next century, based on current trends, might convert a significant portion of the world's grasslands into desert. "These changes may affect regions that are far removed from arid lands and possibly conditions of the entire planet," says Schlesinger. "If the climate models are right, the breadbasket of this country will move north. Iowa, Nebraska, and Kansas will become less productive, and the wheat and corn belt will probably shift to southern Canada."

A worst-case scenario, according to Schlesinger, is that "a large portion of west Texas and eastern Colorado will be permanently converted to desert shrub land of low productivity" that will no longer be able to support agriculture or even serve as quality grazing lands.

Major changes could also be expected in American forests. For example, spruce, fir, and pine trees might relocate from the upper Midwest to Canada. Daniel B. Botkin, head of a study on the topic out of the University of California at Santa Barbara, reported in 1989 that "if the climate warms as rapidly as currently predicted, there will be visible and dramatic changes in U.S. forests in our lifetimes."

A panel of experts convened by the American Association for the Advancement of Science (AAAS) in a recent report concluded that global warming would have a major impact on the distribution of water in the United States, with drier summers in the interior of North America.

Extremes, such as floods or droughts, are likely to lead to the following:

- It will be hard to maintain present irrigation levels in the arid West; spring floods will come earlier.
- Plants—including weeds—will grow faster because of higher levels of carbon dioxide, which acts as a fertilizer.
- Costs will rise for the eight out of 10 Americans who depend on municipal water systems.
- "Governments at all levels," the AAAS report states, "should re-evaluate legal, technical, and economic procedures for managing water resources in light of the climatic changes that are highly likely."

Worldwide, matters could be even more severe in regions already subject to water stress, defined by Swedish hydrologist Malin Falkenmark as the level of scarcity reached when a society's per capita renewable water supply sinks below 530,000 gallons per year. Ten countries in Africa will probably reach this level—even without taking greenhouse effects into account—by the year 2000. Parched Egypt, where 55 million people subsist on the waters of the Nile, is particularly vul-

nerable. Egyptian Foreign Minister, Esmat Abdel Meguid, commenting on the relentless tug-of-war over water that is now taking place among Ethiopia, the Sudan, and Egypt, has said that "The next war in our region will be over the waters of the Nile, not politics."

Ironically, global warming could cause some islands and coasts to literally drown, because of rising sea levels. Water expands when it is heated; such thermal expansion alone could create a one- or two-foot rise over the next century, and some climatologists believe that melting of glaciers and the polar ice caps could add three to five feet more.

Recently, some scientists have considerably moderated the forecast for the sea level rise, based on the observation that the polar ice caps seem to be

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Kunin presses environmental issues with Bush

MONTPELIER, Vt. (UPI) - Vermont Gov. Madeleine Kunin took the case for an international global warming policy to the White House Monday, but returned from the meeting with a mixed report.

Kunin, a Democrat, and Republican Governors Terry Branstad of Iowa and James Thompson of Illinois met with Bush, EPA head William Reilly and White House Chief of Staff John Sununu.

The three governors urged Bush to build a national and then an international consensus on a plan to avoid a global warming trend.

"The important thing is this is a consensus document and that the recognition is that we must act now and that the United States should take a strong leadership role at the earliest possible date," Kunin said after emerging from the Washington meeting.

The governors were armed with a report calling for greater energy conservation, an international agreement on reductions in the production of environmentally harmful gasses and the re-forestation of large areas.

The report was prepared by Kunin and several other governors for the National Governor's Association.

Some scientists believe manmade pollution is making the earth's climate warmer, with potentially dire environmental consequences.

Kunin said she told Bush it is up to the United States to take a leadership role on the issue.

Kunin said Bush told the governors he will consider their report carefully, but that Bush did not say exactly how he would use it.

However, Kunin believes the report should be used to rally support for national and international action because it represents a consensus developed by diverse states with varied economic, energy and political realities.

For example, coal-producing states signed onto the report along with northeastern states worried about acid rain, believed to be a by-product of emissions generated by coal-fired power stations in the midwest.

"I think it's important to continue to give the president and this administration ammunition to move forward on a very strong environmental policy, particularly on the global arena," Kunin said.

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The panel also heard testimony from Rep. Curt Weldon, R-Pa., chairman of the Congressional Fire Services Caucus. Weldon said the Mega Borg accident "has pointed up the need to specifically address the danger of fires aboard multi-million barrel oil tankers" in the spill legislation before Congress.

The former firefighter said available technology might have prevented the Mega Borg fire if regulations existed to require it on commercial ships.

"The Navy has technology today that we could require on commercial vessels that would detect and suppress these kinds of fires," Weldon said. "Stricter controls for fire and safety are needed on all commercial ships, especially those under foreign flags."

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USA TODAY • MONDAY, JUNE 25, 1990 • 3A

# Govs offer global warming goals

## Report contains 7 proposals

By Dennis Camire  
USA TODAY

The USA's governors today give a reluctant President Bush seven "reasonable" goals to greatly cut emissions of carbon dioxide, the main gas responsible for global warming.

"We literally owe the habitability of our planet to the phenomenon commonly known as the greenhouse effect," says a report by the National Governors' Association.

Iowa Gov. Terry Branstad, president of the group, says in the report that, although uncertainty exists about global warming "and the costs of prevention could be substantial, we must take action."

The report's reception at the White House is uncertain. In February, Bush said more research is needed before action can be taken. His chief of staff, John Sununu, has adamantly opposed taking measures against global warming.

But the U.N. commission Bush said should be the sole authority on the subject warned last month that global warming has begun and urgent measures should be taken to deal with it. World average temperatures will rise 5.4 degrees before the end of the next century, causing a yearly sea-level rise of 2.3 inches a decade — unless emissions are curbed.

The report urges the federal government and the states to:

- ▶ Develop an international agreement to protect the air so reductions in greenhouse gases here would not be offset by increases in other countries.

- ▶ Use energy conservation and heightened efficiency to cut carbon dioxide emissions. Options include taxing gas-guzzling autos and improving appliance efficiency standards.

- ▶ Stop producing chlorofluorocarbons, used in air conditioners and other products, and reduce the production of other greenhouse gases, such as methane and nitrous oxide.

- ▶ Develop alternative energy systems, including clean coal technologies, solar and geothermal energy, wind power and safe nuclear power.

- ▶ Plant more trees, which absorb carbon dioxide, in both rural and urban areas.

- ▶ Adapt to a changing climate, with special emphasis on problems related to sea-level rise, water resources, agriculture and forestry.

- ▶ Support research to eliminate uncertainties about global warming, including the cost and effectiveness of ways to deal with it.

*Dennis Camire writes for Gannett News Service.*

WARREN BROOKES

# \$1 trillion radon rip-off

## Irrational toxic goal

If Congress and the Environmental Protection Agency get their way, American homeowners will have to spend \$1 trillion to bring the radon levels in their houses down to natural background levels. Those levels are 70 percent lower than even the present EPA danger target and they are the ludicrous goal set by Congress as an amendment to the 1988 Toxic Substances Control Act.

A paper in this month's *Journal of Environmental Science and Technology* says: "The implications of measures needed to achieve this goal are staggering. Even if it is technically feasible, the costs would be prohibitively large, on the order of \$1 trillion (\$10,000 to \$16,000 per household times 70 million households)."

Yet, as the paper points out, less than 3 percent of total risks of radon exposure are among those who do not smoke. That's fewer than 500 people per year nationwide. Ninety-seven percent comes from smoking and radon. In other words, non-smokers make up 60 percent of the population but only 3 percent of the radon risk.

The author of this paper is William Nazaroff of Lawrence Berkeley Laboratory at the University of California. He and his colleague, Anthony Nero, are generally regarded as the nation's foremost experts on radon risk and its mitigation.

Mr. Nazaroff's paper is a scorching indictment of the EPA and Congress for a radon policy that "is developing without careful analysis of the premises and objectives for con-

trolling risk in the indoor environment."

In short, we have here a replay of Congress and the EPA's asbestos disaster, where billions are being mispent because of a failure to accurately identify real risk. In that case as well, much of the miscalculation of asbestos risk was failure to identify the 88 percent role of smoking in the original study of asbestos exposure.

At the heart of the radon risk problem is the fact that although the current risk estimates project some 16,000 cancer deaths from this source, "only 3 percent of this mortality rate (about 500 cases) is projected to occur among individuals who have never smoked." Even that is based on models which deliberately overstate risk by at least 10 to 100 times or more, suggesting an insignificant public health risk.

The respected *Journal of Health Physics* will soon publish a study by Dr. Linda Titus Ernstoff of the University of Pittsburgh and Dr. Thomas Gerusky of the Pennsylvania Department of Health which shows that among a sample of 800 residents of very high radon exposure homes in the infamous "Reading Prong" — 10 times the EPA danger level — there was no evidence of raised lung cancer death rates.

Partly because of this kind of data, Pennsylvania has adopted an official policy of offering professional testing help only to those whose basement canister readings are above 20 picocuries per liter. That's five times the EPA level of 4 picocuries per liter and is the same

level now used in Canada to detect possible remediation targets.

The economic significance of this is huge. At 20 picocuries per liter, less than 80,000 U.S. homes would need radon mitigation at a cost of about \$150 million or about 0.1 percent of the cost of meeting the EPA's current standard, which targets 8 million to 10 million homes. Mr. Nazaroff also suggests that the Canadian 20 picocuries per liter level would make more sense.

One reason, he says, is that "More than 90 percent of the lung-cancer

risk associated with radon could be controlled by eliminating smoking without any changes in radon concentrations."

He estimates even the total cost of meeting present EPA standards of 4 picocuries per liter is about \$20 bil-

lion. He points out that "A reduction by about 3 percent in the number of cigarette smokers would reduce the annual mortality due to lung cancer by the same amount as a radon-mitigation program" at current standards.

As Mr. Nazaroff puts it, "From a public-health perspective, the goal of reducing lung cancer incidence may be more easily met by changing the population's smoking habits rather than by aggressive measures to reduce indoor radon concentrations."

This is reinforced by the work of University of Pittsburgh radiation physicist Bernard Cohen. He looked at 411 U.S. counties and discovered the correlations between lung cancer deaths and radon levels are on the average negative — higher radon levels are associated with lower lung cancer deaths. A similar lack of correlation has been just reported in a study of more than 200,000 medical records in Florida.

Mr. Nazaroff says, "It has not yet been possible and will be difficult in the future to demonstrate a compelling association between environmental radon exposure and lung cancer rates."

In the March 1990 issue of *Epidemiology*, Fanny Ennever of the Case Western Reserve School of Medicine says the lifetime risk of lung cancer for someone never exposed to radon (at EPA danger levels) and who has never smoked is 1.1 percent. That risk only rises to 1.5 percent from 40 years of exposure to EPA's radon danger levels! By contrast, the lifetime risk for the full-time smoker is 12.3 percent which rises to 15.8 percent with radon exposure. She concludes: "Ceasing to smoke is considerable more beneficial than easing radon exposure" — and a whole lot less costly.

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# The Great Climate Debate

*Greenhouse effect and the prospect of global warming is the subject of scientific and political controversy. Should we take steps now to avoid consequences we cannot foresee?*

by Robert M. White

In the waning years of the 10th century, millions braced themselves for the apocalypse, believing that the approaching year 1000 was the very millennium—the end of the heavens and the earth prophesied in the Bible's Book of Revelation. Not surprisingly, the prospect of the impending Day of Wrath terrified normally sane people into rash and (in retrospect) foolish actions. Some gave away all of their possessions; others hastened to do harsh penance for their deeds.

In this final decade of the 20th century, a different kind of apocalypse causes widespread concern. This time the hand of God has been replaced by more visible agents: belching smokestacks, gasoline-powered automobiles, power-generating stations and the voracious destruction of forests, all of which may be turning up the heat on an overburdened environment. Global climate warming, some claim, threatens the very habitability of the planet. Others hold that the predictions of environmental collapse are not well founded and are goading us into hasty political action. Is our planet the "En-

ROBERT M. WHITE is president of the National Academy of Engineering. He was formerly chief of the U.S. Weather Bureau and administrator of the National Oceanic and Atmospheric Administration. He has also served as president of both the University Corporation for Atmospheric Research and the American Meteorological Society. In 1979 he was chairman of the first World Climate Conference of the World Meteorological Organization.

dangered Earth," as *Time* magazine would have it in its 1988 year-end cover story? Or is it as *Forbes* magazine put it, "The Global Warming Panic: A Classic Case of Overreaction"?

Debate in the media reflects uncertainty among climatologists and geophysicists. Some of the world's eminent authorities on the atmosphere recently hurled verbal brickbats at one another in the pages of the prestigious journal *Science*. Their charges of "junk science" and "science by consensus" reflect the acrimonious nature of the debate within the scientific community. Some members of the National Academy of Sciences, including one of its former presidents, charge that policymakers are being induced to take unwise actions on the basis of uncertain scientific evidence. Set against this view is the recent statement of the Union of Concerned Scientists urging action by the government. It was signed by 52 Nobel laureates and more than 700 members of the NAS.

In spite of the scientific uncertainty, government and nongovernment groups are rushing to outdo one another in urging drastic action now to "stabilize" the global climate. From Washington to Toronto and The Hague, from Cairo to Moscow, international conferences of experts and political leaders have called for action. Soviet President Mikhail S. Gorbachev, President George Bush, British Prime Minister Margaret Thatcher and French President François Mitterand share similar views on the climate-warming issue.

Back home, debate within the Bush administration on how the U.S. government should act is intense. Caught be-

tween the urgings for action from the Environmental Protection Agency and Congress and cautions from his science adviser and chief of staff, President Bush called two major conferences to address the issue of climate warming. The first, held in April, brought together the heads of scientific, economic and environmental agencies of many governments. The second will be an initial meeting of governments, scheduled for early 1991, to begin negotiation of an international convention to stabilize global climate.

While there are still doubts in the White House, Congress has been environmentally hyperactive. Many pieces of legislation have been introduced to address the predicted climate warming. Leading the bipartisan effort have been Senator Timothy E. Wirth of Colorado, Senator Al Gore of Tennessee and Congresswoman Claudine Schneider of Rhode Island. Some of this legislation is comprehensive and far-reaching. It offers suggestions for action on the energy, agriculture and transportation fronts as well as for intensified research.

The actions proposed would radically change the most vital functions of human economies. They could include such diverse actions as using energy more efficiently, shifting the fossil-fuel mix from oil and coal to natural gas, relying more heavily on renewable energy sources and using more nuclear and solar energy. Measures could also include implementing reforestation, phasing out use of chlorofluorocarbons (CFC's) and changing agricultural practices.

Policy initiatives of this kind would

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alter the technology and economics of energy. Our use of land and water would also need to change. Economic growth in nations dependent on fossil fuels might be slowed. And the problems of arresting the growth of global population would become even more pressing. How can national and international policy formulation be moving so rapidly to address the specter of climate warming when agreement about the science is lacking and the economic and social costs of action have hardly been tallied? At the root of this thinking is a confluence of diverse scientific, economic and environmental forces.

The idea that the actions of humanity might change the composition of the atmosphere and hence the world's climate has deep historical roots. As early as the 1860's, it was suggested that slight changes in atmospheric composition might bring about major variations in climate. Increases in carbon dioxide (CO<sub>2</sub>) and other atmospheric trace gases can contribute to what has been called greenhouse warming because these compounds allow the sun's energy to reach the surface of the earth, thereby warming it, while pre-

venting much of that energy from being reradiated to outer space.

At the end of the 19th century the Swedish scientist Svante A. Arrhenius calculated how changes in carbon dioxide content would affect the temperature at the earth's surface. He estimated that a doubling of carbon dioxide would produce a global warming of about seven to 11 degrees Fahrenheit (four to six degrees Celsius), not too far off modern calculations. Yet it was only with the inception of the International Geophysical Year, a worldwide experiment in 1957 to monitor the global environment, that scientific data validating the increase of carbon dioxide in the atmosphere became available.

Roger Revelle, then director of the Scripps Institution of Oceanography, his colleague Hans E. Suess and C. David Keeling, his student, undertook such measurements. Revelle had long contended that humans were carrying out an unintended geophysical experiment on the atmosphere by burning fossil fuels. Determined to monitor the carbon dioxide content of the atmosphere, he persuaded Keeling to develop the instrumentation.

The measuring devices were placed in the Mauna Loa climate observatory in Hawaii at an altitude of about 11,000 feet. Beginning in 1957, the data they collected revealed a systematic increase in atmospheric carbon dioxide. Keeling's observations were verified at the South Pole and at other locations around the world. To date, the change from 290 parts per million in 1880 to 352 parts per million in 1989 represents more than a 20 percent increase over the course of the past century.

Just before the International Geophysical Year began, on the other side of the continent from Scripps, another development key to unraveling the climatic consequences of increasing carbon dioxide emissions was taking place. Under the leadership of the world-famous mathematician John von Neumann at the Institute for Advanced Study in Princeton, N.J., the first attempts were made to represent the atmosphere mathematically on digital computers.

Von Neumann's team of brilliant young scientists was headed by Jule G. Charney. Later known as the father of

numerical weather prediction and arguably the most important American figure in the transformation of weather prediction from art to science, Charney demonstrated the feasibility of using computers to perform the task. Von Neumann and Charney calculated the first 24-hour weather forecast in 1950 on a primitive digital computer, the ENIAC, maintained by the U.S. Army Signal Corps in New Jersey.

Looking beyond these efforts, von Neumann called climate forecasting the "infinite prediction." One of the young scientists in the Princeton group, Norman Phillips, made the first attempt at modeling the global atmosphere in 1956. It was coincidence that later, in 1963, an unusual laboratory of the National Oceanic and Atmospheric Administration (NOAA) was established on the campus of Princeton University under the leadership of Joseph Smagorinsky, a strong-willed and hard-driving young scientist who had been one of von Neumann's group. The laboratory was totally devoted to the mathematical modeling of the atmosphere using the largest and fastest digital computers available.

Called the Geophysical Fluid Dynamics Laboratory, the center harbored researchers from many nations interested in this new approach to the study of the atmosphere. Among them was a young Japanese scientist, Syukuro Man-

abe. Modest and retiring but completely dedicated to the work, he developed the first climate model in collaboration with his colleague Richard T. Wetherald in the 1960's. In 1975 they calculated that a doubling of the carbon dioxide content of the atmosphere would produce a global climate warming of about five degrees F (three degrees C), averaged over the surface of the earth. This calculation has been verified in many different laboratories and has not changed substantially.

Keeling's observations, together with the calculation of Manabe and Wetherald, triggered the wave of climate-change research that has marked the past two decades. Studies have since been undertaken in many parts of the world, including Europe and the Soviet Union. In the U.S. the National Research Council conducted studies in 1966, 1977, 1979, 1983 and 1987. These inquiries were chaired by such leading scientists as Gordon J. F. MacDonald, Revelle, Thomas F. Malone, Charney, William A. Nierenberg and economist William D. Nordhaus.

Yet because there were no immediate consequences for human health and no evident manifestation of climate change, the work was slow to arouse political concern. The most politically influential study was the one prepared in 1979 at the request of Frank Press, now president of the NAS, who was then White House science adviser to President Jimmy Carter. It was also in 1979 that the World Meteorological Organization in Geneva, recognizing the potential global significance of the issue, convened the first World Climate Conference.

Gradually, scientific awareness that humanity might actually be causing a planetary disruption began to register in the political world. Although there was much debate over the validity of projections from computer models, the observations of greenhouse-gas increases, however, were precise, well measured and verified in many parts of the world. These were corroborated by additional data that documented increases in other greenhouse gases such as methane, or natural gas, and CFC's.

Meanwhile mathematical-modeling groups in this country had been established not only by the NOAA but also by the National Aeronautics and Space Administration, the Department of Energy and the National Science Foundation. The leaders of these laboratories became the "gurus" of climate warming. Incisive and original in their work, Stephen H.

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Schneider of the NSF's National Center for Atmospheric Research in Boulder, Colo., and James E. Hansen, the leader of NASA's Goddard Institute for Space Studies, were soon to become frequent witnesses at innumerable congressional committee hearings on the subject.

Although the mathematical models of all the groups yielded similar results, the details of the geographic distribution of climate changes differed from one model to the other. All projected that an increase in carbon dioxide would bring about a gradual warming, but the timing of this warming would depend on the rate of global energy use. They all agreed that

if reasonable assumptions were made about future global energy consumption, it would be around the middle of the next century that the carbon dioxide content of the atmosphere might double.

Just how much this doubling of carbon dioxide would increase temperatures, however, varied greatly from model to model. Some predicted as little as a two-degree F (one-degree C) increase, whereas others predicted increases of as much as nine degrees F (five degrees C). The differences in predictions became central elements in the debate about whether the models were sufficiently reliable to warrant policy actions. Further, it made a great difference whether the actual increase was at one or the other end of this range. At the low end, the normal resilience of society would probably be sufficient to accommodate the changed climate. Changes at the high end portended severe disruptions.

These projected temperature changes may appear innocuous because variations of this magnitude are experienced in the normal course of daily and seasonal weather. Their full implications can be appreciated by noting that it took only a two-degree F average decrease in temperatures in Europe to cause the run of several frigid centuries (from the 1400's to the 1800's)

known as the Little Ice Age. Nine degrees F is believed to be the difference in temperature that separates the end of the last great ice age 12,000 years ago from the present. Further, the projections indicate that the Northern Hemisphere would experience in just a half century an unprecedented temperature change, 10 to 50 times faster than the change since the last ice age.

Those who are not familiar with mathematical models or the way com-

puters are used to make these projections can be forgiven for being confused—or even annoyed—by the great disparities in the results. Among investigators it is understood that mathematical models are only approximations that attempt to simulate the processes that govern atmospheric behavior. The atmosphere is so complex that it is impossible to represent it in very great detail in these mathematical models. It is possible to represent only certain features and to make assumptions about how the oceans and the atmosphere interact, how the rate at which the oceans take up carbon dioxide varies and how clouds affect the exchange of energy between the earth and the atmosphere. Even the largest computers cannot represent the atmosphere, oceans and land surface in fine detail. Indeed, scientists approximate the conditions in the atmosphere by thinking of it as a set of observations spaced about 500 kilometers apart.

The political calls for action are being played out against the backdrop of that uncertainty. On one side, the view is that if there is a chance that model predictions could be correct, the consequences could be so dire that immediate action to arrest climate change would be imperative. The alternative view, equally cogent, is that commitment to action with vast economic and social consequences is unwarranted in light of both the scientific uncertainty and the absence of knowledge of the economic costs. John H. Sununu, White House chief of staff, in remarks he made at the annual meeting of the National Academy of Engineering in the fall of 1989 gave voice to this position:

*Although I agree that [global warming] is a critical issue, the fact is that the models with which analysis is being done and with which policy is being moved, as good as they may be, still are based on element sizes measured in hundreds of kilometers in length and width, and tens of kilometers in thickness. I suspect that no one who has ever been involved in engineering simulation would feel comfortable making major*

*decisions in which the elements were orders of magnitude greater than the details on which they were looking for information. And yet the fact is that we are moving toward binding international policy based on conclusions being drawn by policymakers who have no sense at all of the difference between*

*the levels of confidence they should have and levels of confidence they want to have. A system is not valid just because it gives you the answers you want. And yet so much policy is being made in reaction to that principle.*

The solution to the dilemma should be simple: Since the carbon dioxide content of the atmosphere has increased by more than 20 percent over the past century, we ought to be able to detect the climate warming in the global temperature record during the same period. Researchers have sought to do this, but it is a much more difficult task than it first appears. The problem is that climate is always in a state of natural fluctuation. Separating out the changes that are caused by increasing carbon dioxide from the natural changes is tricky scientific business. Moreover, the climatic temperature record is based on scattered and irregular observations not taken specifically for the purposes of determining climatic conditions.

Even so, careful analysis of these temperature records by scientists in the U.S. and in the U.K. sought to detect whether a climate warming has occurred and whether such warming is consistent with the prediction of the models. The prevailing view is that the climatic record over the past century for the entire globe reveals a net increase in temperature ranging from .5 to 1.0 degree F (from .3 to .8 degree C). But set against this conclusion is the disturbing result that similar increases in temperature cannot be detected over the past century in the U.S., where observations are numerous and accurate.

Even if the temperature rise is real, a puzzle remains that workers have been unable to unravel: Is the rise in global

temperatures a natural fluctuation or a result of the increase in greenhouse gases? All that can be said is that the observed increase is consistent with the lower end of the temperature increases predicted by the computer models. Consequently, the temperature records, as well as the predictions of mathematical models, provide substance both to those who believe the evidence warrants action now and to those who believe the evidence is still too weak.

The rush to policy action was, I believe, catalyzed by the disastrous drought of the summer of 1988. During this drought, one of the worst on record, the water in the Mississippi River fell so low that navigation was impossible over long stretches, urban water supplies were threatened and crops

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throughout the grain belt were devastated. Both officials and the public wondered whether this was the greenhouse effect manifest. Indeed, records show that in the U.S. five of the years of the 1980's were among the hottest on record, and the average temperature for the decade as a whole was the warmest since instrumental records have been kept.

Prompted by heat and drought, congressional hearings addressed the question of whether the greenhouse effect had arrived. These hearings were unremarkable except for a statement by Hansen. When he stated that he was 99 percent certain that the greenhouse warming had begun, as evidenced by the sequence of warm years in the 1980's, the public took notice. His opinion prompted members of Congress to consider whether the prudent course was to move rapidly to legislation aimed at protecting the habitability of the planet from catastrophic consequences.

Hearings followed hearings. Both the atmospheric researchers and the more general environmental community began to choose sides on whether immediate policy action was justified. The reaction from environmentalists was quick and vociferous. Several environmental and scientific groups began to advocate international agreements restricting the emissions of greenhouse gases.

At this point, some influential atmospheric researchers, who believed that policy actions were beginning to outrun the scientific evidence, weighed in with their views. Richard S. Lindzen of the Massachusetts Institute of Technology and Jerome Namias of Scripps, the nation's most distinguished long-range weather-forecasting expert, wrote a letter to President Bush urging that no action be taken. Three other members of the NAS, including its former president Frederick Seitz, joined in a report, published under the auspices of the Marshall Institute, calling into question the scientific basis for policy actions. They recommended a major research program in mathematical modeling. They pointed out that there might be alternative explanations for the climate warming that had taken place. Thus, the great climate debate had been joined.

Meteorologists did not look with favor on the prospect of yet another public debate involving their field: they had

been proved wrong many times before. As long ago as 1924, Sir Gilbert Walker, then head of the British government's Indian weather service, discerned unusually close connections between rainfall, temperature and pressures in the Pacific Ocean and the Indian subcontinent. Claims were made that the problem of forecasting the Indian monsoon was solved. Were it true, it would have been a great boon to Indian agriculture. But it was soon recognized that the correlations had little predictive power.

Later, in the 1940's and 1950's, widespread claims were made, based on the work of the late Irving Langmuir, Nobel laureate from the General Electric Company, and Vincent J. Schaefer of the State University of New York at Albany, that seeding clouds with dry ice or crystals of silver iodide could bring about an increase in rainfall. Several decades of research into the possi-

bilities of increasing rainfall, changing the intensity of hurricanes and modifying hailstorms by cloud-seeding techniques proved abortive.

Then, in the early 1980's, it was postulated that dust thrown into the atmosphere by a nuclear exchange between the Soviet Union and the U.S. would result in a "nuclear winter." This idea was deflated by Schneider and his colleague Stanley L. Thompson, who showed with the same models used in the prediction of climate that the "initial nuclear winter hypothesis can now be relegated to a vanishingly low level of probability."

Given this "cry wolf" history, it is not surprising that many meteorologists harbor deep reservations about taking costly actions on the basis of the predictions of a climate warming. But the push for policy has other constituents. Climate warming also unites those who are concerned about biodiversity and species extinction, economic development, human population growth, urban air pollution, acid precipitation and ozone depletion.

Political leaders stimulated by public concerns about environmental deterioration see these issues as important platforms and as springboards to public office. Those interested in increasing the competitiveness of American industry see greater energy efficiency as an important step toward that goal. It also serves the interest of those concerned about U.S. dependence on foreign energy sources. The issue of nuclear power is also underscored. Because fossil fuels are the main source of atmospheric carbon dioxide, strategies for stabilizing climate must en-

vision non-fossil-fuel sources. Here at last is justification that proponents of nuclear power can forcefully advance to support expansion of nuclear power facilities throughout the world.

The issue of global climate warming also offers an opportunity for advancing the "new economic order" long advocated by Third World nations. International action will require technological and economic assistance to such nations if they are to participate in a global effort to reduce atmospheric pollution or arrest deforestation. In fact, the world faces the prospect that the greatest increases in emissions of carbon dioxide will occur in developing countries as their need for economic growth is followed by increased demand for energy.

In like manner, those interested in arresting population growth, especially in the Third World, point out that the climate-warming problem is probably not solvable as long as the number of human beings continues to rise. After all, it is people who consume natural resources and energy and who farm the land. Without population control,

prospects for stabilizing the climate and arresting the deterioration of the habitability of the planet are abysmal.

Are the consequences of climate warming to be feared? People experience extremes of temperature in the natural course of events. The fact is that we do not know enough to predict the severity of the consequences. Because the warming would not be uniform over the surface of the earth, it would probably produce both winners and losers among regions and nations. Some parts of the earth would become warmer, some wetter and some drier. It is not possible on the basis of the evidence at hand to predict who would benefit and who would lose in such a global redistribution of so-called climatic resources.

Some aspects of global climate warming would be greatly beneficial in the view of agricultural researchers. Increased carbon dioxide will foster more active photosynthesis and enhance crop growth, to say nothing about the lowered plant requirements for water in a CO<sub>2</sub>-enhanced atmosphere. In the words of Jerry D. Mahlman, director of the Geophysical Fluid Dynamics Laboratory, "The things we can say with confidence, the policymakers are not interested in. And the things [they] are interested in, we don't know with confidence."

Models do, however, agree that the polar regions of the world would undergo greater increases in temperature

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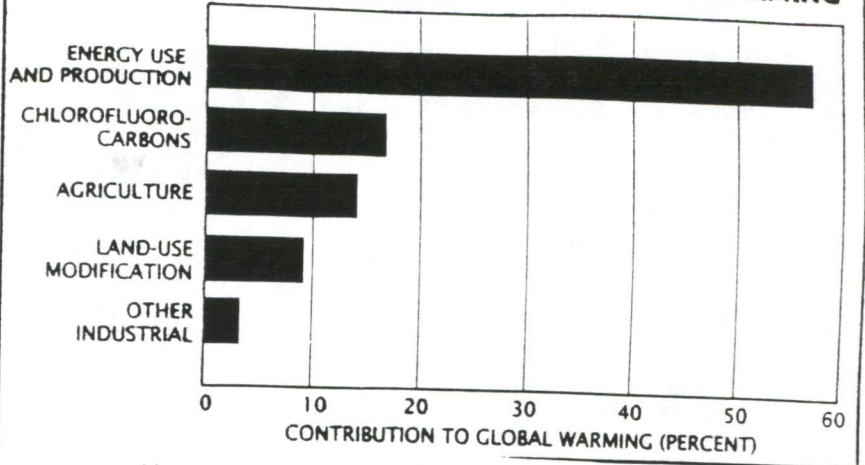
Present cities with their great suburban sprawl are not energy efficient, and so we might return to more compact cities. If we chose to maintain agriculture in dry areas, society would need to decide whether to invest in the necessary irrigation systems. In fact, the economic growth of the entire western part of the U.S. has been based on major investments in water storage and transport for irrigation and industrial use.

Fortunately, time may for once be on our side. Governments generally act only when threats become real. They act in the face of military threats or when areas are endangered and destroyed by natural disasters. If the climate changes, the expectation is that it will do so gradually. We should be able to see the initial evidence of coastal inundation in an increasing frequency of high tides and in the undercutting of seacoasts. Climate warming itself should be evident in a rising frequency of heat waves or in other weather anomalies. The effects of a global climate warming are likely to take 30 to 50 years to become serious, and that is a long enough span in which ac-

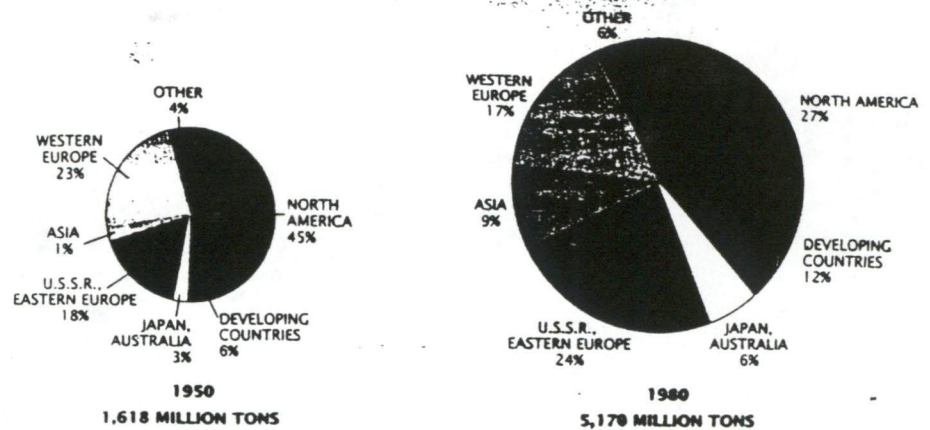
tions to adapt to these changes should be possible.

What of the debate in the atmospheric, environmental and political communities? Our global environment is under attack on many fronts. Climate warming is but one, perhaps the most complex, of these issues. If the changes occurring in our atmosphere are likely to cause consequences, we must understand the problems and promote sensible policies to remedy them. What would be unwise is to lapse into apocalyptic thinking or ostrichlike denial. We like to believe ourselves far more sophisticated, more enlightened, than preceding generations. Until we can calmly and objectively approach our environmental challenges without promoting public hysteria and exciting shortsighted, self-interested reaction, we cannot claim that we are.

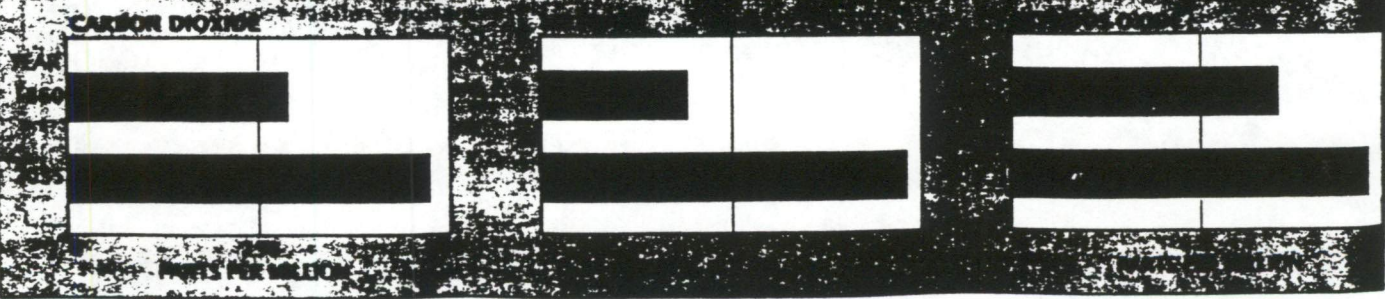
### HUMAN ACTIVITIES THAT MAY CAUSE GLOBAL WARMING



### THE CHANGING PATTERN OF GLOBAL CARBON DIOXIDE EMISSIONS



### THE PROJECTED GROWTH OF CARBON DIOXIDE IN THE ATMOSPHERE



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than would the tropics. Some of the projections of temperature increases in polar areas are startling in their magnitude, predicting as much as 18 degrees

F (10 degrees C) on the average in the Northern Hemisphere and only slight increases in tropical regions.

What are the general consequences of such a change in the temperature difference between equatorial and polar regions? We experience similar differences every year as the seasons change. In summer when arctic temperatures are warm, we do not suffer the great storms of winter; precipitation belts move farther north. Areas such as the southwestern part of the U.S. experience very dry conditions.

If arctic regions were to undergo significantly greater warming than equatorial regions and if precipitation belts were to move farther north, countries in the north temperate and polar zones would probably stand to benefit greatly. Their growing season would lengthen, and their precipitation would increase. With suitable soils, agriculture might thrive. These are speculations, however.

Such speculations are formulated in "scenarios" asking the question, What if? Unfortunately, an infinite number of such "what if" questions may be asked. What if the flow of rivers in the American Southwest, already fully utilized, were to be reduced by 20 percent? What if temperatures were to increase in the corn belt and precipitation were to move farther

north? What, then, would be the consequences in the U.S. for agriculture, for resource availability, for energy generation, for national parks and conservation of nature?

The consequences of changed climates can be seen in historical records going back thousands of years, and we have seen them in recent climatic events. We know, for example, that the Danes were able to settle Greenland and the Vikings to sail the North Atlantic to North America during a period of warm climate around the year 1000. Then a significant change in climate caused the collapse of the Danish settlements, prevented further exploration of the North American continent and ushered in the Little Ice Age. In just the past few years we have witnessed the effects of drought in the Sahel region of Africa and northeast Brazil, as well as in parts of North America.

Such scenarios can suggest apocalyptic possibilities. A recent film in the *Infinite Voyage* television series showed the U.S. Capitol under water as the result of one possible climate-warming scenario. Some foresee vast migrations of people as areas of the world become uninhabitable. Others see threats to national sovereignty and national security. President Gorbachev has stated that ecological security, not military security, will be the principal concern of

all nations in the next century as environmental conditions cause disruptions worldwide.

But scenarios should be qualified with the caveat that although the events portrayed might in some cases be plausible, they are not real predictions. What, then, is a wise course in the face of great uncertainty? Clearly, it would be one that recognized uncertainty but would not permit that uncertainty to forestall action. Steps for which other economic and environmental reasons make sense would be taken first, whether or not a climate warming is taking place [see "The Changing Climate," by Stephen H. Schneider; *SCIENTIFIC AMERICAN*, September, 1989].

Then, as scientific knowledge reduced uncertainties, more costly measures could be taken if warranted, hence closely tying policy actions to the state of knowledge. Scientists and others have called this a "no regrets" policy. In gambling it would be known as "spreading your bets."

A recent report of the Council of Economic Advisers lends weight to this approach. It states that the cost of controlling carbon dioxide emissions and of taking other actions to address climate change would run into hundreds of billions of dollars. Because such reallocations of resources raise the specter of grave economic consequences, we need to be reasonably sure such actions are worth the cost. Any rational no-regrets policy would foster as one of its prime objectives adequate investment by governments in global monitoring and mathematical modeling to reduce the scientific uncertainties.

Where might we start? Energy conservation and efficiency along with the phaseout of CFC production would be the first priority for national and international action. Achieving greater energy efficiency justifies itself handily in economic terms. Increased energy efficiency would also ameliorate urban air pollution and acid precipitation. Shifts in the fossil-fuel mix from coal and oil to natural gas could significantly reduce carbon dioxide emissions per thermal unit. Technology is also avail-

able for more efficient power generation and for increased gasoline mileage.

Wisdom would also dictate major investments in non-fossil-energy sources. The circumstances favor significant new investments in passively safe, publicly acceptable nuclear power. Further development of forms of solar energy—photovoltaics or biomass, for example—makes good sense. Reforestation and forest preservation constitute a benign policy that yields many ecological and climatic benefits. Research aimed at producing stress- and disease-resistant crops would also be wise.

The public, however, must not be misled. These no-regrets initial policy steps will not solve the climate-warming problem. Their effectiveness will only modestly retard climate warming, and the future may require more drastic actions. No matter what policy actions we take, fully arresting the climate warming just does not seem to be in the cards.

The difficulties of reaching an international agreement on procedures for mitigating climate warming will be difficult and lengthy. The negotiations for the Law of the Sea Treaty provide a good lesson. They consumed 15 years and produced a treaty that the U.S. has yet to sign because of demands by developing nations for significant technology transfer and economic assistance. These issues will be even more complicated and more pervasive in any "Law of the Atmosphere Treaty."

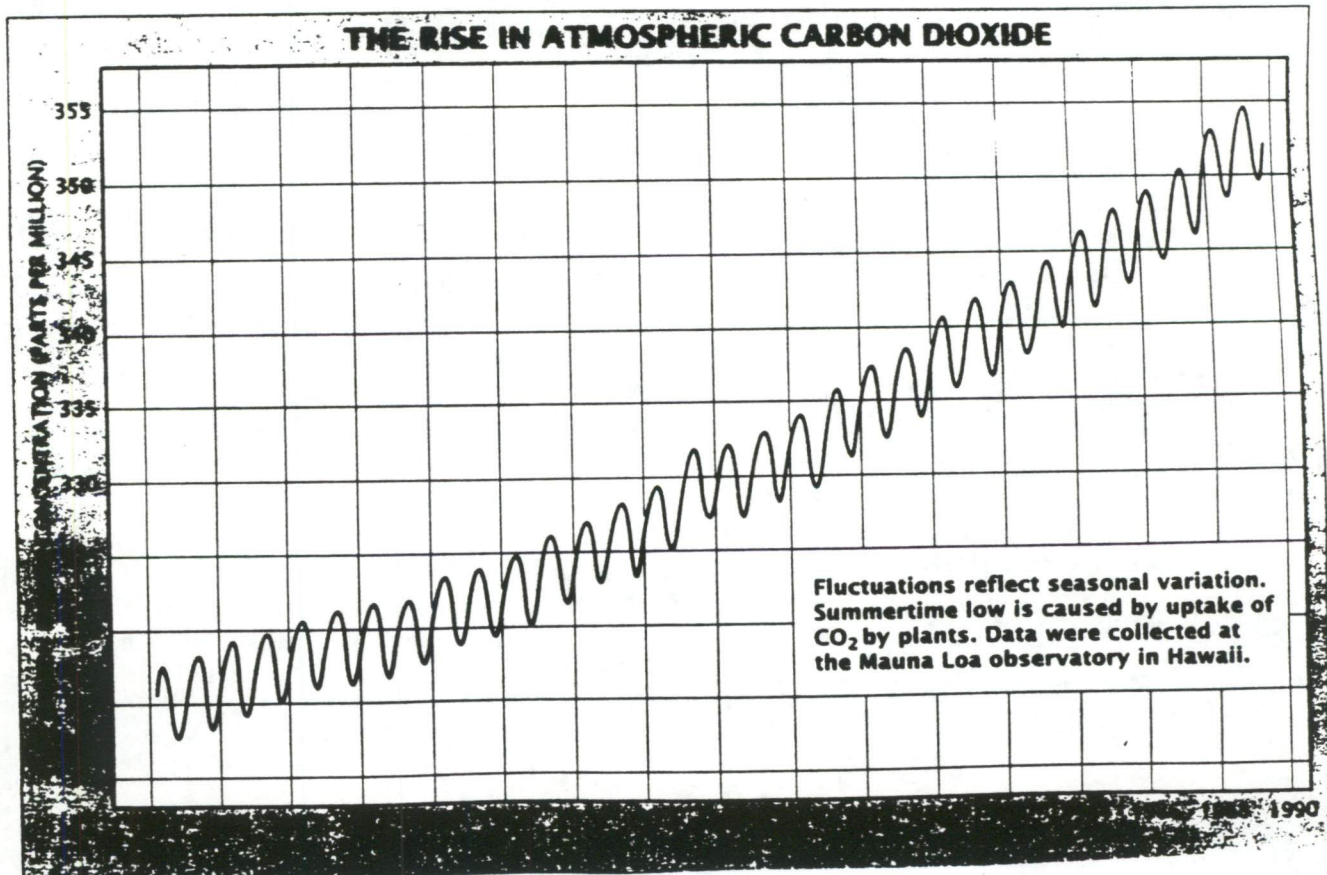
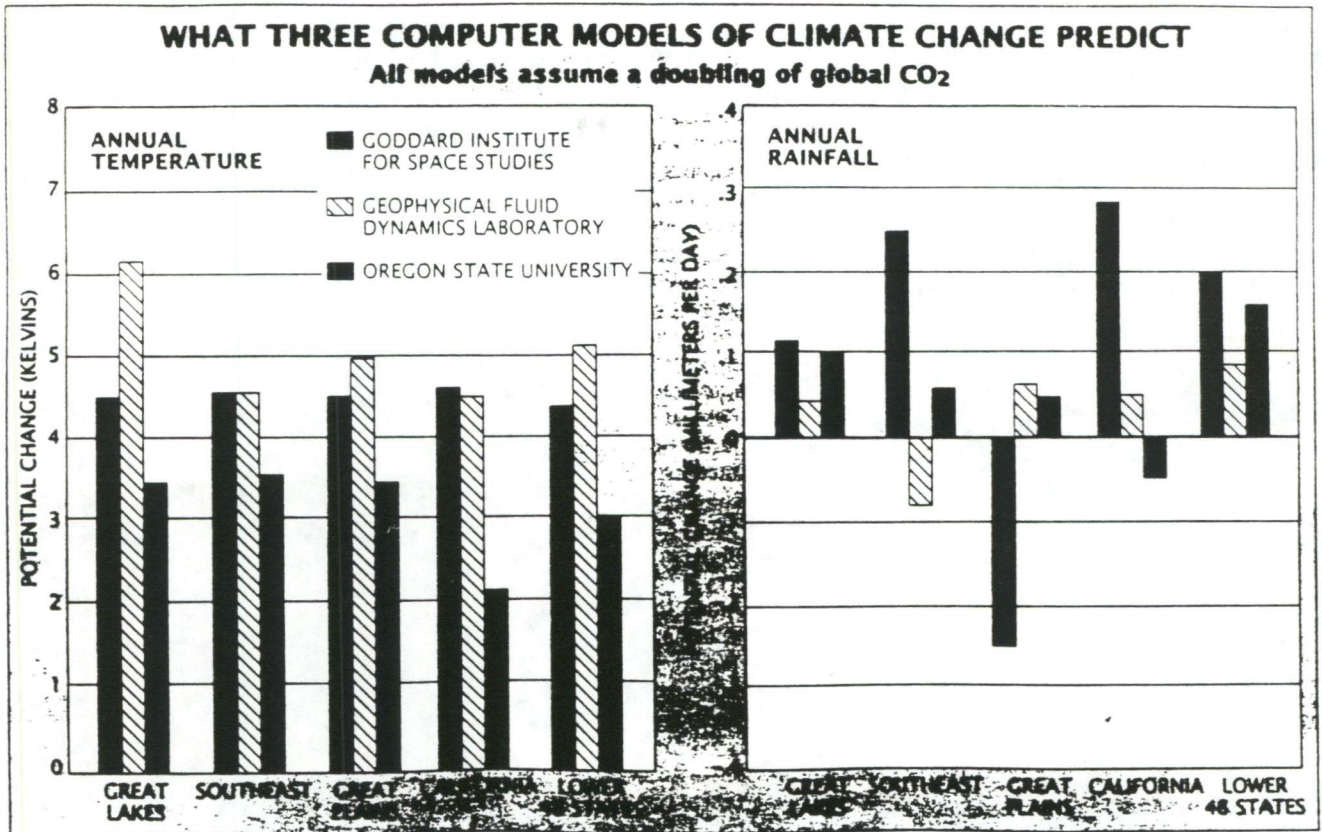
It is likely that humanity will have to adapt to some climate changes. Modes of adaptation by society have not been well studied. Individuals, corporations and communities can adapt to climatic vicissitudes in myriad ways. Farmers can change crops, water use can be regulated and management practices can be altered.

Other modes of adaptation would be needed if climate changes were severe. Sea-level rise, which is one of the predicted concomitants of a climate warming, might inundate low-lying coastal areas and cause salt water to intrude into freshwater bodies. Were this to occur, society would have to decide whether to invest in protective structures along coasts or adapt by changing land-use patterns. The North Sea dikes in the Netherlands are an outstanding example of adaptation to relative rise in sea level.

Some adaptations would take considerable time to implement. If the price of energy were to escalate, energy-efficient habitations would be necessary.

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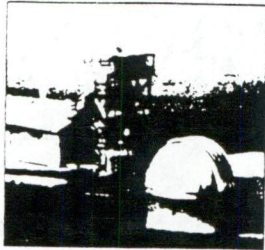
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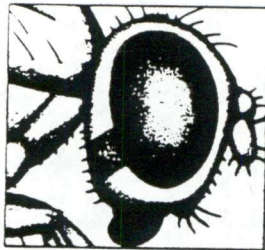


### The Great Climate Debate

*Robert M. White*

There is no doubt that human activity is increasing the amount of carbon dioxide and other greenhouse gases in the atmosphere. Whether that spells sweeping global climate change is still much debated. Should we act to blunt the impact in the face of this uncertainty? The author thinks so.

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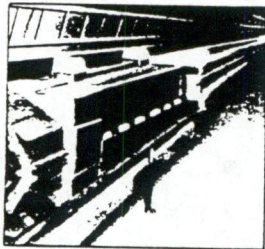


### Homeobox Genes and the Vertebrate Body Plan

*Eddy M. De Robertis, Guillermo Oliver and Christopher V. E. Wright*

What tells some embryonic cells to become limbs and other seemingly identical cells to form complex organs? It is a fascinating group of genes with a common feature called the homeobox. Key to development in many animals, these genes are remarkably similar in fruit flies, frogs—and humans.

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### The LEP Collider

*Stephen Myers and Emilio Picasso*

Until the U.S. builds its Superconducting Supercollider, Europe's Large Electron-Positron Collider is the big gun in particle physics. Almost from the very start in July, 1989, the LEP has produced important results. The design and construction of this giant research tool is a story in its own right.

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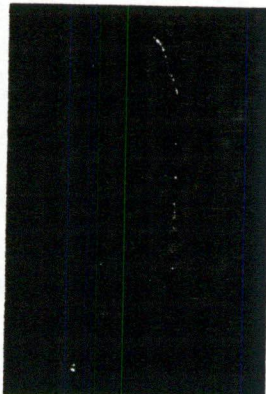


### What Causes Diabetes?

*Mark A. Atkinson and Noel K. Maclaren*

With insulin injections, the diagnosis of type I diabetes is no longer a death sentence. But this treatment is not a cure. A new understanding of how the immune system is turned against the body's own insulin-producing cells is pointing to ways this devastating disease may one day be prevented—or halted.

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### TRENDS IN AEROSPACE

#### The New Space Race

*Elizabeth Corcoran and Tim Beardsley*

This time around the prize is not military supremacy—it's market share. The U.S., Europe, the Soviet Union, China and Japan are competing intensely for the satellite-launch business. The front-runners will be those nations that apply fuel chemistry, materials science and electronics to engineer less expensive ways to reach orbit. There aren't enough payloads to go around, and the prospect of manufacturing in space is still elusive. So the contest won't be over until researchers discover what—if anything—is commercially viable in space.

End

LOS ANGELES TIMES MONDAY, JULY 2, 1990 A1

# Ozone Victory Spurs War on Global Heating

By LARRY B. STAMMER  
TIMES ENVIRONMENTAL WRITER

LONDON—For 10 days last month, delegates from nearly 100 nations labored on the banks of the River Thames across from Parliament to write a new chapter in environmental diplomacy.

They succeeded.

Agreement was reached on unprecedented amendments to the Montreal Protocol binding the industrialized West and developing nations in a single global cause—protection of the Earth's eroding ozone layer.

But even before the ink dried on the new accord, world leaders were looking ahead to a major international conference scheduled for 1992 in Brazil to fashion a broad framework treaty to address an even more daunting environmental threat—global warming.

"We have established here the model for the way in which we're going to have to carry out future environmental diplomacy . . . [to] save this small and fragile planet," declared Chris Patten, Britain's environmental secretary.

Equally enthusiastic was Mostafa K. Tolba, who, as executive director of the U.N. Environment Program, shepherded the negotiations here to a successful conclusion.

"We are starting a new era of not only cooperation but, really, partnership," Tolba said. "What we have been aspiring for has come true in a legally binding treaty."

But that achievement, significant as it was, pales by comparison with the hard work that lies ahead in fashioning a treaty on global warming.

Diplomats caution that the world has not yet entered the era sought by environmental gadfly Jeremy Rifkin, who has called for a new politics that is "species-oriented instead of ideologically oriented."

There is much to suggest that even though the world may be confronted by a common threat, its peoples may not pull together to meet that threat.

Differences in how nations view environmental problems, and the unequal sharing of the costs and benefits of international accords, complicate environmental diplomacy.

Should a nation go along with efforts to allay the greenhouse effect if it knows that global warming might bring it more abundant harvests? Should poor nations struggling to raise their standards of living spend money to reduce ozone depletion so that fair-skinned Europeans don't get skin cancer?

The theory of global warming holds that increased concentrations of carbon dioxide, produced mostly by the burning of fossil fuels, have produced a so-called greenhouse effect in which the Earth's surface traps more of the sun's rays, raising global temperatures. This will lead to such things as rising sea levels and the spread

of disease, it is feared.

While few participants in the London conference doubted the genuine concern over the Earth's deteriorating environment, success in strengthening the Montreal Protocol was possible largely because practical substitutes for ozone-destroying substances are near.

There are comparatively few ozone-destroying substances. They include man-made coolants—called chlorofluorocarbons (CFCs)—used in air conditioning and refrigeration, as blowing agents in foam manufacturing and as solvents.

Chemical manufacturers in the United States and Europe are well

on their way to developing and marketing substitutes, known as HCFCs, that are only one-tenth as damaging to the ozone layer.

And while it is relatively simple to address a single issue such as ozone depletion, the agreement nearly came unraveled over the issue of how industrialized nations would transfer that technology to the Third World.

The question: When does the need to protect the world's environment take precedence over private property rights—in this case the right to protect patented HCFC technology?

Manufacturers say that after investing millions of dollars in research and development of patented HCFC alternatives, they do

not want to give the results away to Third World nations and enable them to build plants and undercut sales.

Developing nations say they are burdened by foreign debt and cannot forever be buying products from the West. They want to make the products themselves. If they cannot, they will not join in the fight to save the ozone layer.

It was a dilemma that India's environment minister, Maneka Gandhi, said is certain to dog future negotiations involving global warming.

"Either you [sell us] the technology or you change your laws or you change your patent rights," she said. "Start working on it! This is a new century coming up in which every single conference which will take place is going to take place for survival."

Gandhi referred to global warming and the new technologies that will be needed to reduce emissions of carbon dioxide, a major greenhouse gas.

"In every case it will involve a transfer of knowledge," she said. "The whole 21st Century's survival will be based on the [transfer] of knowledge."

Negotiators settled on somewhat vague language that, at least for the moment, appeared to resolve the dispute.

But the drafting of a global-warming treaty will present far greater obstacles, in part because the phenomenon, unlike ozone depletion, has no single cause.

To turn down the temperature on global warming will get at the very heart of national economies.

The greatest single contribution to global warming is carbon dioxide emissions, which come from the burning of fossil fuels like coal, gasoline and oil—the energy of modern society and the fuels that the Third World counts on to raise standards of living.

Will people drive less or use less energy to heat their homes? Will the Third World turn aside the demands of burgeoning populations for a higher living standard?

William K. Reilly, chief of the U.S. Environmental Protection Agency and head of the American delegation, said that global warming will put environmental diplomacy to a severe test.

"These are enormously complicated issues," Reilly said in an interview. "They have nuances that involve economic advantage for countries. . . . We're dealing

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A14 THE NEW YORK TIMES, MONDAY, JULY 2, 1990

## Plant Trees. Then Protect Them.

Global warming poses an uncommon threat to life on the planet, but what can ordinary people do about it? Plant a tree. This requires a shovel, a stake — in the ground and the future — and a seedling. If people live in an urban hardscape, they may want to follow the advice of Andy Lipkis, founder of a growing California organization called TreePeople, who has prompted the planting of a million trees in Los Angeles.

Plant a tree by your apartment building, shop or school. Better yet, consider becoming a citizen forester — volunteers trained in the art of arboreal skills like getting city permits, breaking concrete and protecting young trees from vandals.

In 1970, when he was 15, Andy Lipkis watched the trees in his summer camp in the San Bernardino mountains die from the smog of Los Angeles. He and a dozen other campers tore up a parking lot and created a meadow. The planting of smog-resistant

trees gave his life new meaning. He obtained seedlings from the California Forestry Division and private nurseries and organized volunteers to plant and adopt trees.

Planting a tree is not, ultimately, so simple, says this bearded latter-day Johnny Appleseed. Nurturing, watering and pruning require a commitment of years. President Bush has joined the effort. He talks about planting a billion trees a year, but there is no long-term commitment to maintain them.

He and other politicians would be wise to note what has happened in the Olympic Forest in Los Angeles. Trees from all over the world were planted by local government with political fanfare, but little community involvement. Now many have withered.

Nurturing a relationship between people and trees is the central message of TreePeople. Without people, trees die. Without trees, so will people.

# Global warming fuels scientific debates

By Jim Detjen  
Knight News Service

Imagine 200 gigantic marine farms — each roughly the size of New Jersey — that drift on the surfaces of the world's oceans. Or satellites bigger than Boston or San Francisco that beam solar energy back to Earth. Or so many tons of chemicals dumped into the atmosphere to cleanse it that the sky is bleached white.

These are just a few of the visionary schemes being dreamed up by some of the nation's most brilliant scientists as possible ways to combat the global warming that is expected to occur as a result of the greenhouse effect.

Most climate-change scientists now believe that the average temperature of the Earth will increase 4 to 9 degrees in the next 100 years, according to a recent survey by the Global Environmental Change Report, an Arlington, Mass., newsletter.

The greenhouse effect is the name given to a theory that says temperatures will rise as carbon dioxide, methane and other gases build up in the atmosphere, much as a greenhouse traps solar heat. Among the effects are melting ice caps, rising seas, shifting of agricultural lands and changing weather patterns.

While other researchers debate whether the planet has begun to

heat up, these scientists are hard at work concocting planetary engineering projects costing hundreds of billions of dollars that they say could stabilize the Earth's climate if the greenhouse effect overheats the globe in the 21st century.

Among the proposals are these:

■ Launching a fleet of 700 jumbo jets to disperse 35 million tons of sulfur dioxide droplets each year into the upper atmosphere — so many that they would turn the sky white. The droplets would form a massive shield over the planet, similar to a one-way mirror, that would reflect sunlight and help cool off the Earth.

■ Building enormous floating beds of kelp — all together, equivalent to five times the size of Texas — that would drift on the ocean's surfaces sucking up carbon dioxide through photosynthesis. The marine plants could then be sunk to store the carbon dioxide at the ocean's bottom.

■ Dumping 300,000 tons of iron pellets into the oceans. These pellets would fertilize "unproductive" parts of the ocean, providing the nutrients for tiny marine plants, which would absorb carbon dioxide. When the plants died, they would sink to the ocean's bottom. Fish eating the plants would excrete droppings containing carbon dioxide that also would sink to the sea floor.

■ Constructing 375 satellites — each containing 50 square miles of solar panels — that would orbit 22,300 miles above the Earth. These satellites, built during the next 75 years, would generate electricity from sunlight and transmit this energy back to Earth on microwave beams. By eliminating the need for new power plants, they would reduce the buildup of carbon dioxide.

A paper discussing the iron-dumping proposal was published in the May 10 issue of *Nature*, a major British science journal. And a panel of the National Research Council, which advises the federal government, has recommended that at least two of the schemes be actively explored.

But some environmentalists are aghast at the proposals, which would be the largest efforts ever undertaken to manipulate nature. They fear that the ideas — if carried out — might cause irreparable damage to the planet.

Wallace Broecker, a geochemist at Columbia University and a proponent of the plan to dump sulfur dioxide into the atmosphere, believes that the time has come to actively discuss such global projects.

"As scientists we should be exploring all of the possible options," he said. "We need to develop insurance policies for the future."

CONTINUED

# Strategies for staving off global warming

Scientists are dreaming up visionary, albeit controversial, planetary engineering projects to combat the greenhouse effect.

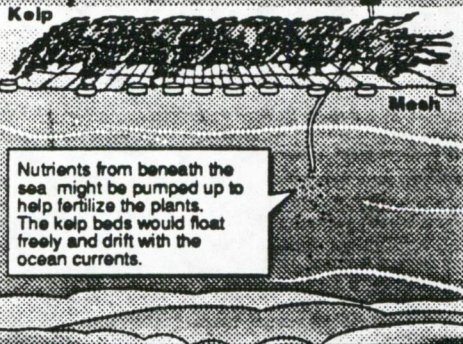
## Harnessing the sun's energy

One idea calls for 375 satellite power stations — each containing 50 square miles of solar panels that would be bathed in constant sunlight. The satellites would transmit microwaves to receiving stations on Earth, whose rectifying antennas would convert the microwaves into electricity. By eliminating the need for new fossil-fuel power plants, they would reduce carbon dioxide buildup.

The 375 satellite power stations would be in geosynchronous orbit 22,300 miles above the Earth. Estimated price tag: \$100 billion for development, and \$12 billion for each satellite.

## Floating beds of kelp

One possible "marine farm" would involve massive beds of giant kelp growing on the surface of the ocean. Each farm would cover 100 or more square miles. Mesh would keep the kelp — a form of seaweed — extended on the surface. The kelp would drift through the ocean, absorbing carbon dioxide, and eventually be sunk to the bottom of the ocean. This would help reduce carbon dioxide buildup.



Nutrients from beneath the sea might be pumped up to help fertilize the plants. The kelp beds would float freely and drift with the ocean currents.

## Other projects:

**Shielding the atmosphere**  
Huge jets would dispense tons of sulfur dioxide droplets into the upper atmosphere, forming a massive shield to reflect sunlight and help cool off the Earth.

**Fertilizing the ocean**  
Hundreds of thousands of tons of iron pellets would be dumped into the oceans to stimulate growth of marine plants that would absorb carbon dioxide.



Solar panels

Microwave beams

Receiving station

SOURCES: Peter E. Glaser, Howard Wilcox, California Institute of Technology

Knight-Ridder Tribune News/KIRK MONTGOMERY

# Reduce Global Warming at Lowest Economic Cost

■ **Environment:** The countries most willing to reduce carbon dioxide emissions should be compensated in cash and goods.

By **MARTIN FELDSTEIN**  
and **KATHLEEN FELDSTEIN**

The problem of global warming is sure to be on the agenda of the economic summit next week in Houston.

Although there are scientific doubts about the extent of the problem, there is no question that whatever is to be done must be accomplished on a global basis. The solution is not to ask individual countries to stabilize their emissions of carbon dioxide, as many environmentalists urge. What's really needed, contrary to recent statements by some Bush Administration officials, is a global fund to compensate those countries that do more than their fair share of cutting carbon dioxide emissions.

Carbon dioxide is a primary cause of global warming. Emissions accompany the burning of carbon fuels such as gasoline and home-heating oil, and through industrial processes that use coal, oil or gas.

The key scientific fact that makes international cooperation necessary is that while carbon dioxide can enter the atmosphere from any point, it is distributed equally around the globe within 12 months. There is nothing to ensure that those countries that heavily rely on the burning of carbon fuels will bear the burden of the global warming that may result.

Reducing emissions of carbon dioxide is a more appropriate subject for international negotiations and coordination than the problems of monetary and budget policy that have been the standard subject of economic summits in the past. Although a change in American monetary or budget policy does affect the other key industrial countries, the primary impact is on the United States. Foreign governments can rather easily offset the effects of policies that spill over from the United States to their economies. But when it comes to carbon dioxide pollution, emissions produced in the United States have the same impact abroad as they do at home.

The global nature of much of the environmental problem was clearly recognized in the 1987 Montreal Protocol, in which the industrial nations agreed to cut in half their emissions of the chemicals

(chlorofluorocarbons, or CFCs) that are destroying the Earth's ozone layer. Many participants saw this as just the first step toward eliminating CFCs completely.

It would be a serious mistake, however, if the economic summit were to take the Montreal approach as the way to deal with the much larger problem of global warming and carbon dioxide emissions. The critical difference between CFCs and carbon dioxide is that it is feasible to eliminate CFCs altogether from the envi-

ronment. In contrast, carbon dioxide can never be completely eliminated since emissions accompany not only virtually all industrial activity, but also are a biological byproduct of animal life itself.

Reducing carbon dioxide emissions involves economic costs. A country can reduce its emissions only by investing in more fuel-efficient technologies, by using more expensive fuels or by reducing its rate of economic growth. The economic cost of reducing carbon dioxide emissions differs among countries according to their current industrial technologies and agricultural practices.

Because global warming depends only on the total amount of carbon dioxide in the atmosphere and not on the country of origin, the goal of policy should be to reduce emissions in a way that has the lowest total economic cost, then distribute that cost among the countries of the world in a fair and acceptable way. Countries that can reduce emissions at lowest cost should take on a larger burden of reductions and receive compensation from the other countries in the form of cash and goods.

It would be wrong, therefore, if international negotiations to deal with global warming called for each country to stabilize carbon dioxide emissions at the current level or to reduce emissions by the same proportion. The United States is the largest contributor of carbon dioxide to the Earth's atmosphere. But it would be inappropriate for America to make any reduction in its emissions if the economic cost per ton were lower elsewhere. A better approach would be for the United States to achieve its fair share of total global reduction by contributing to a fund that compensates other countries with lower cost opportunities.

The less-developed countries have some of the lowest cost opportunities to reduce carbon dioxide emissions. Those countries would rightly complain if they were simply told to reduce their emissions in order to improve the global atmosphere. But suffi-

cient cash compensation from the rest of the world could make the request very welcome.

The economic summit is obviously not the time to work out the difficult issues of just how much global carbon dioxide reduction is desirable, nor how the total world cost of achieving that reduction should be divided. Those are problems to be assigned to the economic and environment officials and their staffs. But President Bush and the other leaders of the industrial democracies can take a big step toward an appropriate policy on global warming by declaring the correct principal: carbon dioxide emissions should be reduced in those countries where the costs of doing so are least, and the countries that bear that burden should be compensated by the rest of the world.

*Martin Feldstein served as chairman of the Council of Economic Advisers during the Reagan Administration. His wife, Kathleen Feldstein, is an economist.*

# Pollution Cited for Swim Ban at Beach

By JEFFREY L. RABIN  
TIMES STAFF WRITER

For the first time on a Santa Monica Bay beach, swimming has been banned within 100 yards of where a major storm drain enters the ocean because testing found the water polluted with sewage containing human viruses.

The city of Santa Monica's decision to prohibit swimming on a popular stretch of beach near the Pico-Kenter storm drain followed disclosure last week of an unprecedented study that found the presence of human enteric viruses.

The viruses, which can cause illness ranging from stomach flu to hepatitis, were detected in samples taken on 11 days over 15 days of testing last summer at the point where the drain enters the bay at the foot of Pico Boulevard.

Although Los Angeles County health officials played down the potential health risk and considered possible changes in the wording of warning signs, Santa Monica took action. The city posted its own large black-and-white signs in English and Spanish along the beach 100 yards north and south of the drain's entry point.

"Swimming within 100 yards of the storm drain outlet is prohibited," the signs read. "Storm drain waters may be contaminated with human disease carrying bacteria or virus or hazardous chemicals washed down from urban areas."

Buoys were placed offshore to designate the area where swimming is banned.

Parts of the bay have been off-limits to swimming when storms have caused Pico-Kenter and other drains to flood. But this is first ban not connected to a storm or sewage spill, officials said.

"It was appropriate to be conservative with respect to public health," Santa Monica Mayor Dennis Zane said. "We are very concerned there are additional forms of contamination at the storm drain that heretofore had not been acknowledged."

The stark warning signs have had an immediate impact since they were erected last week. On the eve of the busy July 4th holiday, the often-crowded stretch of beach was mostly empty.

To underscore its belief that the public should not swim near the drain, the environmental group Heal the Bay plans to hold a rally at the site this morning at 11.

Heal the Bay's staff scientist Mark Gold, who was the principal investigator on the study, praised Santa Monica officials for acting swiftly to ban swimming. "What they did was extremely responsi-

ble," Gold said. "There is no way you can go to the beach there and not know that there is a problem."

The \$125,000 study conducted by the Santa Monica Bay Restoration Project was the first of its kind in California and possibly the nation, director Catherine Tyrrell said.

Samples taken last August and September from the drain, which carries street runoff from Brentwood and Santa Monica, were tested for human enteric viruses.

Tyrrell said the results showed evidence of viruses from human fecal contamination in the storm drain. The report speculated that the most likely sources of the waste are illegal sewage connections to the storm drain, leaking sewer lines or the local homeless population. Members of the federal and state-funded project agreed that the information should be made available to the public.

With holiday crowds expected, Santa Monica City Manager John Jalili decided that swimming should be banned in the immediate area near the drain. "We felt that it was a prudent thing to do until more information becomes available," Jalili said.

The findings have sparked concern in Santa Monica's tourist industry.

Beverly Moore, executive director of the city's Convention and Visitors Bureau, concurred that the public should not swim within 100 yards of a storm drain or two days after a storm.

But with the summer tourist season in full swing, Moore took pains to point out that "the bay is swimmable and our beaches are safe. . . . We want to make sure that the public knows the areas that are safe to swim in and the areas that are not safe to swim in," she said.

The distinction is important because Santa Monica draws 2.5 million visitors a year and tourism contributes substantially to the city's economy. The affected area of the beach is immediately in front of the construction site of the Park Hyatt Hotel, which is scheduled to open late this year.

County officials expressed surprise at Santa Monica's decision.

Jack Petralia, director of the Health Services Department's Bureau of Environmental Protection, said he could not remember swimming ever being banned near a storm drain.

Petralia and other county offi-

cial downplayed the health risk of swimming near the drain's discharge point. "There is no indication that there is any great risk being in that water," he said.

He said, however, that a full epidemiological study needs to be conducted.

USA TODAY • THURSDAY, JULY 5, 1990 • 9A

# INQUIRY

## Topic: PROTECTING EARTH

David Gardiner is legislative director of the 416,000-member Sierra Club, a group that lobbies for environmental legislation at all governmental levels. The organization hopes to influence leaders from the USA, West Germany, Japan, Canada, Britain, France and Italy at the 1990 Economic Summit July 9-11 in Houston. Gardiner was interviewed by USA TODAY's editorial board.



Susan Bascomb, USA TODAY  
David Gardiner

## This experiment with the planet is dangerous

**USA TODAY:** You want to influence world leaders at the economic summit next week. In what way?

**GARDINER:** We see an opportunity at this meeting in Houston to have the leaders of the industrial nations of the world take action on two of the biggest global environmental problems that our nations all contribute to — global warming and the destruction of tropical rain forests.

**USA TODAY:** Why focus on the summit as a forum on these issues?

**GARDINER:** The rest of the world watches what happens at this summit meeting because these are the richest nations of the world. If at this summit meeting they do little or say nothing new about the environment, it can be viewed in the rest of the world that the richest nations in the world continue to exploit the environment for their own benefit.

**USA TODAY:** How concerned about the environment are these leaders?

**GARDINER:** There has

been a lot of talk since the last summit a year ago in Paris. A third of the communique that the leaders issued at the Paris summit was about the environment, and it included some very positive statements about

the need to take action on global warming — for example, they recommended joint action to curb the emissions of carbon dioxide and other greenhouse gases that cause global warming.

**USA TODAY:** If there's been a lot of talk, what about action?

**GARDINER:** There have been lots of international meetings, and the president himself here in this country has hosted a global warming conference. So far, unfortunately, what we have seen is very little action to control the pollutants that cause global warming.

**USA TODAY:** Pollutants such as what?

**GARDINER:** We are particularly focused on the need to control carbon dioxide. That's responsible for about 50% of the global warming, and it's chiefly a product of fossil fuels.

The United States is the largest single contributor, with about 25% of all of the carbon dioxide emissions.

**USA TODAY:** So what has to be done?

**GARDINER:** It means that you need to have a new energy policy that steers away from fossil fuels and in the direction not only of energy efficiency and conservation, but also renewable energies like solar that do not contribute to global warming.

**USA TODAY:** Is that your message for the leaders at the summit?

**GARDINER:** There is an opportunity at this summit meeting for these leaders to make what we think is the important first step that any country needs to make, but particularly the ones that are causing the primary problem. That is to make the commitment to reduce by 20% their own emissions by the year 2000.

**USA TODAY:** How can that be done?

**GARDINER:** Here in the United States, probably the single most important step would be to improve the efficiency of the automobile fleet. There is legislation, for example, pending in Congress that would increase the fuel efficiency of automobiles from their current level of 27½ miles per gallon — average of new cars sold — to 40 miles per gallon.

**USA TODAY:** Aren't there other benefits of more fuel-efficient cars?

**GARDINER:** If you are using less oil, you might not need to drill in sensitive areas that are on the oil industry's wish list. Perhaps it will mean we will have fewer oil spills. And it would reduce our imports of foreign oil, which are currently at a level of about 54%.

**USA TODAY:** What's being done to save the tropical rain forests?

**GARDINER:** A year ago at the summit in Paris, they endorsed what is known as the Tropical Forest Action Plan, which is designed to have money come from the industrial nations to projects where tropical forests are located, particularly in the Third World, and to

steer in the direction of positive forestry projects as compared to ones that completely destroy the tropical forests and the environment.

**USA TODAY:** Is it working?

**GARDINER:** The unfortunate thing we found out from two new reports that have come out recently as well as our own look at this problem is that, in fact, the tropical forest protection plan is being used not to preserve tropical forests but to destroy them.

**USA TODAY:** What can be done?

**GARDINER:** We are lobbying all of the leaders who will be represented at the summit meeting to insist that there be major reforms so this program becomes not only more protective of tropical forests, but also more inclusive of the local citizens. In many of these developing countries, participation in government as we have here doesn't happen. A major goal of the Tropical Forest Action Plan is to bring in citizen groups to the government process as a way of improving the democracy of those countries. And if you have a better decision-making process, you will end up with a better decision about how to go forward with developing or protecting any particular tropical rain forest.

**USA TODAY:** What is the difference between cutting down acres of trees in Brazil in the name of economic development and cutting acres of trees in metropolitan areas here to extend suburbia out farther?

**GARDINER:** It is not possible for us to be persuasive in getting other countries, particularly in the developing world, to take steps to protect their environment if we are not willing to take the same steps ourselves.

**USA TODAY:** Our economy is dragging. Can we really afford to do the kinds of things environmentalists are calling for?

**GARDINER:** In the short run, we're looking at a bunch of policies that are designed, we hope, to actually save people money. What that means for the average consumer is buying a more fuel-efficient

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car so they buy less gasoline, having a more energy-efficient refrigerator or heating or cooling systems, having more efficient light bulbs. I think the public is very much prepared to pay a little bit more up front because they understand they will pay less money to their utilities, to the oil companies, over the course of the life of the product.

**USA TODAY: But some people may not want to make those changes in lifestyle.**

GARDINER: To me, we are basically conducting a huge experiment with the planet. And that is fine for scientists — they like experiments. But for the average person, it is entirely likely that that person may be dead by the time this experiment is completed. But that person's children or grandchildren will be around to survive with the consequences, and we cannot predict with very much precision what the consequences are. But the fundamental issue is, do we want to conduct the experiment at all? It's a little bit to me like the question of buying insurance. Basically, that is what we are talking about adopting here — an insurance policy to prevent this experiment with the planet.

End

Jessica Tuchman Mathews



# The Greenhouse Effect: Apparently It's For Others to Worry About

It has been considered axiomatic that little can be done to slow the progress of global warming without U.S. leadership. Yet one by one the countries of Western Europe and Japan are adopting explicit national goals to cut their emissions of greenhouse gases. Without intending to, or even fully realizing that it has done so, Europe has assumed the mantle of international leadership on this central environmental issue, leaving the United States increasingly isolated.

Greenhouse warming is caused by the accumulation of several gases in the atmosphere, most importantly carbon dioxide. Since carbon dioxide is the inevitable outcome of burning a fuel, the question of what to do about greenhouse warming is largely a matter of energy policy—except where there is large-scale deforestation. The choices at issue are how much energy a country needs to grow on (largely determined by the efficiency of energy use), and what mix of fuels will supply it (nuclear, solar and other non-fossil sources produce no carbon dioxide; of the fossil fuels, coal produces the most and natural gas the least).

West Germany's greenhouse-control target is the most ambitious. It intends to cut the country's carbon dioxide emissions by 25 percent from 1987 levels by 2005. Government spokesmen have noted that the comparable figure for a united Germany would be even higher, since energy waste in East Germany offers so many possibilities for easy cuts.

The German announcement followed earlier goals set by Britain, the Netherlands, Denmark and Canada. Denmark plans a 20 percent cut by 2005. The others intend to stabilize their carbon dioxide emissions at 1990 levels sometime between 1995 and 2005.

The means by which these goals will be met are still to be worked out, but the goals have been set—often after fierce internal debate—feasibil-

ity studies have been done and planning processes are in place. Each of these countries has concluded not only that greenhouse warming is a real phenomenon but that present scientific understanding, while riddled with uncertainties, is nonetheless adequate to merit launching a major policy response.

Recently Japan, which had heretofore followed the U.S. lead on greenhouse policy, announced that it too

will stabilize carbon dioxide emissions "at the lowest possible level" by 2000. The precise target and program for doing so are to be announced by early autumn. France also is debating cuts in emissions, and the European Community as a whole may not be far from agreement on a stabilization goal. At the last vote, only Spain, Greece and Portugal were opposed.

What makes this trend particularly noteworthy for Americans is that most of these countries are already twice as energy-efficient as the United States. That is, they consume half as much energy to produce a dollar of GNP as do we. Put another way, the United States would have to cut its energy use by an astounding 46 percent without any loss of GNP to reach Germany's present energy efficiency, and then by an additional quarter to reach its planned level.

U.S. greenhouse policy remains as it was articulated at the disastrous international conference sponsored by the White House in April, namely that scientific uncertainties are too great to justify a serious effort to control carbon dioxide emissions, but that further research is a high priority. The United States continues to do the lion's share of basic research on greenhouse warming, but its carbon dioxide emissions are rising each year, and progress toward the articulation of any national energy policy, let alone one that might incorporate greenhouse goals, is questionable. The Department of Energy has been

directed by the White House merely to send over options rather than recommendations when it finishes two years of work developing an energy strategy at the end of 1990.

If Japan and the West Europeans are correct and the greenhouse phenomenon proves to be a trend that must soon be reversed, their recent decisions to begin moving in that direction could hold bad news for U.S. economic competitiveness. The means by which carbon dioxide emissions will be cut depend on advances in energy supply technologies, in transportation, agriculture, industry, appliances, building construction—in short in every corner of the economy where energy use is important. An international agreement to control greenhouse warming would dramatically change criteria of choice in the international marketplace.

The United States is already far behind in many respects, especially in the automobile industry. If the emissions goals now being set elsewhere are met, the gap will steadily widen. Moreover, technological innovation, at which the United States is still pretty good, will generally be the easy part. Commercializing the new technologies, changing social patterns and mobilizing political commitment, in all of which we have recently lagged, will be the key to success.

United States leadership on greenhouse control is no longer an option. The question is whether we or Europe and Japan have the more prudent approach to global warming, and if the latter, for how long—and at what economic cost—we will be playing catch-up.

THE NEW YORK TIMES WEDNESDAY, JULY 4, 1990

# COST OF CLEANUP AT NUCLEAR SITES IS RAISED BY 50%

## \$28.6 BILLION IN 5 YEARS

### Energy Department Gives New Estimate for 17 Weapons Plants in 12 States

By KEITH SCHNEIDER

Special to The New York Times

WASHINGTON, July 3 — The Energy Department today raised by 50 percent its estimate of the cost of cleaning up radioactive and toxic wastes at nuclear weapon production sites around the country over the next five years.

Leo P. Duffy, the department's top environmental official, said the higher cost estimate partly reflected a better assessment, put together by the department for itself and for Congress, of the technical requirements of the cleanup and its scope. And he said the new estimates partly reflected money that contractors are demanding from the Government to protect themselves from criminal investigations, civil suits, or penalties that could arise if state or Federal officials believe they have not complied with environmental laws.

He could not specify which money in the higher estimate would go for the cleanup and which for the added costs of liability.

#### 30-Year Project Seen

The new estimate, which the Energy Department said was a rough figure, raised to \$28.6 billion the cost of starting the cleanup in the fiscal years 1991 through 1995. Just 11 months earlier, Energy Secretary James D. Watkins predicted that it would cost \$19.5 billion in the same period to begin cleaning up more than four decades of accumulated waste, a project that he said then would take 30 years.

And at the news conference today Mr. Duffy said that the new estimate assumed that the department would be able to move ahead with its present plans for finding and building sites for permanent disposal of the wastes. The agency's efforts to build repositories for nuclear waste in Nevada and New

Mexico have been stalled by technical problems and political opposition.

#### Total of 122 Nuclear Sites

The total five-year cost of \$28.6 billion would go to cleaning up the wastes at 17 plants and laboratories in the department's 12-state nuclear weapons industry. Previous estimates by Congress, environmental groups, and the Energy Department had put the total cost of that cleanup at \$100 billion to \$200 billion.

The 17 plants are part of an overall cleanup project involving more than 122 nuclear sites in 30 states and the Marshall Islands in the South Pacific and Puerto Rico. The other sites were once research laboratories, production factories and uranium mills where materials for nuclear weapons were developed, produced and tested. Many of the sites are owned by universities and corporations.

Members of Congress said today that the new cost estimates were not surprising. "We've been pushing the Energy Department for years to come up with a plan and a cost estimate for dealing with their wastes," said Senator John Glenn, the Ohio Democrat who is chairman of the Senate Committee on Governmental Affairs. "Now they're making a start at something that was neglected for 40 years. The costs are going to be high but it's something we have to take care of."

This year the House passed an appropriation bill adding \$400 million to the Bush Administration's request of \$2.8 billion for the Energy Department's cleanup programs for the fiscal year 1991. Senate leaders have said they would agree to the same level of support.

Mr. Duffy said that a provision of the hazardous waste law makes contractors liable for criminal prosecution by states or the Environmental Protection Agency if they do not ask for enough money to adequately complete a project. Thus, Mr. Duffy said, contractors were asking for more money to protect themselves in case a project was larger and more complicated than they originally believed. But he could not identify any specific instances when a contractor had asked for more money because of liability.

"The liability associated with cleaning up our sites has been fairly high," said Mr. Duffy, director of the Office of Environmental Management at the Energy Department.

He said that "not too many companies in the United States are going to be willing to bet their assets" on environmental contracts unless they are protected financially.

The difficulty in precisely estimating the cost of cleaning up nuclear and chemical wastes is illustrated by the agency's problems in handling pollution at the Feed Materials Production

Center in Fernald, Ohio. The plant, a uranium processing factory operated under contract to the Energy Department, poured its radioactive and toxic wastes into large open pits that have been leaking into underground water supplies. In heavy thunderstorms the pits also overflow and radioactive and toxic wastes rush into nearby streams.

#### Suit Settled for \$78 Million

In 1988, a lawsuit alleging that pollution at the uranium processing center caused property values to drop was settled by the Energy Department for \$78 million.

One solution the problem offered by the Energy Department is to build a concrete cap over the pits at a cost estimated at \$7 million. The State of Ohio, and residents of Fernald are pressing the Energy Department to completely excavate the pits and ship the chemical and nuclear wastes for permanent disposal in Nevada. The cost of that project is estimated at \$1.1 billion.

Similar billion-dollar environmental projects are facing the Energy Department in Hanford, Wash., Aiken, S.C., Denver, Los Alamos, N.M., St. Louis, and Oak Ridge, Tenn. The enormous costs of the Energy Department's pollution problems have begun to affect other programs in the nuclear weapons industry, especially the multi-billion plan for repairing nuclear weapons plants and building new ones.

Earlier this year, the Bush Administration canceled a \$1.2 billion project to build a new plutonium plant in Idaho to save money. Last month, the House of Representatives voted to delay spend-

ing \$65 million on a new plutonium reprocessing factory at the Rocky Flats Plant in Colorado. Plans for new plants in New Mexico and South Carolina also are receiving new scrutiny from Congress and the Administration because of their cost.

Mr. Watkins, however, has not moved away from his public commitment last year to make the Department of Energy more accountable on environmental issues.

#### Need for New Approach

The need for a new approach to environmental issues was reinforced in June 1989 when Federal agents raided the Rocky Flats Plant near Denver as part of a investigation of potential criminal violations of Federal environmental laws. The inquiry is still in progress.

Mr. Watkins responded to the raid and other developments by proposing a new system for penalizing Energy Department contractors for failing to do work properly. The Energy Department also has forged agreements that give states the authority to penalize weapons plant managers and the Government for failing to comply with environmental laws. Under the Clean Water Act, for example, states can levy fines of up to \$10,000 a day for a violation.

In addition to the Fernald suit, other citizens in Ohio and in Colorado have sued the Energy Department for what

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FOR DEPARTMENT OF ENERGY

PROGRAM ABC World News Tonight STATION WJLA-TV  
ABC Network

DATE July 10, 1990 6:30 P.M. CITY Washington, D.C.

SUBJECT International Response to Global Warming Concerns

TED KOPPEL: On the American Agenda tonight, global warming. As Brit Hume reported earlier, the seven summit leaders meeting in Houston have failed, thus far, to agree on global warming policy. In fact, though, six of the seven nations already are working to reduce the pollutants they emit in such vast quantities, pollutants that many scientists say are warming the planet.

As ABC's Ned Potter reports, the one nation out of step is the United States.

NED POTTER: This is the world that would be affected by global warming.

This is the political world that would have to find solutions, and its leaders are divided over what to do.

PRESIDENT GEORGE BUSH [April 17]: What we need are facts, the stuff that science is made off.

POTTER: The White House has maintained that the danger of global warming is unproved, saying to wait for a major report from 300 scientists assembled by the United Nations. But a month ago that report came, and it was more than the President bargained for. It predicted in the next three decades a rate of increase of global mean temperature greater than that seen over the last ten thousand years.

PRIME MINISTER MARGARET THATCHER [May 25]: The problems don't lie in the future. They are here and now.

POTTER: Every country at this week's summit, except

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America, has now announced specific targets for reducing carbon dioxide, the gas from power plants, cars and factories that is blamed for most of global warming. Britain has pledged to stabilize its output by the year 2005. West Germany, by then, plans to cut its emissions 25 percent. The White House, by contrast, has set no target at all, still unconvinced by the United Nations report.

BRICE LALONDE [French Environmental Minister]: And I'm sure that the pressure will be so strong that the United States will have to reconsider some of its positions.

POTTER: But the Administration says tough environmental controls would cripple the economy and be contrary to the American ideals of free enterprise and freedom from big government.

BUDGET DIRECTOR RICHARD DARMAN [May 1]: Americans did not fight and win the wars of the 20th Century to make the world safe for green vegetables.

POTTER: Actually, from atmospheric research to tree planting, the White House says it is doing plenty. It has joined the international agreement to phase out ozone-depleting CFCs, and parts of the Clean Air Bill would cut emissions. But scientists say that is much less than what Germany and Holland are doing, and they are already twice as energy-efficient as America.

MICHAEL DELAND [White House advisor]: We are a fossil-fuel-based economy. And for us, the economic considerations are far more substantial than they are for other countries.

POTTER: Those countries are specifically going after fossil fuels, forcing car makers to quadruple fuel efficiency, demanding better home insulation, and, most dramatically, putting tremendous taxes, as much as ten times American levels, on anything that burns oil or coal.

Those taxes sound crippling, but they may have an economic benefit. They already have pushed business to seek alternatives. BMW hopes to market electric cars in five years. The Germans are taking the lead in solar power. And the French government is trying to expand nuclear power. When global warming is felt worldwide, they expect to sell these technologies to other countries.

PIER VELLINGA [Dutch Climate Program Director]: What I experience in the U.S. right now, but I hope it will change, is that climate-change policy is looked upon as a threat to economy. Whereas in my feeling, it is a challenge.

# White House Gases A18

Reduce greenhouse gases? The Bush Administration has again made clear, at the economic summit meeting in Houston, that it wants no part of an international timetable to limit emissions of carbon dioxide, which many fear will lead to a catastrophic warming of the earth's climate.

There are valid arguments against rushing into speculative, costly fixes. But Mr. Bush and his chief of staff, John Sununu, aren't making them. They cloak their inaction in gaseous language and dubious science. That's an insult to the allies and a political embarrassment for Mr. Bush.

The computer models that predict global warming are full of uncertainties — good reason to resist a draconian program to reduce emissions. But these same models, and many scientists, suggest that some warming is likely. And that's reason enough to take sensible precautions.

Chancellor Helmut Kohl says that Germany is prepared to reduce its carbon dioxide emissions by 25 percent in 15 years and urges the allies to follow suit. Some economists think that's an affordable goal. Mr. Sununu thinks it's a recipe for national suicide that would force the U.S. to abandon fossil fuels and drive it into a depression.

Mr. Sununu, whose impatience with environmentalists stops just short of contempt, adumbrates his dark vision with half-truths. Most carbon dioxide emissions, he says, come from decaying vegetation. That's true; but what threatens to shatter the global balance isn't nature but a century of

man-made emissions from automobiles, electrical utilities and industry.

Except for the U.S., every industrial nation represented at the summit meeting has pledged to stabilize greenhouse gases. Mr. Bush's negative response might be understandable if he would offer an alternative. But he's been so busy saying no that he hasn't even opened for public discussion any number of sensible ideas to reduce carbon dioxide that are worth pursuing on their own merits.

Compared with other countries, for example, the U.S. uses energy recklessly. Improved automobile mileage standards would improve energy efficiency. So would an energy tax, which, quite apart from its value as insurance against global warming, would ease the deficit. A sensible plan would also include incentives for using forms of energy that don't produce carbon dioxide, like solar and a new generation of safe nuclear plants. There would also be incentives for third world countries to stop the burning of tropical forests, an act of ecological vandalism that releases huge amounts of carbon dioxide.

Mr. Bush takes pride in his innovative clean air bill and his decision to join an international agreement to abolish ozone-threatening chemicals. Those are fine achievements, but they do not unhook him from a campaign promise he made on Aug. 31, 1988.

"Those who think we are powerless to do anything about the 'greenhouse effect' are forgetting about the 'White House effect,'" he said. "As President, I intend to do something about it." Do what?

# First Civilian Named To Head SDI Program

By R. Jeffrey Smith  
Washington Post Staff Writer

A17

Secretary of Defense Richard B. Cheney yesterday named Henry F. Cooper, a former U.S. arms negotiator and strong advocate of space weaponry, to become third director of the Strategic Defense Initiative (SDI) program that is aimed at developing a comprehensive defense against Soviet ballistic missiles.

Cooper, whose selection is not subject to Senate confirmation, inherits a program that faces what some officials are predicting will be the most intense funding fight in its six-year history. Some legislators are proposing that its \$3.8 billion fiscal 1991 budget be cut by 40 percent, while the Pentagon insists on a 22 percent increase.

The program is facing an identity crisis due to warming U.S.-Soviet relations, which many experts say have dimmed the likelihood of a strategic conflict, and which have prompted some U.S. allies to advocate direct economic aid to Moscow.

While some experts have advocated that SDI be reduced and re-directed toward the threat of an accidental strategic missile launch or regional attack by tactical missiles, Cooper recently completed a special SDI review for Cheney by urging that it remain focused on protecting the United States from an all-out Soviet assault.

He said in a telephone interview yesterday that his primary goal will be "to try to help the secretary focus the program and move toward picking the exact architecture for a feasible defense. . . and hopefully move toward deploying defenses as soon as the program can demonstrate they are feasible."

He said he shares Cheney's "commitment to making it happen."

Cooper, SDI's first civilian manager, indicated he will replace senior officials who have recently retired, including the program's chief scientist, deputy director and chief of staff.

As an Air Force deputy assistant director for research in the early 1980s, Cooper played a key role in developing a small rocket that was to be launched from F-15 fighters at orbiting Soviet satellites. The program was canceled several years ago due to technical problems and congressional opposition to space weapons tests.

As chief U.S. negotiator on defense and space matters from 1987 to 1989, Cooper strongly supported the Reagan administration's controversial "broad," or permissive, reading of the 1972 Anti-Ballistic Missile (ABM) Treaty, allowing virtually unlimited tests of sophisticated space weaponry. Congress has repeatedly barred such tests as a violation of the "narrow," or traditional, reading of ABM constraints.

Cooper said yesterday that he believes the program's current plan to orbit thousands of small interceptor rockets, known as "Brilliant Pebbles," has "a lot of promise." His predecessor, Air Force Lt. Gen. George Monahan, estimated recently that deploying such a system would cost \$45 billion, but others have said the lifetime costs would be nearly \$100 billion.

The Brilliant Pebbles system would be aimed at defending against less than half of Soviet missiles launched in an all-out attack, allowing thousands of additional warheads to penetrate and detonate on U.S. territory.

Former Air Force lieutenant general James A. Abrahamson, the SDI program's first director, strongly backed Cooper in a February 1989 memorandum to senior Pentagon officials, calling him "uniquely qualified. . . at a critical time in the history of these defense programs."

## The Houston Summit: Wrangling Threatens Unity

# Europeans Accuse the U.S. of Balking on Plans to Combat Global Warming

By ROBERTO SURO

Special to The New York Times

HOUSTON, July 9 — Senior European officials at the economic summit conference accused the United States today of frustrating their efforts to reach a new accord to combat global warming.

The European officials, including members of the British, French and Italian delegations who asked not to be identified, angrily complained that John H. Sununu, the White House chief of staff, had taken the leading role in organizing American opposition to the global warming initiative.

Asked at a news briefing this morning why the United States was resisting a West German proposal to set a target for reducing gases that cause global warming, Mr. Sununu replied, "The issue is being addressed with a level of haste." He added, "There seems to be some propensity to deal with the issue without putting all the data on the table."

### Kohl Asks 'Radical Measures'

In a letter sent to summit leaders last month, Chancellor Helmut Kohl of West Germany called for "internationally binding regulations with 'radical measures to limit' gas emissions that contribute to the greenhouse effect.

Chancellor Kohl said: "We must view the threat of climate change as a global challenge to all mankind. The world expects the seven summit countries to come up with far-reaching, specific proposals."

Mr. Sununu insisted today that the Bush Administration had endorsed limits on some emissions through the Clean Air Act, but he opposed new emission limits, contending that they would require major changes in the American way of life and the nation's industrial structure.

He noted, for instance, that because the United States was much larger than Japan or any of the European nations it had a greater reliance on cars and trucks to transport people and products.

Commenting on Mr. Sununu's position, James T. B. Tripp, general counsel of the Environmental Defense Fund, a Washington-based advocacy group, said, "These statements may serve to explain why United States per capita consumption of fossil fuels is so high compared to Western Europe and Japan, but they are not legitimate excuses for United States refusal to limit carbon dioxide emissions and take

steps to use energy much more efficiently."

Although President Bush has mustered allies to support his views on the two other major issues being addressed at the summit talks — aid to the Soviet Union and international trade — he now stands alone on the third area of the agenda, the environment.

### Pledges Made by Others

As the summit meeting's official sessions began today, European officials worried that the United States would block their effort to win a commitment to stabilize and then reduce emissions of carbon dioxide and other gases that contribute to the greenhouse effect. Many scientists believe that these gases trap heat from the sun that would otherwise escape back into space. The trapped gases then produce a gradual warming of the earth's atmosphere.

Except for the United States, all the industrial nations represented at the summit meeting have now pledged to stabilize greenhouse gas emissions, at least by early in the next century.

Even Britain and Japan, which formerly sided with Washington in insisting that more scientific and economic information was needed before taking action, are developing plans to reduce carbon dioxide emissions. West Germany has taken the lead, with a goal of reducing such emissions by 25 percent in the next 15 years.

President Bush's apparent determination to block a global warming initiative at this summit meeting stands in sharp contrast to his embrace of major environmental commitments at last year's economic summit talks in Paris.

In the final communiqué of that meeting, the national leaders declared that "decisive action is urgently needed to understand and protect the earth's ecological balance."

### 'Common Efforts' Urged

On the issue of global warming the communiqué stated, "We strongly advocate common efforts to limit emissions of carbon dioxide and other greenhouse gases, which threaten to induce climate change, endangering the environment and ultimately the economy."

Even as the summit delegations began gathering here this weekend, European officials hoped that the Houston talks would build on the rhetoric of the Paris communiqué. But at a

meeting Sunday night American officials raised a series of paralyzing objections, a European participant said.

"We had thought we were making progress," the European official said today, "but at last night's meeting it was discouragingly obvious that Sununu was back in the ascendancy, and the United States was yielding nothing."

European officials said that the first sign that President Bush would resist a global warming initiative came when William K. Reilly, the administrator of the Environmental Protection Agency was left behind in Washington. Mr. Reilly was a prominent member of the Bush delegation to the Paris talks.

In Mr. Reilly's absence the role of chief adviser on environmental matters has been assumed by Mr. Sununu, who has publicly disagreed with Mr. Reilly on assessments of environmental dangers. At the news briefing this morning, Mr. Sununu rejected the kind of joint commitment to specific limitations on gas emissions that the West Germans among others are pressing the meeting to adopt.

He said, "There is a concern that this idea of a permanent cap in perpetuity does not understand not only our growth needs, but the growth needs of the developing countries of the world."

He added, "so what we are seeking is a commitment that is broader, a commitment that would allow both the industrialized countries and the developing countries to address the broad issue of greenhouse gases without picking them one by one, setting caps on them individually."

## EPA Sets Toxic-Waste Cleanup Rules; Heavy Costs Likely for Chemical Firms

By ROSE GUTFELD

Staff Reporter of THE WALL STREET JOURNAL

WASHINGTON — The federal government proposed hazardous-waste cleanup standards that would impose heavy costs on chemical and other companies but generally spur brisk growth among treatment and disposal companies.

The standards, proposed by the Environmental Protection Agency, spell out procedures for decontaminating waste generated routinely during manufacturing or resulting from accidents or spills. The agency put the cost to private industry at between \$7 billion and \$42 billion over 20 years, with the biggest impact falling on chemical companies, petroleum refiners, wood preservers, metal finishers and auto manufacturers.

The new rules, called "corrective action" rules, would affect 3,000 to 4,000 operating facilities, including several hundred owned by the federal government. They would result in a cleanup effort bigger than the federal Superfund program, which is designed to clean up abandoned waste sites. Currently, the agency has no comprehensive standards for cleaning up hazardous wastes at sites that haven't been abandoned.

Much of the cleanup business resulting from the proposed rules probably would go to companies such as Chemical Waste Management, International Technology Corp. and Canonie Environmental Services Corp., according to Debra Coy, environmental analyst at Washington Analysis Corp., a research arm of County NatWest Securities. "My sense is there is some pent-up demand out there that should be released," she said.

EPA officials and private analysts predicted that the rules, along with other federal actions tightening cleanup and permit requirements over the past few years, would force marginally profitable polluters and cleanup companies out of business. The EPA said industries that may have a rough time complying include the sanitation services, coatings and engravings and wood products industries.

The new standards would address treatment, storage or disposal of hazardous wastes by any company that has such wastes on hand for 90 days or more. Don Clay, an assistant EPA administrator, said a growing number of companies would be covered because more and more substances are considered toxic.

The cost of cleaning federal sites, which mostly are owned by the Energy and Defense departments, would range from \$3 billion to \$18 billion.

The rules aren't likely to become final for a couple of years, largely because the White House Budget Office, which held up the rules for two years, is requiring the agency to develop more precise estimates of the projected costs. The environmental agency also plans to hold hearings and consider public comments on the proposal.

But release of the proposal is expected to get work started at a variety of facilities where companies have been waiting to get a sense of what form the regulations would take.

The EPA, under its existing authority, has imposed cleanup requirements at more than 600 facilities. Mr. Clay said the proposal aims to standardize rules and procedures while expediting cleanups. In some cases, requirements are designed to deal with existing environmental hazards; in other cases they are meant to prevent potential future threats, he said.

# Scientists concoct fantastic ways to combat global warming

**Jim Detjen**  
Knight-Ridder Newspapers

**I**MAGINE 200 gigantic marine farms — each roughly the size of New Jersey — that drift on the surfaces of the world's oceans. Or satellites bigger than Boston or San Francisco that beam solar energy back to Earth. Or so many tons of chemicals dumped into the atmosphere to cleanse it that the sky is bleached white.

These are just a few of the visionary schemes being dreamed up by some of the nation's most brilliant scientists as possible ways to combat the global warming that is expected to occur as a result of the greenhouse effect.

While other researchers debate whether the planet has begun to heat up, these scientists are hard at work concocting planetary engineering projects costing hundreds of billions of dollars that they say could stabilize the Earth's climate if the greenhouse effect overheats the globe in the 21st century.

## Among the proposals are these:

- Launching a fleet of 700 jumbo jets to disperse 35 million tons of sulfur dioxide droplets each year into the upper atmosphere — so many that they would turn the sky white. The droplets would form a massive shield over the planet, similar to a one-way mirror, that would reflect sunlight and help cool off the Earth.

- Building enormous floating beds of kelp — all together, equivalent to five times the size of Texas — that would drift on the ocean's surfaces sucking up carbon dioxide through photosynthesis. The marine plants could then be sunk to store the carbon dioxide at the ocean's bottom.

- Dumping 300,000 tons of iron pellets into the oceans. These pellets would fertilize "unproductive" parts of the ocean, providing the nutrients for tiny marine plants, which would absorb carbon dioxide. When the plants died, they would sink to the ocean's bottom. Fish eating the plants would excrete droppings containing carbon dioxide that also would sink to the sea floor.

- Constructing 375 satellites — each containing 50 square miles of solar panels — that would orbit 22,300 miles above the Earth. These satellites, built during the next 75 years, would generate electricity from sunlight and transmit this energy back to Earth on microwave beams. By eliminating the need for new power plants, they would reduce the buildup of carbon dioxide.

While some of the proposals seem fantastic, they are being seriously discussed by scientists in important journals and at prestigious workshops.

A paper discussing the iron-dumping proposal was published in the May 10 issue of *Nature*, a

major British science journal. And a panel of the National Research Council, which advises the federal government, has recommended that at least two of the schemes be actively explored.

But some environmentalists are aghast at the proposals, which would be the largest efforts ever undertaken to manipulate nature. They fear that the ideas — if carried out — might cause irreparable damage to the planet.

Wallace Broecker, a geochemist at Columbia University and a proponent of the plan to dump sulfur dioxide into the atmosphere, believes that the time has come to actively discuss such global projects.

"As scientists we should be exploring all of the possible options," he said. "We need to develop insurance policies for the future."

Broecker said many scientists did not want to discuss these proposals because they believe the public is against climate engineering.

But Rodney M. Fujita, a staff scientist with the Environmental Defense Fund, a nonprofit group, said these schemes were dangerously misguided. "These proposals are bad ideas. They signify an arrogance towards nature. There are many simpler things that could be done to slow down global warming — such as improving energy efficiency, planting forests and developing alternative fuels."

Fujita said that virtually every effort people have taken to manipulate nature has backfired, causing unforeseen environmental consequences. "We don't know what we are doing," he said. "These proposals could have disastrous results."

**Most climate-change** scientists now believe that the average temperature of the Earth will increase 4 to 9 degrees in the next 100 years, according to a recent survey by the Global Environmental Change Report, an Arlington, Mass., newsletter.

The survey found that 76 percent of the 330 scientists who participated believe that global warming caused by human activities has already begun; 90 percent believe countries should take immediate steps to reduce carbon dioxide emissions.

The greenhouse effect is the name given to a theory that says temperatures will rise as carbon dioxide, methane and other gases build up in the atmosphere, much as a greenhouse traps solar heat. Among the effects are melting ice caps, rising seas, shifting of agricultural lands and changing weather patterns.

Of the proposals to counteract the greenhouse effect, the iron-dumping plan has received the most acceptance. A National Research Council workshop on the subject was held last December.

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Environmentalists report the Feinstein camp has been wooing them ardently since the primary election.

Third reason: Many environmentalists believe that Wilson's record is not as good as their rhetoric indicates, and that, for political reasons, Wilson is praised more for his good deeds than blamed for his bad ones.

That may be an overstatement, but there is a curious symbiotic relationship at work here.

Environmentalist leaders are painfully reluctant to criticize Wilson. They need him, and they think they sway his vote. And even if Wilson loses this race, he will be a U.S. senator for another four years.

Wilson, in turn, eagerly courts the environmentalists, hoping to win their election-year support, or neutrality, by listening to their arguments and often coming around to their position. He makes them feel important.

Both sides are served well by this relationship. But with the governorship on the line, it won't be enough.

end.

SAN FRANCISCO EXAMINER

# Earth warming worsens, dividing world leaders

## U.S., Soviet Union called top culprits in befouling of air

EXAMINER NEWS SERVICES

SF

GENEVA — Deforestation has increased to the point that developing countries are becoming major contributors to global warming because of the vast amounts of carbon dioxide being released by burning of tropical forests, according to a new study.

"The sources of the problem are global, and any solution to the problems must also be global," said Alan Brewster, vice president of the U.S.-based World Resources Institute. It conducted the study for the United Nations.

The report concluded Brazil had emitted more carbon dioxide than the United States in 1987 because of intensive forest burning in the Amazon jungle, the world's largest remaining rain forest.

The study found several Third World countries also ranked higher than the United States and other industrialized nations in terms of per-person emissions of greenhouse gases. Laos, Brazil and the Ivory Coast all ranked ahead of the United States in that respect.

But in calculating overall releases of the major greenhouse gases, the report said, the United States had the highest "greenhouse index."

Developing nations now spew out 45 percent of the world's major greenhouse gases — carbon dioxide, methane and chlorofluorocarbons. But these nations are quick to point out that the industrialized world had already loaded the atmosphere with these gases before they started serious development.

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When the gases soar to the upper atmosphere they trap the Earth's heat like greenhouse glass. Scientists say this could cause the

flooding of entire nations as ocean levels rise and cause potentially catastrophic changes in rainfall and crop yields.

Using data mainly from 1987, the study ranks the United States and the Soviet Union as the main culprits, contributing 17.6 and 12.0 percent respectively to overall greenhouse emissions.

The next three are developing countries — Brazil with 10.5 percent, China with 6.6 percent and India with 3.9 percent.

Most of the industrialized countries' emissions are from burning hydrocarbons — coal, gas and oil. India and China both burn a lot of coal, but 27 percent of India's contribution was also due to deforestation.

The report added that the world is losing its tropical forests much faster than previously thought, with deforestation running at a rate of 40 million to 50 million acres a year — an area the size of the state of Washington.

New analyses of satellite photos show tropical rain forests are being

wiped out 50 percent faster than was indicated by previous studies.

The Soviet Union, China and Saudi Arabia on Thursday joined the United States at a major inter-

national conference in opposing early action to tackle global warming.

The division among world governments on the issue deepened further when 14 countries, including France, Italy and the whole of Scandinavia, tabled a motion calling for immediate negotiations on diplomatic accords, known as protocols, to reduce emissions of

greenhouse gases.

The Bush administration believes that reducing carbon-dioxide emissions — which could be accomplished by cutting the use of fossil fuels — will be so expensive that more scientific information is needed before proceeding. Britain and other European nations have made commitments to stabilize or reduce carbon dioxide emissions by early next century.

The divisions emerged more sharply Thursday at a meeting of the U.N.-backed Intergovernmental Panel on Climate Change in Geneva, attended by more than 30 countries.

The split concerned the way nations should arrive at an agreement to reduce emissions of greenhouse gases. A draft report by the panel proposed an early agreement, but Saudi Arabia called for a go-slow approach.

Delegates saw the Saudi opposition as reflecting growing concern among oil-producing countries that steps to reduce the emission of carbon dioxide might cut the demand for oil.

The Soviet Union and China backed Saudi Arabia by saying that they couldn't meet early targets to cut greenhouse gas emissions.

# Despite regulatory obstacles, waste firms expect to clean up

By Pamela Sherrod

Chief executives from some of the largest companies that deal in waste management say their future depends on a lot of outside forces: the "Green Movement," new technology and legislation for special or hazardous waste.

It also depends on a particular kind of supply and demand: Though garbage is in anything but short supply, nobody wants it.

Dozens of companies, including Chicago-area firms Waste Management Inc., Chemical Waste Management Inc. and Safety-Kleen Corp., participated in a two-day environmental investment conference last week that attracted more than 200 money managers from major pension funds and other institutional investors.

Waste management firms have been one of the darlings of Wall Street as attention in the last decade has turned to environmental cleanup, and in general their stocks have outperformed the market. The company officers who spoke at the conference offered the analysts hopes that growth will continue but tempered that by noting waste management faces obstacles on many fronts.

"One of the primary things affecting the waste industry is that we have not handled our waste in an environmentally sound manner in the past, and our methods need improving," said Kay Hahn, an environmental analyst at First Chicago Corp.

Jerry Dempsey, president and chief executive of Chemical Waste Management, said state legislation is affecting his company.

In particular, he noted legislation in Alabama that bans hazardous waste imports from 20 states.

"Alabama is the focal point now, but there is a chance that developments in Alabama could spread to other states," Dempsey said. "Alabama has legislated regulations for prior approval of certain incoming waste shipments,

and the state banned land disposal of certain types of waste materials in superfund sites and other clean-up projects."

Dempsey said the waste management industry also will be hurt by tax legislation that takes effect July 15 in Alabama. The state is raising taxes on the waste it receives to \$40 per ton on in-state waste and \$112 per ton on out-of-state waste from \$22 per ton. Louisiana is considering a similar tax.

Even with those developments, Chemical Waste, which handles hazardous waste, said it expects to continue to grow at a healthy rate. The company ended 1989 with a 23.4 percent increase in its net income to \$144.2 million and a 27 percent sales increase to \$891.9 million.

Chemical Waste's remedial service group recently received a contract from Exxon Corp. to assist in the cleanup of Prince William Sound. The U.S. Drug Enforcement Agency awarded Chemical Waste's technical service group a three-year contract estimated at \$40 million to dispose of chemicals discovered in drugs busts.

Michael Hutchison, an analyst with Barrington Research Associates, said Chemical Waste is benefiting from its hazardous waste disposal sites.

"They have one-third of this market in the U.S.," Hutchison said. "Further 'permitting' of sites for other companies is going to be difficult because no one wants these sites around. This is an area Chemical Waste is ahead in.

"They have a leading share of this market, and there is still the demand to dispose of hazardous materials. It has to go somewhere, and Chemical Waste has the sites," he said.

Waste Management's Chief Financial Officer James E. Koenig said one way waste management firms can continue to grow is through acquisitions.

Waste Management, which 20 years ago only hauled garbage, has grown into a leader in the field, handling all sorts of solid waste. The Oak Brook-based firm provides integrated systems to reduce, collect, treat and dispose of urban and industrial waste with services that include waste reduction, recycling programs and recycling waste collection.

Koenig said the \$3.6 billion company has grown by expanding and re-evaluating its role in the industry and through acquisitions. Koenig especially noted recent acquisitions in Europe.

Kay Hahn, an analyst with First Chicago Corp., said Waste Management has been successful at expanding its business over a long period of time, a key to long-term economic health for a company.

"The key thing I've seen with Waste Management is they have grown from being garbage hauler to be on the leading edge of the waste management industry," she said.

Donald W. Brinckman, Safety-Kleen's chief executive, said his company, whose 1989 sales rose 15 percent to \$478 million, has come to see itself as a diversified waste management firm.

Before 1984, Safety-Kleen thought of itself as a parts cleaner business and never regarded its disposal functions as important, he said.

"That changed for us because recycling became regulated under the laws at the time, and we were dragged into the environmental fold," said Brinckman.

Brinckman said the company expects to be affected by pending legislation on the classification of used oil, but could benefit regardless of whether oil is determined to be a special or hazardous waste.

Michael Hutchison, an analyst with Barrington Research Associates, said Safety-Kleen can handle used oil as either type of waste.

# The New York Times

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## White House Gases

Reduce greenhouse gases? The Bush Administration has again made clear, at the economic summit meeting in Houston, that it wants no part of an international timetable to limit emissions of carbon dioxide, which many fear will lead to a catastrophic warming of the earth's climate.

There are valid arguments against rushing into speculative, costly fixes. But Mr. Bush and his chief of staff, John Sununu, aren't making them. They cloak their inaction in gaseous language and dubious science. That's an insult to the allies and a political embarrassment for Mr. Bush.

The computer models that predict global warming are full of uncertainties — good reason to resist a draconian program to reduce emissions. But these same models, and many scientists, suggest that some warming is likely. And that's reason enough to take sensible precautions.

Chancellor Helmut Kohl says that Germany is prepared to reduce its carbon dioxide emissions by 25 percent in 15 years and urges the allies to follow suit. Some economists think that's an affordable goal. Mr. Sununu thinks it's a recipe for national suicide that would force the U.S. to abandon fossil fuels and drive it into a depression.

Mr. Sununu, whose impatience with environmentalists stops just short of contempt, adumbrates his dark vision with half-truths. Most carbon dioxide emissions, he says, come from decaying vegetation. That's true; but what threatens to shatter the global balance isn't nature but a century of

man-made emissions from automobiles, electrical utilities and industry.

Except for the U.S., every industrial nation represented at the summit meeting has pledged to stabilize greenhouse gases. Mr. Bush's negative response might be understandable if he would offer an alternative. But he's been so busy saying no that he hasn't even opened for public discussion any number of sensible ideas to reduce carbon dioxide that are worth pursuing on their own merits.

Compared with other countries, for example, the U.S. uses energy recklessly. Improved automobile mileage standards would improve energy efficiency. So would an energy tax, which, quite apart from its value as insurance against global warming, would ease the deficit. A sensible plan would also include incentives for using forms of energy that don't produce carbon dioxide, like solar and a new generation of safe nuclear plants. There would also be incentives for third world countries to stop the burning of tropical forests, an act of ecological vandalism that releases huge amounts of carbon dioxide.

Mr. Bush takes pride in his innovative clean air bill and his decision to join an international agreement to abolish ozone-threatening chemicals. Those are fine achievements, but they do not unhook him from a campaign promise he made on Aug. 31, 1988.

"Those who think we are powerless to do anything about the 'greenhouse effect' are forgetting about the 'White House effect,'" he said. "As President, I intend to do something about it." Do what?

# Cleanup Plan for Atom-Arms Plant Called Perilous

*Group Says Energy Dept. Should Try Other Methods of Processing Spent Nuclear Fuel*

By Thomas W. Lippman  
Washington Post Staff Writer

The Energy Department's preferred method of cleaning up 2,100 metric tons of highly radioactive spent nuclear fuel at its Hanford, Wash., plant is the most dangerous and probably the most expensive of the available options, an independent study organization charged yesterday.

According to the Institute for Energy and Environmental Research, of Takoma Park, the department's proposal to remove the stored fuel from tanks of water and process it to extract plutonium "reveals fundamentally inadequate technical analysis, a cavalier attitude toward issues of the most serious nature and a narrow-minded reluctance to consider the intent of environmental law."

The report, financed by the Washington state government, was written by Scott Saleska and Arjun Makhijani, the institute's president. Both are longtime critics of the Energy Department's weapons complex.

Makhijani said at a news conference that "there is no good way" of removing or neutralizing the spent fuel. But of all possible methods, he said, the "most irresponsible" is the plan submitted by DOE's primary contractor at Hanford: to restart Hanford's Plutonium-Uranium Extraction facility (PUREX) to process the spent fuel. This is actually "a back-door way of producing plutonium" for nuclear weapons, Makhijani said.

He said the United States has more plutonium than it needs for defense purposes. Activating

PUREX to extract more would generate at least 500,000 gallons of radioactive liquid waste that would have to be stored in Hanford's subterranean tanks, which he said might explode. He said it would be preferable, and \$300 million cheaper, to leave the spent fuel where it is until an above-ground, dry cask storage system can be developed.

Department spokesman Tim Tomastik said no decision to restart PUREX has been made. He said the department was "going to determine whether or not to proceed with preparation of an environmental impact statement that would examine the options for handling the spent fuel that's in those ponds. . . . The conclusions they

[the critics] are drawing are based on incorrect assumptions."

Energy Department waste management director Leo Duffy said last week that restarting PUREX was "one option" under consideration. But the text of the department's five-year plan for managing wastes at the weapons complex refers to a "final campaign to recover weapon-grade materials" from the Hanford fuel, which could only be done at PUREX.

At issue is the fate of 2,100 metric tons of spent, or used, fuel rods from the Hanford reactor known as N-reactor. That reactor, once the primary source of plutonium for nuclear weapons, has been shut down since 1988 because of similarity in design to the Soviet reactor that blew up at Chernobyl.

PUREX, built in the mid-1950s, is a huge factory-like building

where chemical processes extract plutonium from the N-reactor's spent fuel. Closed in 1972, it was restarted in 1983 during the Reagan administration's defense buildup, but was shut down again for safety reasons in December 1988, leaving no outlet for the N-reactor fuel.

About half the spent fuel is in canisters that were welded shut in the 1970s. The rest is in open canisters in direct contact with the storage water. Makhijani said the Energy Department gave no explanation for failing to complete the sealing process, but Tomastik said the process is under way and Makhijani and Saleska should have known that. "One of their premises is that we are wantonly disregarding this," he said. "We have ordered the parts and it will be finished by the end of this year."

DALLAS MORNING NEWS, 7/9/90, p. F1

# PRESIDENT IN THE HOT SEAT

## Bush faces increased pressure to act on global warming issue

By Randy Lee Loftis

Environmental Writer of The Dallas Morning News

HOUSTON — Houston's latest promotional slogan, "Houston's Hot," will set the stage for what environmentalists and some foreign leaders want the economic summit to generate: more heat on President Bush to do something about global warming.

The president still is preaching a go-slow sermon concerning the greenhouse effect, but to an increasingly empty church.

His most vocal congressional critic on global environmental issues, Sen. Albert Gore, D-Tenn., says he fears that Mr. Bush will make the United States "an environmental outcast, isolated within . . . (the) world community."

This week's summit is likely to test Mr. Gore's prediction.

Armed with a major report calling global warming a genuine threat, West German Chancellor Helmut Kohl is expected to ask the other summit nations to cut carbon dioxide emissions by 25 percent within 15 years, a pledge West Germany has already made.

That kind of specific commitment is unlikely this week, observers say. But Mr. Kohl has some support for his attack on global warming — and Mr. Bush is finding fewer allies as the political and scientific momentum seems to turn against him.

"The truth of the matter is that a Bush balance of compromise and consensus-building is killing our world," said Jay D. Hair, president of the National Wildlife Federation.

British Prime Minister Margaret Thatcher, no favorite of most environmentalists, now says she's a greenhouse believer. She has committed Britain to stabilizing carbon dioxide emissions at 1990 levels. British environmentalists aren't satisfied, however.

The Japanese government, after skirting the issue for months, has made a similar promise, but without specific targets.

Mr. Bush's aides say current U.S.

policies on energy and clean air will cut carbon dioxide emissions by 15 percent. But the White House refuses to make any formal commitment until the Intergovernmental Panel on Climate Change, the premier scientific group studying the greenhouse effect, releases its final report. That is expected in November.

U.S. environmental leaders have blamed White House Chief of Staff John Sununu, who often advocates "balancing" environmental and economic concerns, for the administration's cold feet on global warming.

The White House sought to counter the criticism during pre-summit meetings Sunday. Mr. Bush and Canadian Prime Minister Brian Mulroney said they have agreed to begin negotiating on acid rain, which is generated by U.S. air pollution and falls on Canadian forests.

Mr. Bush told Mr. Mulroney that the pact is "long overdue." Mr. Mulroney called it a "significant departure" from past antagonism between the two nations over acid rain.

Previous economic summits have described global environmental priorities in such broad terms that Mr. Kohl and Mr. Bush could feel comfortable with the results.

The environmental communique from the 1989 Paris summit touched on virtually every major worldwide concern, from the greenhouse effect to tropical rain forests, without making any identifiable commitments.

Environmentalists hope to capitalize on the split over global warming. On Sunday, a coalition of environmental groups from the United States and other nations issued an environmental scorecard on each summit nation.

Their proposals reflect the relationship between the global environment and the global economy. They include cutting carbon dioxide emissions, with huge ramifications for energy policies; slashing ozone-destroying chlorofluorocarbons, among the most important

industrial chemicals; reforming development-aid policies that encourage environmental destruction; protecting the oceans; aiding population control efforts; tying aid for Eastern Europe to environmental cleanup and energy efficiency; and reducing Third World debt payments.

Some analysts say the greenhouse effect and other environmental ills will dominate world economics in the 1990s, partly because global warming could spell doom for oil as the world's predominant fuel. Some even suggest that environmental issues will replace military concerns as the main focus of international security.

That may be overstated, but signs of change are apparent. Last month, Democrats in the U.S. Senate, including Sam Nunn, chairman of the Armed Services Committee, called for the redirection of military and intelligence resources toward environmental protection.

Environmentalists aren't the only ones to sense the momentum on environmental politics. Several of the summit governments are hustling to appear as "green" as possible.

In preparation for the Houston summit, Great Britain and Japan sent out slick color publications touting their environmental initiatives. British officials also distributed background papers on tropical rain forests, global warming and ozone-destroying chlorofluorocarbons.

Mrs. Thatcher and her government's Environment Department haven't directly criticized Mr. Bush's environmental policies. But with the prime minister casting herself as a broker of environmental politics, the implication is that Mr. Bush has dropped the ball.

Japan, not generally considered an environmental leader, has been more blunt in distancing itself from the United States. A 16-page Japanese Foreign Ministry booklet reminds readers that U.S. auto and industrial emissions are five times higher than Japan's. "Japan intends to take the initiative" in protecting the global environment, the

could

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booklet says.

U.S. officials have gotten into the act, too. The State Department's Agency for International Development sent out press releases June 28 saying it wants to hire 60 environmental experts in the next three years and promising to reform its policies to reflect environmental concerns. The agency also made a

pre-summit pledge to be a worldwide force for the environmental good.

The U.S. Environmental Protection Agency sent to the summit stacks of brochures on its activities — but didn't send its administrator, William Reilly. Mr. Reilly had thought he might be invited, as he was to Paris last year, but the call never came.

Some environmental observers say they've found little substance to match the image-making.

"For unleashing the greatest number of speeches, reports and conferences in the shortest amount of time, the global warming issue is hard to beat," Michael G. Renner of the Worldwatch Institute wrote recently in *World Watch*.

None of the economic summit nations may be able to get away with wearing the white hat on global warming. The summit may be a gathering of the guilty.

Figures from the World Resources Institute show that although all regions share blame for greenhouse-causing gases, few can match the summit nations' responsibility. With 11.9 percent of the world's population, they emit 33 percent of the emissions that cause global warming.

The United States is far and away the biggest greenhouse polluter. It has 4.7 percent of the world's population and releases 17.6 percent of greenhouse-causing gases, according to *World Resources 1990-91*, the World Resources Institute's almanac.

Given such a record, it has been tough for the White House to keep ignoring the critics. Just two weeks ago, evidence cropped up that the pressure may be working.

Earlier this year, administration officials said Mr. Bush would oppose economic aid to help poorer nations wean themselves from chlorofluorocarbons — a big issue in India and China, where plans to boost CFC use could offset other countries' reductions.

At a recent CFC negotiating session in Bergen, Norway, delegate after dele-

gate rose to criticize U.S. environmental policies. The scenario was repeated in a half-dozen global forums this spring, including one in Washington that Mr. Bush hosted.

When the CFC treaty was renegotiated in London two weeks ago, the United States backed down on helping its neighbors protect the ozone. It joined 92 other countries in endorsing the aid — something the administration had said for months that it would not do.

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# Frozen World Holds Warming Clues

*Scientists Drilling Through 200,000 Years of Greenland Ice Sheet*

AI

By William Booth  
Washington Post Staff Writer

THE SUMMIT, Greenland—High above the Arctic Circle, in a flat white world of snow and ice, scientists are drilling a hole through time.

In the most ambitious ice drilling project ever attempted, two teams of European and American researchers are boring down through more than two miles of ice—the compressed snow of ancient winters—searching for the trapped air bubbles and entombed crystals that will reveal what the weather was like during the past 200,000 years.

The scientists hope that by understanding the past, and learning what pushes the swinging pendulum of climate, they can predict the future, which many fear will bring a rapid and unprecedented warming caused by the accumulation of pollution in the atmosphere.

Here on the summit of Greenland—the highest point on the vast ice mound that almost completely covers the world's largest island—they seek an answer to the most pressing question in climatology: will rising levels of carbon dioxide and methane heat the Earth and melt the polar ice caps? And if so, how fast?

Already there is preliminary evidence from ice cores drilled by Soviet researchers in Antarctica that rising levels of carbon dioxide gas at the end of the last ice age preceded an increase in temperature, a discovery that could bolster the most popular scenarios of global warming. But the record is still hazy and the measurements are imprecise

enough that it is possible the warming did not come until thousands of years after the carbon dioxide rose. As such, the relationship between carbon dioxide and climate remains shrouded in mystery.

"There's great urgency in the work," said Paul Mayewski of the University of New Hampshire. "The ice has trapped the past and held it for us to rediscover."

Mayewski is the scientific coordinator for the second Greenland Ice Sheet Project, a \$15 million venture, involving more than 30 U.S. investigators, assisted by the Polar Ice Coring Office at the University of Alaska and funded by the National Science Foundation. Collaborating with the Americans is a

group of Europeans who are drilling a companion core 20 miles from the Americans' site. Together their work should provide some of the most detailed records ever gathered linking past climate to rising and falling levels of carbon dioxide.

The Americans and Europeans have come to a world that is as difficult as it is beautiful. It is a place where the summer sun wheels around the sky, but never sets, and flakes of snow called ice diamonds glitter in the air like a hallucination. It is so cold that even in the laboratory, built in a trench in the snow, the computers must be swaddled in heating pads to protect them from subzero temperatures.

And because the summit is 10,200 feet above sea level, the air is so thin that newly arrived researchers stumble around for a few days like zombies, chewing aspirin and sucking on oxygen bottles to kill the pounding headaches and nausea caused by the sudden ascent to high altitude.

The plan is to drill to the bedrock of Greenland, down through nearly two miles, or more than 10,000 feet, of ice. Begun last summer, the work proceeds this year. The cutting is done by a hollow tube with a sawtoothed end. It spins, grinding a circle around the ice that becomes the core as it is surrounded by the descending drill. Piece by piece, the researchers and technicians then pull six-foot and twelve-foot lengths of ice core to the surface.

Like new babies, the ice cores must be handled with care. Upon delivery from the hole at the drill site, the cores are rushed to a frozen laboratory dug into the snow itself, a long trench 12 feet deep

and several feet wide, where the samples are processed.

Researchers bundled in parkas and snow pants bombard the ice with laser beams and electric jolts. They sift and sniff the ice for traces of volcanic acids and dust, for greenhouse gases such as carbon dioxide and methane and for the special species of heavy hydrogen and heavy oxygen whose abundances tell the temperature when the snow fell.

Last week the Americans' main drill reached 412 feet and brought to the surface ice that researchers estimate was deposited in the year 1569, about half a century before the Pilgrims landed in the New World and right in the middle of a period of worldwide coolness known as the Little Ice Age.

Such precise dating to the exact year is possible for at least the first 5,000 years. The scientists date the core by looking for evidence of known events, such as historically dated volcanic eruptions, which they compare with known rates of ice accumulation and the flow and dynamics of the glacier itself.

By summer's end, the researchers hope to reach past ice laid down when Jesus was born, to the time of the pyramids about 2800 B.C. At the close of the project three years from now, the ice could be as much as 200,000 years old—snow that fell before anatomically modern human beings evolved.

For scientists clever enough to read the clues, ice can reveal evidence that helps them date the core with considerable precision.

Researchers, for example, can see in the dust trapped in the ice evidence of annual summer winds that have swept the Gobi Desert for thousands of years, thereby giving them a dusty equivalent to the annual growth rings of trees. They

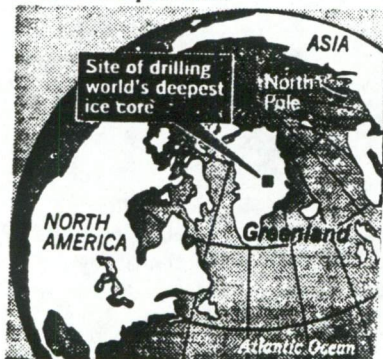
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can watch the sulfur levels begin to rise at the dawn of the industrial age. Layers of radioactive fallout pinpoint the fire at Chernobyl in 1986 and atomic bomb tests on the Bikini Atoll in 1946. By watching for traces of methanesulfonic acid, a substance one smells at low tide, the scientists can also gauge and time the biological productivity of marine plants in the North Atlantic, which themselves might play an important role in altering climate, according to Eric Saltzman of the University of Miami, who is examining the ice in Greenland.

The scientists are interested in dates because they want to time the Earth's cooling and warming cycles.

For a glaciologist such as Richard Alley of Pennsylvania State University, the Greenland ice can be read like geological sediment. Alley can back-light a segment of core and see light and dark layers left by the summer melts and the winter storms. He believes that he can date ice accurately by counting the seasons back to about 750 years ago. After that, dating by eye becomes almost impossible.

One reason for the difficulty is that deep down, where the pressure becomes greater, ice begins to compress and flow. "It stretches and thins like taffy," Alley said. "It shears and twists and flows. The visual data gets really flakey and shakey the further back you go." The Greenland ice sheet flows toward the sea like a ponderous river. Indeed, the drilling site itself may be moving toward the sea at 10 feet a year. This motion can make it difficult to date older ice precisely. But researchers are devising ways around the problem.



Ken Taylor of the University of Nevada, for example, runs electric probes across the ice to measure acidity. When more electricity passes through the ice, it usually means the ice is more acid and that is usually the result of hydrogen sulfate being dumped by volcanoes. So with his electric probes, Taylor can see signs of eruptions. He already has detected the eruptions of dozens of known volcanoes, from Mount St. Helens in 1980 to the Laki eruption, which blew in Iceland in 1783. Eventually, Taylor hopes to find the eruption that buried Pompeii in 79 A.D.

Another investigator, Michael Ram of the State University of New York in Buffalo, is attempting to date the ice by the dust trapped in it. Using a laser beam to scatter light through melted ice, Ram said he can spot the seasonal increases in a certain type of grit known to blow off the Gobi Desert during spring and summer storms. Though his technique is unproved, Ram believes he and his colleagues will be able to date the ice by Gobi dust back as far as 10,000 years.

Researchers know the planet moves through a cycle of ice ages and warmer interglacial periods based on the timing of the slow wobble in Earth's axis. But they also know that increases and decreases in carbon dioxide and other greenhouse gases accompany climate change. Are these gases causing the temperature to rise or are they simply a byproduct? Will the current burning of fossil fuels and forests put enough extra carbon dioxide into the atmosphere to significantly alter climate? "That's the million-dollar question," Alley said.

Preliminary evidence from ice cores retrieved by the Soviets at Vostok station in Antarctica, the coldest spot on Earth, suggests increases in carbon dioxide preceded warming. More than a mile of Vostok ice examined by Todd Sowers and Michael Bender of the University of Rhode Island suggest that carbon dioxide levels rose 3,000 to

7,000 years before continental ice began melting at the close of the great ice age that ended 140,000 years ago, presumably as a result of warming temperatures. A similar finding accompanied the end of the last ice age some 18,000 years ago.

"It is a question of thresholds," Sowers said. "Is the carbon dioxide driving the system or responding? It may be that things happen in different ways depending on whether or not the Earth is moving into or out of glacial periods."

At present, the uncertainties loom. In addition to the apparent lag between a rise in carbon dioxide and warming, there are signs that climate may resist change for many years and then suddenly jump to a warmer phase. Perhaps, some scientists argue, such a sudden surprise is in store—perhaps sooner, perhaps much later—as a result of humanity's currently growing output of greenhouse gases.

"Ice is an amazing scientific medium," said Alley of Penn State. "If we were just clever enough to understand what it is telling us."

# Heat Is More Lethal When It Is Unusual, Researchers Find

Killer air masses are a matter of hot air, not pollution. *cu*

By WILLIAM K. STEVENS

**W**HAT New Yorkers and other Northerners consider a heat wave often feels like a routine summer day to residents of Dallas or Phoenix or Jacksonville. Now scientists say that such feelings are not just a matter of discomfort, but also of life and death. Heat, they have found, generally begins killing people at lower temperatures in New York and other Northern cities than in the South and Southwest, where people are more acclimated to hot weather.

And in an attempt to create an early warning system for killer heat waves, scientists have lately identified a special set of climatic conditions that appear to send summer death rates soaring and that also have much to do with the regional variations in mortality thresholds.

Not just any stretch of extremely hot weather, they have found, trips the temperature threshold switch that causes mortality to soar. Rather, the switch is tripped by one special, sharply defined sort of extremely hot, humid, oppressive air mass that only infrequently develops over a given area, overwhelming people's ability to adapt. If its arrival and duration can be reliably forecast, the scientists believe, cautionary warnings can be issued and lives can be saved.

### Case Study: St. Louis

The extraordinarily oppressive weather system responsible for most heat-related deaths is described in a paper to be published in a forthcoming issue of the journal *Environmental Health Perspectives*. It can afflict any number of cities, including New

York, and is essentially the same kind of system in each city. But so far it has been studied most thoroughly in St. Louis.

There it brings temperatures that reach at least 96 degrees, the recently established threshold for a surge in mortality in that city. It also displays a number of other features that distinguish it from nine other kinds of summer air masses, some of them also quite hot, and it combines humid air from the tropics with dry, torrid air borne on winds from southwestern deserts. These huge systems originate in one part of the United States but retain their coherence as they move from region to region. They bring clear skies and high nighttime temperatures that in St. Louis stay near 80 degrees.

This air mass dominates St. Louis's summer weather only 7 percent of the time on the average. It appears several times in some years and not at all in others. When it does arrive it generally stays in place for several days. The longer it stays, the more people die, as many as 10 to 20 a day in a big city.

"By the time the fifth day rolls around, you are killing a lot of people," said Dr. Laurence S. Kalkstein of the University of Delaware's Center for Climatic Research, who has come up with the findings. A specialist in the field of medical climatology, he is now a visiting scientist at the Environmental Protection Agency in Washington, where he coordinates a major research project on the health implications of global warming.

According to a preliminary analysis of a selected sample of 10 cities by Dr. Kalkstein, three besides New York and St. Louis are apt to be visited by a killing air mass: Boston, Philadelphia and Memphis. Chicago and San Francisco are susceptible to a lesser degree.

### Dangerously Out of the Norm

What makes these air masses so deadly, said Dr. Kalkstein, is that their particular combination of features suddenly pushes the level of heat stress far above the summer norm to which people have become adapted. In Northeastern cities, he said, "a hot, oppressive air mass doesn't occur that often, so it has tremendous impact."

In the South and Southwest, he said, the summer norm may itself bring extremely high temperatures, but in the absence of a sudden jump to another level of heat stress, there is no spurt in deaths. Since Southerners are acclimated to the higher temperatures they normally experience, those normal temperatures cause no more deaths, per capita, than the lower temperatures Northerners normally experience.

The researchers have ruled out the possibility that the most susceptible people have already succumbed in the South.

The paper in *Environmental Health Perspectives* is the latest in a series by Dr. Kalkstein and colleagues that in the last 14 months have dealt with regional variations in weather-related deaths.

In the early 1980's, Dr. Kalkstein devised a new index of weather discomfort, the weather stress index. It assumed that the discomfort caused by any given set of weather conditions varies depending on the normal weather people are used to in their area. Developed under a contract with the National Oceanographic and Atmospheric Administration, the measure is incorporated in the discomfort indexes of today's routine weather reports.

Now Dr. Kalkstein and colleagues in both government and academia have extended their research on regional differences from discomfort to mortality and the role of large weather systems in boosting it.

Among the findings common to all areas of the country is that heat, not air pollution, is the primary short-term killer associated with summer weather systems. "Over the long run," Dr. Kalkstein said, "air pollution is very damaging to human health." But on a day-to-day level, he said, it appears that heat rather than the more concentrated pollution that often accompanies it is more important in pushing susceptible people over the edge.

CONTINUED

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Mortality data are not yet available for this year's hot spells in Phoenix, Los Angeles, New York, Washington and other cities, but Dr. Kalkstein said he had "no doubt" that they have caused a lot of damage. The mid-July hot spell in New York, with its temperatures in the 90's, was "a candidate" for the most-damaging category, he said, but its impact may have been less than it would have been, say, in June because heat waves become less damaging later in the season. This is because people become more acclimated as the season progresses, Dr. Kalkstein believes.

Last year, Dr. Kalkstein and a colleague, Robert E. Davis of the University of Virginia, reported on a study of mortality data and temperature records that revealed the regional differences in susceptibility to heat. For a number of cities, they established threshold temperatures at which deaths begin to rise.

**Fatal Temperatures Vary**

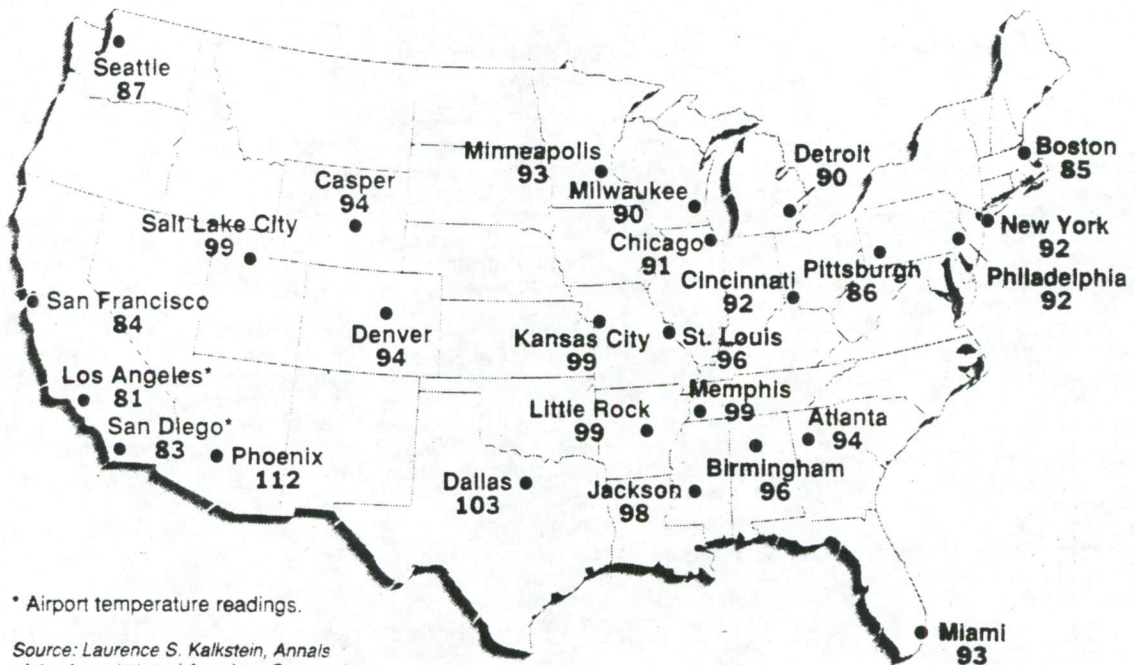
In New York, for instance, the threshold is 92 degrees; in St. Louis, 96; in Dallas, 103; and in Los Angeles, 81. (The Los Angeles figure is low

because the weather station where it was taken is at the airport, which is cooled by the nearby ocean; temperatures downtown and in the valleys are higher.) In many southern and southwestern cities that are normally hot and whose residents have become acclimated, no threshold can be detected and excess deaths generally do not occur. Phoenix has been one such city. The big question now, Dr. Kalkstein said, is whether the 120-degree-plus temperatures recorded in Phoenix earlier this year — by far the highest ever — were such a big departure from the norm that heat-related deaths soared for the first time.

Changes in the local environment, especially development and construction, are probably responsible for whatever change may be taking place in Phoenix's climate, he said, although global warming could have similar effects over a broader area in the future.

**City Heat: Thresholds of Danger**

When daily maximum heat exceeded thresholds in these cities, deaths rose significantly. In other cities studied, thresholds could not be established.



\* Airport temperature readings.

Source: Laurence S. Kalkstein, *Annals of the Association of American Geographers*

DEVELOPING THE COMPREHENSIVE APPROACH:  
HOW CAN SCIENCE HELP?

DEPARTMENT OF JUSTICE, 19 JUNE 1990

DAN ALBRITTON, NOAA

THIS INTRODUCTION...

● THINGS NOT AT ISSUE

(WE HOLD THESE TRUTHS TO BE  
 SELF-EVIDENT...)

● KEY SCIENTIFIC FACTORS IN  
 THE COMPREHENSIVE APPROACH

(WHAT IS THE ROLE OF  
 EACH?)

FOR EACH FACTOR: - HOW WELL IS IT KNOWN?

- WHAT ARE THE MAJOR UNCERTAINTIES?

- WHAT IS THE STATUS OF THE RESEARCH?

● SECONDARY FACTORS

(WHAT SHOULD ONE BE AWARE OF?)

● SPECIFIC SUGGESTIONS  
 TO THIS GROUP

(FOR WHATEVER THEY ARE WORTH!)

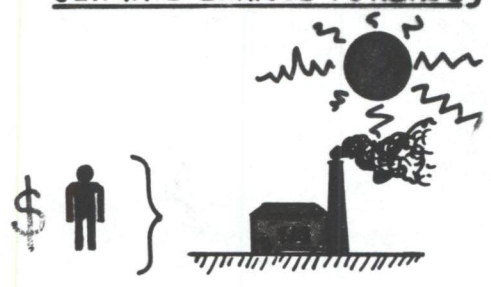
# THINGS NOT AT ISSUE

① THE "ARENA" OF CHOICE FOR THE COMPARITIVE INDEX IS

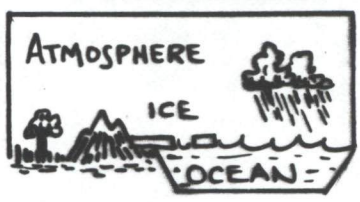
TRACE SPECIES  
VIS-A-VIS  
RADIATIVE FORCING } I.E.,

**THE CLIMATE SYSTEM**

• CLIMATE CHANGE FORCINGS



• PHYSICAL PROCESSES



• PHYSICAL RESPONSES



• BIOLOGICAL PROCESSES



• IMPACTS



RATIONALE :

KNOWLEDGE IS MAXIMUM THERE

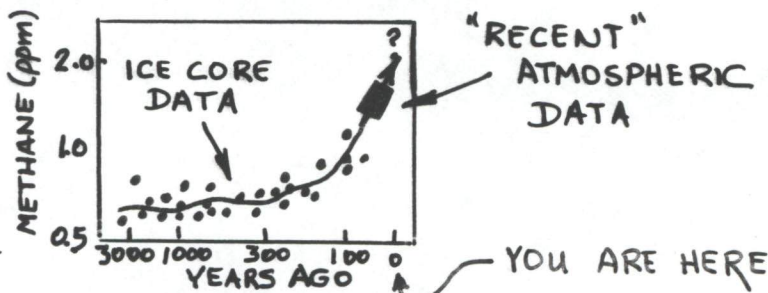
② CO<sub>2</sub> IS NOT THE WHOLE TRACE-GAS/CLIMATE PICTURE.

- THERE ARE OTHER GREENHOUSE MOLECULES -

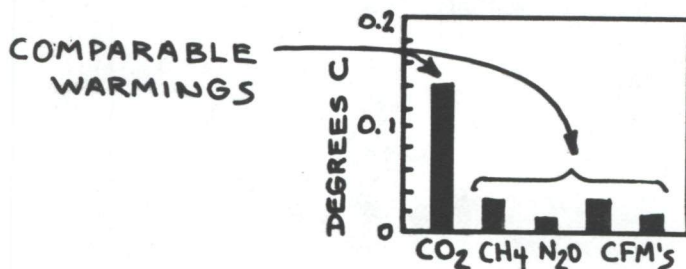


- TROPOSPHERIC OZONE - O<sub>3</sub>
- METHANE - CH<sub>4</sub>
- CFM's - "FREONS"
- NITROUS OXIDE - N<sub>2</sub>O
- ⋮

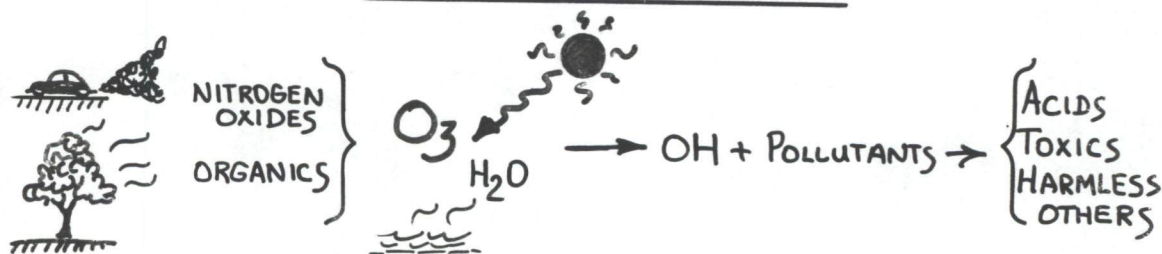
- THEIR ABUNDANCES ARE INCREASING -



- THEIR GREENHOUSE EFFECT IS COMPARABLE TO CO<sub>2</sub> -



- THEY ARE ALSO CHEMICALLY ACTIVE -



# THE POLICY-RELEVANT TRACE GAS PROPERTIES

POSED  
POLICY  
QUESTIONS

- CAN SCIENCE DEVISE A COMPARATIVE INDEX THAT REPRESENTS THE RELATIVE RADIATIVE FORCING OF THE TRACE SPECIES.
- CAN A UNIVERSAL EMISSIONS ABATEMENT APPROACH BE IMPLEMENTED?

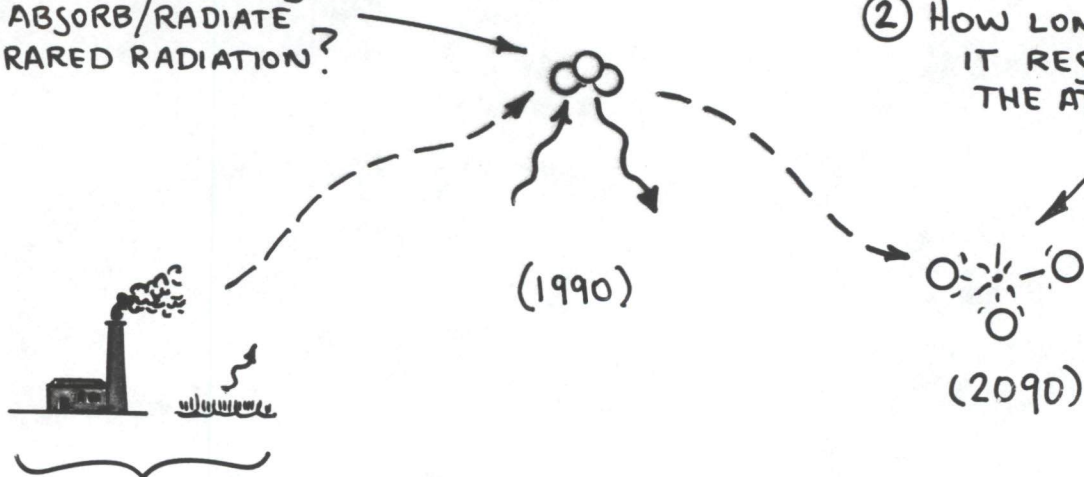
## ● THE SCIENCE :

THERE ARE 3 MAJOR TRACE GAS PROPERTIES THAT RELATE TO THESE QUESTIONS.

○ FOR EACH SPECIES (E.G., CO<sub>2</sub>, METHANE, OR CFC):

① HOW WELL DOES IT ABSORB/RADIATE INFRARED RADIATION?

② HOW LONG DOES IT RESIDE IN THE ATMOSPHERE?



③ HOW WELL IS THE SOURCE UNDERSTOOD?

(THE DETAILS...)

# ① MOLECULAR RADIATIVE PROPERTY

## ● MAJOR POINTS:

### ● THEY VARY CONSIDERABLY.

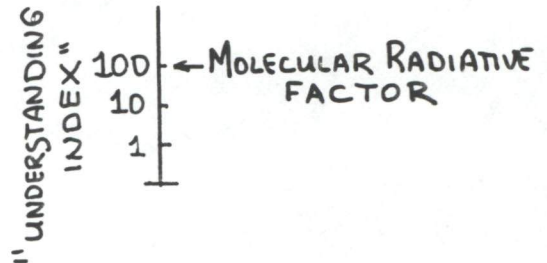
EXAMPLES :

	CALC. RADIATIVE FORCING*
CO <sub>2</sub>	1 (REFERENCE)
METHANE (CH <sub>4</sub> )	21
NITROUS OXIDE (N <sub>2</sub> O)	206
CFCs	12000 - 18000
CARBON TET. (CCl <sub>4</sub> )	5700
HCFC-22	11000

### ● THEY ARE RELATIVELY VERY WELL KNOWN.

THEY ARE BASED ON:

- MOLECULAR SPECTROSCOPY ✓
- RADIATIVE SCATTERING ✓



### ● RESEARCH IS ONGOING ON UNCERTAINTIES.

EXAMPLES: BAND STRENGTHS OF CFC-SUBSTITUTES.

### ● OTHER POINTS:

THE RELATIVE EFFECT DEPENDS SOMEWHAT ON:

- THE ATMOSPHERIC ABUNDANCE (\* TODAY'S ATMOSPHERE)
- H<sub>2</sub>O & TEMPERATURE PROFILES
- ASSUMPTIONS ABOUT CLOUDS
- REFERENCE FOR FLUX
- ⋮

BUT REASONABLE PEOPLE SHOULD BE ABLE TO REACH A COMMON ACCEPTABLE APPROACH!

## ② ATMOSPHERIC LIFETIME

- THE RESIDENCE TIME IS A MEASURE OF THE TIME THAT A MOLECULE FORCES THE RADIATION BALANCE.



- LIFETIMES VARY SUBSTANTIALLY.

EXAMPLES:	CFC-115	400 YEARS
	CFC-12	130
	CO <sub>2</sub>	~100*
	CFC-11	65
	CH <sub>4</sub>	10

- THEY DEPEND ON THE NATURE OF THE "SINK".

CFCs	STRATOSPHERIC UV BREAKUP - SLOW
CH <sub>4</sub>	TROPOSPHERIC CHEMICAL REMOVAL - FASTER

- THE DEGREE OF UNDERSTANDING VARIES.

STRATOSPHERIC BREAKUP - "VERY GOOD" (GOOD CLEAN PHYSICS)  
 & CONFIRMED BY OBSERVATIONS!

TROPOSPHERIC REMOVAL - "FAIR ESTIMATE" (COMPLEX CHEMISTRY)

CIRCULATION AMONG RESERVOIRS - "POOR" (CO<sub>2</sub>)

"SATURATION" OF SINK - "UNKNOWN" (BIOSPHERE? CO<sub>2</sub>?)

[CONT]

● GREENHOUSE WARMING POTENTIAL (GWP) IS THE PRODUCT OF MOLECULAR RADIATIVE FACTOR AND LIFETIME.

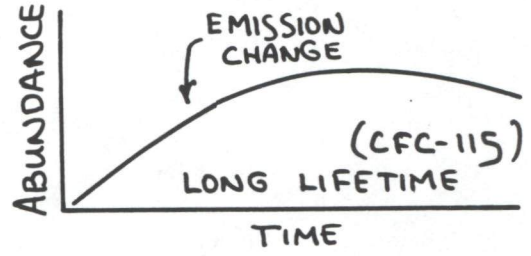
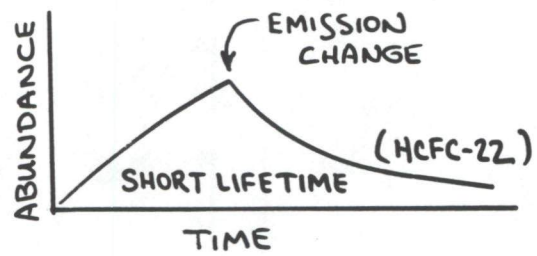
EXAMPLES:	GWP: OVER	20	100	500	YEARS
CO <sub>2</sub>		1	1	1	(REFERENCE)
CH <sub>4</sub>		63	21	9	
N <sub>2</sub> O		270	290	190	
CFC-11		4500	3500	1500	

(NOTE THAT AGREEMENT WILL HAVE TO BE REACHED ON THE TIME HORIZON)

(THE UNCERTAIN CO<sub>2</sub> "LIFETIME" IS A SERIOUS COMPLICATION.)

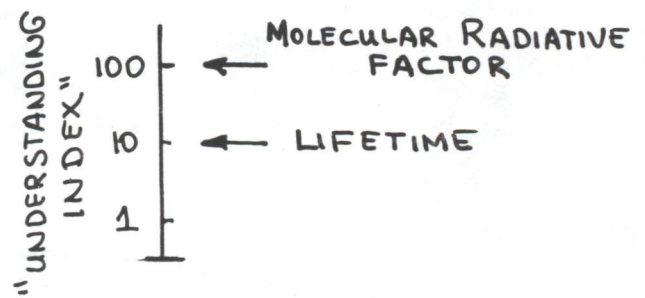
● THE LIFETIME IS AN EXTREMELY POLICY RELEVANT PROPERTY.

LONG LIFETIMES: WE CAN'T QUIT THE GAME AFTER WE DISCOVER THAT WE ARE DEALT LOSING HANDS.



● A BROAD SPECTRUM OF RESEARCH IS UNDERWAY.

- BIOSPHERIC PROCESSES
- ATMOSPHERIC CHEMISTRY
- OCEANIC CIRCULATION
- FLUX TECHNIQUES
- ⋮
- (SERVAL AGENCIES)



### ③ THE NATURE OF THE SOURCE / SINK

#### ● HOW WELL DO WE UNDERSTAND THEM?

(AND HENCE HOW AMENABLE ARE THEY TO THOUGHTFUL, QUANTITATIVE, & DEFENSIBLE ALTERATION?)

THERE IS QUITE A SPECTRUM:

o PURELY INDUSTRIAL: CHLOROFLUOROCARBONS



1/3 (MONITERED CLOSELY)

o COMBUSTION: CARBON DIOXIDE

FOSSIL FUELS 63 ± 3%

o HUMAN INFLUENCED NATURAL PROCESSES: METHANE



RICE AGRICULTURE- 6-30%

o SUBSTANTIALLY UNKNOWN: NITROUS OXIDE



Vs.



FACTOR OF 2

#### ● SINKS ARE GENERALLY MORE POORLY KNOWN THAN SOURCES.

EXAMPLES:

CO<sub>2</sub> SOURCES: COMBUSTION (WELL KNOWN)

SINKS: VEGETATION, OCEANS (NOT AS WELL)

↑ GENERALLY NATURAL PROCESSES

[CON'T]

● IDENTIFICATION / QUANTIFICATION (THE LATTER IS HARDER!)

ILLUSTRATIVE CASES: (ASSUME AN AGREED-UPON COMPARATIVE INDEX)

NATION X PROPOSES TO REDUCE ITS FORCING BY: SCIENTIFICALLY DEFENSIBLE?

- (1) xxx CO<sub>2</sub>-EQUIVALENTS OF CFC,  
BY REDUCTION OF REFRIDGERATION USE - STRAIGHTFORWARD
- (2) yyy CO<sub>2</sub>-EQUIVALENTS OF CH<sub>4</sub>  
BY CHANGING CATTLE FEED - MUCH, MUCH HARDER

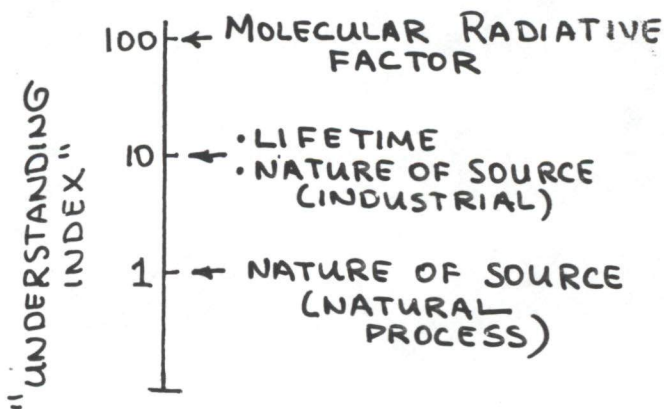
● THE NEEDED SCIENTIFIC "PRODUCT" IS SOURCE/SINK CHARACTERIC ALGORITHMS.



● THERE ARE A NUMBER OF RELATED RESEACH THRUSTS UNDERWAY OR PLANNED.

FAIR QUESTIONS:

- HOW AWARE ARE THEY OF YOUR NEEDS?
- HENCE, ARE THERE GAPS RELATIVE TO YOUR NEEDS?



SECOND-ORDER POINTS RELATIVE TO THE COMPARATIVE INDEX



- NON-IR GASES CAN INFLUENCE THE IR GASES.

EXAMPLE:  
 POLLUTANTS (NO<sub>x</sub>, VOCs, ...) → HYDROXYL RADICAL ABUNDANCE → METHANE, HCFC LIFETIME

- ISSUES / PHENOMENA ARE COUPLED.

EXAMPLE:

METHANE : • INFLUENCES STRATOSPHERIC OZONE.  
 • PARTICIPATES IN RADIATIVE FORCING.

- SOME GASES HAVE  UP AND  DOWN SIDES.

EXAMPLE:

CO<sub>2</sub> : • PLANT GROWTH  
 • RADIATIVE FORCING

- MONITORING OF ATMOSPHERIC CONCENTRATIONS OF TRACE GASES CANNOT YET YIELD SOURCE / SINK STRENGTHS.

MAYBE OVER NEXT SEVERAL YEARS, INVERSION METHODS CAN GIVE CONTINENTAL-SCALE VALUES FOR LONG-LIVED SPECIES.

- DIRECT MONITORING OF FLUXES ON USEFULLY LARGE SCALES IS BEYOND THE STATE OF THE ART.

HENCE, "PROXIES" ARE WHAT WE MUST DEAL WITH IN THE FORESEEABLE FUTURE.

EXAMPLE: TONNES COAL → CO<sub>2</sub> FLUX PER YEAR

## SOME SUGGESTIONS (RELATIVE TO THE SCIENCE)

- FOCUS ON PRIMARY ISSUES FIRST: LIFETIMES & NATURE OF SOURCE/SINK.
  - THERE IS ENOUGH THERE FOR AN EXTENDED, BUSY 1ST PHASE!
  
- USE THE IPCC WG 1 FULL REPORT AS THE MAJOR RESOURCE FOR LAYING OUT WHAT IS KNOWN.
  - IT IS VERY GOOD!
  - IT IS SCIENTIFICALLY BROAD BASED AND RIGOROUS.
  - THERE WAS CONSIDERABLE U.S. INPUT/INVOLVEMENT.
  - IT ALREADY HAS AN INTERNATIONAL BASIS.
  
- EXPLICITLY CONSIDER MECHANISMS FOR ACCOMADATING SCIENTIFIC IMPROVEMENTS OF SUBSTANTIAL MAGNITUDES.
 

E.G., WOULD A MAJOR CHANGE IN CO<sub>2</sub> "LIFETIME" CAUSE SHOCKS THAT WOULD BRING THE INTERNATIONAL "CURRENCY" MARKET DOWN?

  - SUCH SCIENCE BREAKTHROUGHS ARE QUITE LIKELY.
  
- BUILD A GOOD WORKING RELATION WITH THE CEES'S U.S. GLOBAL CHANGE RESEARCH PROGRAM.
  - THEY ARE PLANNING MUCH OF THE RESEARCH THAT YOU NEED DONE.
  - BRIEF THEM ON YOUR PLANS/NEEDS.
  - REQUEST THAT THEY ANALYZE HOW THE U.S. GCRP WILL MEET YOUR NEEDS. WHEN?
  - EXAMINE THE FY 1991 PLAN WHEN AVAILABLE (~3 WEEKS)
  - REQUEST THE CO<sub>2</sub> & CH<sub>4</sub> CROSS CUTS WHEN COMPLETED.
  
- FOLLOW THE TALK ABOUT AN "IPCC Round Two".

## Scientist Who Exposed Global Warming Proposes Satellites for Climate Research

By BOB DAVIS *BD*

Staff Reporter of THE WALL STREET JOURNAL

WASHINGTON — James Hansen, the NASA scientist who helped make the "greenhouse effect" an international issue, is proposing a \$200 million satellite program to settle the question of whether the Earth is warming and why.

The climate satellite proposal, which has circulated among scientists, already has provoked considerable controversy. It calls into question the necessity and timing of a gargantuan National Aeronautics and Space Administration satellite program, called the Earth Observing System, or EOS, which could cost as much as \$50 billion over 25 years.

Mr. Hansen's proposal comes out of a series of private meetings that Sen. Albert Gore (D., Tenn.), chairman of the space and science subcommittee, has held with about 20 environmental scientists. Sen. Gore says he plans to release a number of proposals in October to accelerate climate research. "Something like what (Mr. Hansen) is proposing does make sense," the senator said.

Essentially, Mr. Hansen suggests taking three instruments off EOS and NASA's proposed space station and putting them on a relatively small satellite, which would study clouds, water vapor and particles suspended in the atmosphere. If NASA launches two climate satellites, for about \$200 million, starting in 1995, Mr. Hansen predicts, the satellites would yield enough information to settle the central debate over global warming by the end of the decade.

"It would answer the questions of whether the Earth is warming and whether humans are the cause of that," Mr. Hansen said. An article giving details of his proposal is scheduled to be published in the fall issue of *Issues in Science and Technology*, a publication of the National Academy of Sciences.

The climate satellites would focus on the role of clouds, Mr. Hansen said. Generally, clouds cool the Earth by reflecting sunlight back into space—something akin to a giant window blind. But scientists don't know whether cloud coverage is increasing or what kinds of clouds predominate, leading to big differences in the severity of global change predicted by different computer models. "Climate satellites are a must," said Veerabhadran Ramanathan, a University of Chicago climate specialist.

Mr. Hansen's proposal puts him in the spotlight for the third year in a row. In 1988, he set off alarms about global change by testifying in Congress, during a blistering heat wave, that he was "99%" certain

that a global warming trend had begun. Last year, he became a cause celebre when the White House Office of Management and Budget tried to censor his testimony. This year, the quiet, determined director of NASA's Goddard Institute for Space Studies in New York is taking on NASA's vast EOS project.

NASA envisions launching a half-dozen \$3 billion satellites, which would carry as many as 16 different instruments to study the Earth, including some as big as cars. The first satellite, EOS-A, is scheduled for launch in 1998 and five others will follow over 15 years. The National Space Council, led by Vice President Dan Quayle, is concerned about the cost and risk of the project and is considering whether to restructure it.

Mr. Hansen says the EOS satellites, already three years behind schedule, are bound to fall further behind—leaving climate scientists with big gaps in needed data. He says NASA could fund the climate satellites out of a portion of the EOS project devoted to smaller satellites.

But EOS officials think that Mr. Hansen is underestimating the cost of his climate satellites and that his project would siphon funds from EOS, undercutting support for the program. "The dumbest thing to do is to say maybe EOS ought to slip a year to solve Jim Hansen's problems," said Gerald Soffen, EOS's project scientist.

Two NASA scientists at the agency's Langley Research Center sent Mr. Hansen a six-page letter criticizing his proposal as too limited because it fails to consider other environmental problems EOS will address, such as ozone depletion, acid rain and deforestation. Berrien Moore, a University of New Hampshire scientist involved with EOS, said he doubts that the climate satellites will settle the global-warming issue. "I don't think you'll get a smoking gun," he said.

For his part, Mr. Hansen says he doesn't want to kill EOS, which will provide data needed to make better predictions of how the climate will change in different places on Earth. But he is willing to forgo EOS data for a time to answer what he considers a more pressing question sooner.

The criticism of Mr. Hansen's proposal is overlaid with a sense of consternation about Mr. Hansen's ability to dominate the global-warming debate and fear of his popularity in Congress. If the climate satellite approach proves popular, Mr. Moore said, "There's a high probability that Congress will say we'll throw up a \$200 million satellite and buy out of the (EOS) project."

# More Fuel for the Global Warming Debate

P.13

**P**ROPHETS of global warming are having a hard time making the case that Earth is already heating up. No sooner does 1990 give us the warmest Northern Hemisphere spring on record than studies appear that muddy the issue.

Last March, Roy W. Spencer of the NASA Marshall Spaceflight Center and John R. Christy of the University of Alabama reported that the first 10 years of relevant satellite data (1979-1988) show no net warming. Yet the decade had some of the warmest years on record. They noted that two strong El Niño events - shifts in Pacific Ocean currents - in 1983 and 1987 produced a temporary global warming. The intermediate years of 1984, 1985, and 1986 were colder. The warmest year was 1987.

Now James Angell, a National Oceanic and Atmospheric Administration climatologist, has extended a comparable analysis back to 1958. He explains in the current issue of *Geophysical Research Letters* that El Niños, which are associated with unusually warm sea-surface temperatures in the eastern tropical Pacific, have a strong effect on lower-atmosphere temperature worldwide. Once the El Niño warming is removed from the data, the reported rise of global air temperature since 1965 drops by a third.

Indeed, he finds that 50 to 55 percent of the annual variance in global average lower-

atmospheric temperature is due to El Niño effects. This means that these effects tend to mask any human-driven warming, unless El Niños are themselves somehow affected by the rise in carbon dioxide, methane, and other heat-trapping gases that are accumulating as a result of human activity.

The uncorrected data show a fairly uniform drop in global temperature from 1959 to 1965, followed by an irregular warming. The five warmest years are in the 1980s. The record high is 0.42 degrees C (0.76 degrees F) above the three-decade average. Corrected for El Niño effects, the data not only show a much smaller overall warming, but 1989 also becomes the warmest year of the 1958-1989 study period, not 1988 as the unaltered record suggests (or 1987 in the satellite data).

The bottom line, Angell says, is that his study "emphasizes the need for extreme caution in using the temperatures of particular years as evidence for or against a greenhouse effect." He also notes that even the unaltered record shows a year-to-year variability of 0.20 degrees C. "This relatively large interannual variability makes it difficult to determine the long-term trends," he says.

To further confuse things, geology professor William E. Leonhard and research fellow R. V. Krishnamurthy, at the California Institute of Technology, have found tree-ring evidence of a warming trend going back hundreds of years. It may have begun before any human-driven greenhouse effect would have started.

So far, they have studied 23 trees. These indicate a warming since at least 160 years ago. One tree suggests the trend could be as old as 500 years. If their analysis is supported by other evidence, this will add yet another natural influence on global temperatures to take into account.

None of this means we can ignore man-made global warming. Human activity already has added around 2.2 watts per square meter to the atmosphere's natural greenhouse heat-trapping of 151 watts per square meter of Earth's surface averaged over the entire planet and for a full year. There's little dispute about that. The annoying fact is that nobody yet can determine whether this has begun to raise the global temperature or merely is expressed in other effects such as undetected changes of cloudiness or ocean circulation.

**ROBERT C.  
COWEN**

STEPHEN CHAPMAN **G3**

# Firm footing on global warming?

**B**y now, all Americans of sound mind and pure heart must be overcome with shame at their government's policy on the greenhouse effect, which is alleged to be turning the planet into a sauna with no off switch. Instead of joining with all the other industrial democracies in pledging to do thrillingly noble deeds, the Bush administration has stuck to its party-pooping insistence on counting costs and nailing down facts.

This is highly unsatisfying to European heads of government, particularly West Germany's Helmut Kohl, whose citizens are a pushover for every environmentalist fashion. It's also infuriating to American environmental groups, who this week were accusing President Bush of nothing more serious than "killing our world."

Don't send a wreath just yet. The Bush administration may have a hard case to sell politically, but it clearly has the best of the scientific and economic arguments. European governments are more willing to vow a crusade against global warming partly because they know it will cost them less than it will cost us.

The global warming alarmists, like most alarmists, behave as if all the important questions were already settled. In fact, we don't know whether carbon dioxide emissions will raise the atmospheric temperature. If so, we don't know by how much. And, if it does so by a substantial amount, we don't know how damaging the results will be.

If carbon dioxide emissions cause warming, we should already be sweating. But over the past century, scientists have found, temperatures have risen only by a tiny amount, or possibly not at all — despite a sharp increase in the level of carbon dioxide and other greenhouse gases in the atmosphere.

Even many scientists who believe the mercury will climb sooner or later think it won't go nearly as high as environmentalists claim. Those scary predictions of huge increases in ocean levels have already been scaled back, making it unlikely that New Yorkers and Houstonians will

need canoes to get to work.

Other experts note that a warming trend, if it happens, will have some benefits, such as boosting harvests, lengthening growing seasons and reducing January gas bills in Chicago. It may also help head off a new ice age, a catastrophe that the green lobby was confidently predicting just a few years ago. Global warming, if it happens, will create some problems but not the apocalyptic threat to human survival that is often advertised.

Europeans, who have historically been more allergic to free markets than Americans, have been forced to retreat from socialism in its various forms. Luckily for them — and the American left — the greenhouse threat arrived just in time to give unreconstructed statist a new excuse for meddling in the lives of ordinary people. They aren't going to

let a few facts get in their way.

It probably hasn't escaped the notice of Helmut Kohl and Francois Mitterrand that the heaviest burden of limiting greenhouse emissions will not fall on Germany and France. Carbon dioxide is produced mainly by burning fossil fuels, which the United States uses in far greater quantities than the Europeans.

One reason for the difference is nuclear power. France gets 29 percent of its energy from nuclear plants. West Germany and the European Community as a whole get 12 percent. The United States gets 6 percent. So Americans will have to spend a lot more money to cut greenhouse pollutants than Europeans.

How much? A study by Alan Manne of Stanford and Richard Richels of the Electric Power Research Institute estimates if the United States wants to cut total emissions 20 percent by 2020, it will even-

tually have to cough up about 3 percent of its gross national product annually, the equivalent of about \$160 billion a year in today's dollars.

That would make the savings and loan bailout look like a blue light special. The other Western industrial nations would have to spend only about half as much as we would, which may explain why they're about twice as enthusiastic. But of course what their leaders demand won't require any real sacrifices for about 20 years. By that time, Mr. Kohl and his colleagues will be comfortably retired from politics.

President Bush has taken the reasonable position that he won't commit the U.S. government to a vast and expensive intrusion into the nation's economy and its citizens' personal lives without more convincing proof of the need. That's only common sense, a commodity that these days is scarcer than the spotted owl.

*Stephen Chapman is a nationally syndicated columnist.*

throughs in battery technology that could affect the car's range and affordability.

Other auto makers, including the Ford Motor Company, the Chrysler Corporation and Fiat, and some independent companies are experimenting with modifications on their existing models so that they could run on battery power. Ford has developed a version of its Aerostar mini-van that runs on electric power in a pilot project sponsored by the Department of Energy.

### Three Promising Types

A battery is simply a device that can store an electrical charge and furnish a current on demand. The most promising battery types, according to the Energy Department, rely on combinations of chemicals like lead and sulfuric acid, nickel and iron, and sodium and sulfur.

Engineers are already familiar with the quirks and capacities of the first two kinds to store and discharge energy. The lead-acid combination is the same type that starts engines in autos; while nickel-iron batteries provided electricity for railroad cars early in the century. Sodium-sulfur batteries, while they were developed 20 years ago in a Ford laboratory, have yet to find a routine use.

Each type has drawbacks as a power source for electric vehicles. Conventional lead-acid batteries are heavy and quickly lose their capacity to store energy under the stress of regular, deep discharging and recharging. Sodium-sulfur combinations produce much more energy for their weight, but go dead if the battery temperature is not 280 to 325 degrees centigrade.

Nickel-iron batteries are durable but cost four to five times as much per unit of output to produce than conventional lead-acid batteries, according to Energy Department officials. Nickel-iron batteries also give off hydrogen, which some engineers regard as hazardous for vehicles parked in garages where a spark might cause an explosion.

In addition, the compounds used in some battery combinations make mass production tricky and raise concerns about recycling the used battery materials. For instance, the handling and disposal of sodium can be a problem.

Many proponents of electric vehicles agree that recently proposed laws requiring manufacturers to sell a certain number of cars, along with the offer of incentives like tax credits to buyers, may be necessary to jumpstart the market.

Nevertheless, a relatively small but important market for electric vehicles is already emerging in the Los Angeles basin, where pollution-control authorities are moving to restrict the sale of gasoline-powered vehicles.

Eagle-Picher Industries, an automotive supplier and battery manufacturer based in Cincinnati, has broken ground on a plant in Joplin, Mo., to produce 500 battery packs a year that use a nickel-iron combination to store electricity. A coalition of California utilities and pollution-control authorities is financing the plant's construction with a \$5 million grant. Initially, the batteries will be used to power modified Chrysler mini-vans operated as service vehicles by Southern California Edison.

Engineers at Eagle-Picher say they have developed a venting system that prevents a dangerous buildup of the hydrogen given off by nickel-iron batteries.

But G.M. is betting on an improved lead-acid battery, hoping it will be available in a few years to power early versions of the Impact.

Electrosource Inc., a small, publicly held technology company in Austin, Tex., has received encouragement from General Motors but no financial support to pursue a manufacturing technique it says prolongs the life of lead-acid batteries and greatly reduces the cost.

When a battery is charged, the electrical current is separated into positively charged ions and negatively charged electrons, which attach to the surface of metal or alloy grids resembling waffles. The surfaces of the grids are porous, like tiny sponges that store and discharge energy.

Batteries can store more energy per pound by increasing the porosity, and therefore surface area, of the grids. But grids that have more pores are less durable.

## A market for electric cars is emerging in the Los Angeles area.

The search for grids strong enough yet sufficiently porous to store the large amounts of power required to run an electric vehicle has led to new manufacturing techniques.

The grid for a conventional lead-acid battery is made by melting lead with various additives and then pouring the mixture into a die or mold. But the life of the battery grid can be reduced by uneven distribution of the alloys, and careful attention to the cooling and drying of the grid is necessary to avoid further weakening.

Electrosource has developed a process to make battery grids without melting the materials. The process begins with a cylindrical billet of lead, which is heated and then squeezed like toothpaste into a special mold, where it surrounds some other material, like copper wire or fiberglass yarn. Under pressure, the lead is squeezed out concentrically attached to the core material, which adds strength.

Electrosource executives say the batteries made by this process, along with some new packaging techniques, last significantly longer than conventional lead-acid batteries and are more easily mass-produced.

Johnson Controls Inc., a leading car-battery maker based in Milwaukee, is pursuing refinements to lead-acid technology, which company officials regard as the most viable power source for electric vehicles in the near term.

### A Radically Different Design

Sodium-sulfur batteries also rely on a chemical reaction to store and discharge energy, but their design differs radically from that of conventional batteries. The battery pack is a sealed steel box with two terminals, packed with some 3,000 cells similar in size and shape to flashlight batteries. Each cell contains a core of liquid sodium surrounded by a ceramic sleeve. Liquid sulfur surrounds the ceramic, and the whole cell is encased in a steel cylinder.

The main advantage of sodium-sulfur batteries is the large amount of power they can store for their weight. Chloride Silent Power Ltd., a British company that has received Energy Department money to develop sodium-sulfur batteries, says its batteries provide twice the range of lead-acid units, at about 60 percent of the weight.

Chloride has supplied a handful of sodium-sulfur batteries to Ford and some smaller electric vehicle developers in the United States.

# Scientists probe link with global warming

By **SHERRI J. WILLARD**  
of The Oregonian staff

**T**he beleaguered Amazon rain forests face another growing threat as a result of human encroachment: wildfires.

An area nearly the size of Oregon is cut and burned in the Brazilian Amazon each year, and that is increasing the likelihood of wildfires, according to fire ecologist J. Boone Kauffman.

"One of the most problematic regions in the world with respect to fires is Brazil," Kauffman said, "with deforestation and fire being significant contributors to global warming."

Deforestation has primarily been a result of slash-and-burn agriculture and conversion to cattle pastures. The Brazilian Satellite Institute estimates that 8 percent of the Amazon has been deforested. Estimates have been as high as 12 percent.

Kauffman, an assistant professor in Oregon State University's Department of Rangeland Resources, has been studying the detrimental effects of fire and deforestation in Amazon rain forests since 1986.

Much of Kauffman's research is in conjunction with Christopher Uhl, an ecologist at Pennsylvania State University, and Robert L. Sanford of the Natural Resource Ecology Laboratory at Colorado State University.

Their research seeks to answer such questions as:

- What is the effect of deforestation on the probability of fires occurring?

- What happens to natural plant species when a fire occurs? Which plants can tolerate fire?

- What gases are released into the atmosphere as a result of fires and burning?

- How much and what kinds of nutrients are lost from the soil as a result of fire and burning?

- Where do those nutrients go?

To understand the conditions necessary for a forest fire to happen, Kauffman is measuring rainfall, temperature and humidity — the microclimate — in both tropical wet forests and tropical dry forests.

Tropical dry forests differ from tropical wet forests principally in the amount of rainfall per year, the height of the tree canopy and the length of the dry season. Wet forests receive about 12 feet of rain per year, while the dry forests receive only 3 feet.

In 1986, Kauffman began his work in an intact, undisturbed tropical rain forest near the small village of San Carlos de Rio Negro in southern Venezuela. Here Uhl and Kauffman wanted to determine whether fire can occur in an undisturbed wet tropical rain forest.

Through measuring the microclimate, and the moisture content and chemical composition of the forest floor, they found that a wildfire is almost impossible in a tropical wet forest.

In 1987, Kauffman went to the Brazilian state of Para in the northeastern Amazon Basin. Para is characterized by extremely high rates of deforestation because of cattle-pasture conversion, logging, mineral extraction and slash-and-burn agriculture.

With the cooperation of local Brazilian ranchers and farmers, Kauffman and his colleagues studied the microclimate of plots used by farmers and ranchers.

Typically in Amazonia, plots are logged and burned, then crops are planted for a couple of years. When the land is no longer useful for crops, it is burned again and converted to pasture for raising cattle. After three or four years, the plot is abandoned. Owing to soil erosion and nutrient loss, the plots can no longer support crops or grass.

The microclimate of the plots was measured before and after logging, before and after the first burn, each year of crop production, before and after the second burn, each year of pasture use, then after abandonment.

Kauffman found that after deforestation there is a dramatic change in microclimate, resulting in a drop in relative humidity from nearly 100 percent to 60 percent and a 19-degree increase in temperature.

"With all of the logs and what not remaining on the sites you have a very, very fuel-rich, hotter, drier, windier environment to where now fires are very likely and can occur after two or three days, and that's what sets the whole scenario for the big fire events," Kauffman said.

Last fall, Kauffman and Sanford traveled to Cerrado, a tropical dry forest in the northeastern state of Pernambuco.

Kauffman described the area as the "least understood and most disturbed and perturbed by human activities that's occurring right now in Latin America."

In Cerrado, Kauffman estimated the input of gases into the atmosphere by measuring nutrient loss from this tropical dry forest due to fire. The smoke — containing greenhouse gases such as carbon dioxide, carbon monoxide, nitrous oxides and methane — contributes to the threat of global warming. It also contains sulfur dioxides, which contribute to acid rain.

"With the exception of fossil-fuel combustion, these are probably the most significant sources of human-caused greenhouse gas input into the atmosphere," he said.

Kauffman found that a lot of his work "is certainly indicating that the problem may be worse than previously thought — that there are more greenhouse gas inputs coming from the rain forest than previously thought."

In addition to deforestation's contribution to the greenhouse effect, it has resulted in unprecedented rates of species extinction. Kauffman and his colleagues have found that as many as 40 percent to 50 percent of the tree species can be lost in a sin-

CONTINUED

## Federal energy use examined

Associated Press

WASHINGTON — The federal government lags far behind private industry in energy conservation and spends too little money to make buildings energy efficient, witnesses told a congressional panel on Wednesday.

The witnesses and several congressmen on two House Energy and Natural Resources subcommittees expressed doubt that federal agencies will be able to reduce energy use by 10 percent by 1995 as required by law.

"Without a greater push from the top this goal will prove elusive," said Rep. Mike Synar, D-Okla., chairman of the panel's gov-

ernment operations subcommittee.

Energy conservation has taken on greater urgency in recent years as environmentalists have argued that the nation must dramatically reduce its consumption to deal with such concerns as global warming.

According to Energy Department estimates, the federal government spent \$3.5 billion last year to heat, light and cool more than 500,000 buildings, while spending only \$44.5 million to make buildings use energy more efficiently.

The government's energy use per square foot of building space has increased by 1.1 percent since 1985.



U.S. Department of Justice  
Land and Natural Resources Division

Office of the Assistant Attorney General

Washington, D.C. 20530

December 18, 1989

MEMORANDUM

TO: C. Boyden Gray  
Counsel to the President

FROM: Richard B. Stewart *RS*  
Assistant Attorney General

SUBJECT: Next Steps on International Approaches to Global  
Climate Change

As undertaken at this morning's meeting in your office, this memorandum outlines the steps that should be taken to develop further the proposed United States approach for international agreements dealing with global climate change. This list of steps represents the items considered significant by the representatives of EPA, Justice, State and your office in attendance this morning.

1. Clearance for new U.S. submissions to the RSWG. Clearance must be obtained in the next two weeks for the materials to be submitted to the Intergovernmental Panel on Climate Change ("IPCC") Response Strategies Working Group ("RSWG") for inclusion in the RSWG papers by the January 1, 1990 deadline. The proposed materials for submission to the RSWG -- a set of "Comments" on the RSWG "Legal Measures" paper, and a "Concept Paper" discussing the U.S. proposal -- were attached to the memorandum sent to you yesterday.
2. DPC review. The Domestic Policy Council's Working Group on Global Change, chaired by Dr. Bromley, should take up these matters at its next meeting. If it were held next week, it could be the vehicle for the clearance described in paragraph 1.
3. Pamphlet on comprehensive approach and trading. A pamphlet should be developed, for dissemination in mid-January to RSWG participants, explaining our position on the

benefits of the "comprehensive" and "international trading" approaches to international agreements on greenhouse gases, their sources and sinks, and the drawbacks of other approaches, such as pollutant-by-pollutant and command-and-control methods. The pamphlet should draw on U.S. and international experience with each regulatory method.

4. Response to UNEP initiative on draft convention. This week Dr. Tolba, on behalf of UNEP in Nairobi, requested that all nations suggest language, by January 15, 1990, for a draft framework convention on global climate change. This request appears to compete with the normal IPCC procedures, and to accelerate the schedule for drafting such language. In addition, there may be growing pressure to address this question in the United Nations General Assembly instead of in the IPCC forum. The U.S. should develop a strategy for dealing with this pressure, including consideration of how far to insist on the IPCC's jurisdiction over these matters, and whether to present our substantive proposals to the U.N. if it takes up these matters.

5. Additional needed background work.

Relevant federal agencies should work on the following matters relevant to our proposed approach:

(a) Economic impacts. Assessments should be developed of the economic impacts, on the U.S. and other principal negotiating nations or blocs, of several scenarios for international agreement, including different timetables, baselines, and variances for developing nations within our "comprehensive" approach.

(b) Global Warming Potential Index. A "global warming potential index" should be developed to relate the contribution of each greenhouse gas to total global warming.

(c) List of greenhouse causal factors. The list of greenhouse gases, their sources and sinks, should be developed for inclusion in a "comprehensive" approach to international agreement on climate change.

(d) Monitoring and implementation assurances. Analysis and recommendations should be developed regarding mechanisms for monitoring and implementation assurance provisions in international agreements on climate change. This work should survey and analyze mechanisms used in past international agreements, and recommend the most appropriate mechanisms for both a "comprehensive" approach and an "international trading" approach.

6. Spring 1990 science/economics conference. Work should commence to develop the materials, key speakers, and exhibits that could be assembled at the President's spring science/economics conference on the global environment, in order to educate those attending as to the benefits of our comprehensive and international trading approaches, the drawbacks of traditional command and control regulatory mechanisms, and U.S. and international experience with each system.



U.S. Department of Justice  
Land and Natural Resources Division

Office of the Assistant Attorney General

Washington, D.C. 20530

December 18, 1989

MEMORANDUM

TO: Hon. D. Allan Bromley  
Assistant to the President  
for Science and Technology  
Chairman, Domestic Policy Council Working Group  
on Global Change

Members of the Domestic Policy Council  
Working Group on Global Change

FROM: Richard B. Stewart *RS*  
Assistant Attorney General

SUBJECT: International Approaches to Global Climate Change

In an effort to develop a new approach to possible international agreement on global climate change, representatives of the Environmental Protection Agency, the State Department, and the Justice Department have met with each other and with the Counsel to the President. This memorandum transmits to you the materials produced by those meetings, and identifies certain issues to which the DPC Working Group may need to give special attention.

Timetable

In the first week of February 1990, the United States will host a meeting of the Response Strategies Working Group ("RSWG") of the Intergovernmental Panel on Climate Change ("IPCC"), followed by a plenary meeting of the IPCC. At its February meeting, the RSWG will consider additional submissions to its October, 1989 Report. Such submissions must be made by a deadline of January 1, 1990.

Follow-up actions in the coming months include further deliberation by the RSWG and the full IPCC over the spring and summer, the President's spring conference on the science and economics aspects of global environmental change, the IPCC conference in the autumn, possible related activities by the United Nations Environment Programme ("UNEP"), and the international conference on a "framework convention" on climate change to be hosted in Washington, D.C. in the fall of 1990. These meetings and others are listed in the last attachment to the memorandum dated December 14, 1989, described below.

### Materials Attached

Attached please find the following materials:

- Memorandum from Richard B. Stewart to C. Boyden Gray, dated December 14, 1989, describing and analyzing the proposed new approaches for international agreement.  
(Tab 1)

Related to this memorandum are the following attachments:

- Comments to be proposed for inclusion in the RSWG Report. The deadline for adding such comments is January 1, 1990.  
(Tab 2)
- "Concept Paper" briefly summarizing the proposed approaches for international agreement, to be submitted for inclusion in the RSWG Report, also by January 1, 1990.  
(Tab 3)
- List of significant meetings and conferences in the coming months.  
(Tab 4)
- Memorandum from Richard B. Stewart to C. Boyden Gray, dated December 18, 1989, outlining the next steps that should be taken to develop the proposed approaches.  
(Tab 5)

### Issues for DPC Working Group Consideration

We respectfully suggest that the DPC Working Group on Global Change consider the proposed approaches contained in the above documents, and the discussion of the strategic questions, advantages and drawbacks related to our approaches contained in those documents. It should be noted that the impacts on the

United States of international adoption of the proposed approaches have not yet been analyzed in detail, and no quantitative predictions of such effects are yet available. Our recommendations are therefore tempered by the need for further research.

In particular, we recommend special attention to the following concerns:

1. Should the United States favor the traditional approach to environmental regulation when addressing potential global climate change, involving a framework convention followed by successive protocols each directing nations to limit their emissions of a separate specific pollutant? That approach has been employed, with some variations, by the Vienna Convention and the Montreal Protocol on Substances Depleting the Ozone Layer, and was proposed by other nations for dealing with global climate change at the Noordwijk Ministerial Conference on Atmospheric Pollution and Climate Change.

Or should the United States actively promote a "comprehensive" approach to collective treatment of all greenhouse gases, their sources and sinks, in which each nation must meet a national performance-based target, but is left to choose its mix of domestic policies to meet that target? This approach is described in the attached materials, and it is the one we recommend.

2. Assuming the United States Government adopts the approach we recommend, should the proposed approach outlined be presented to the RSWG and/or the IPCC as the official United States position, or should it be put forward more tentatively, as an issue for consideration by the RSWG and/or the IPCC?

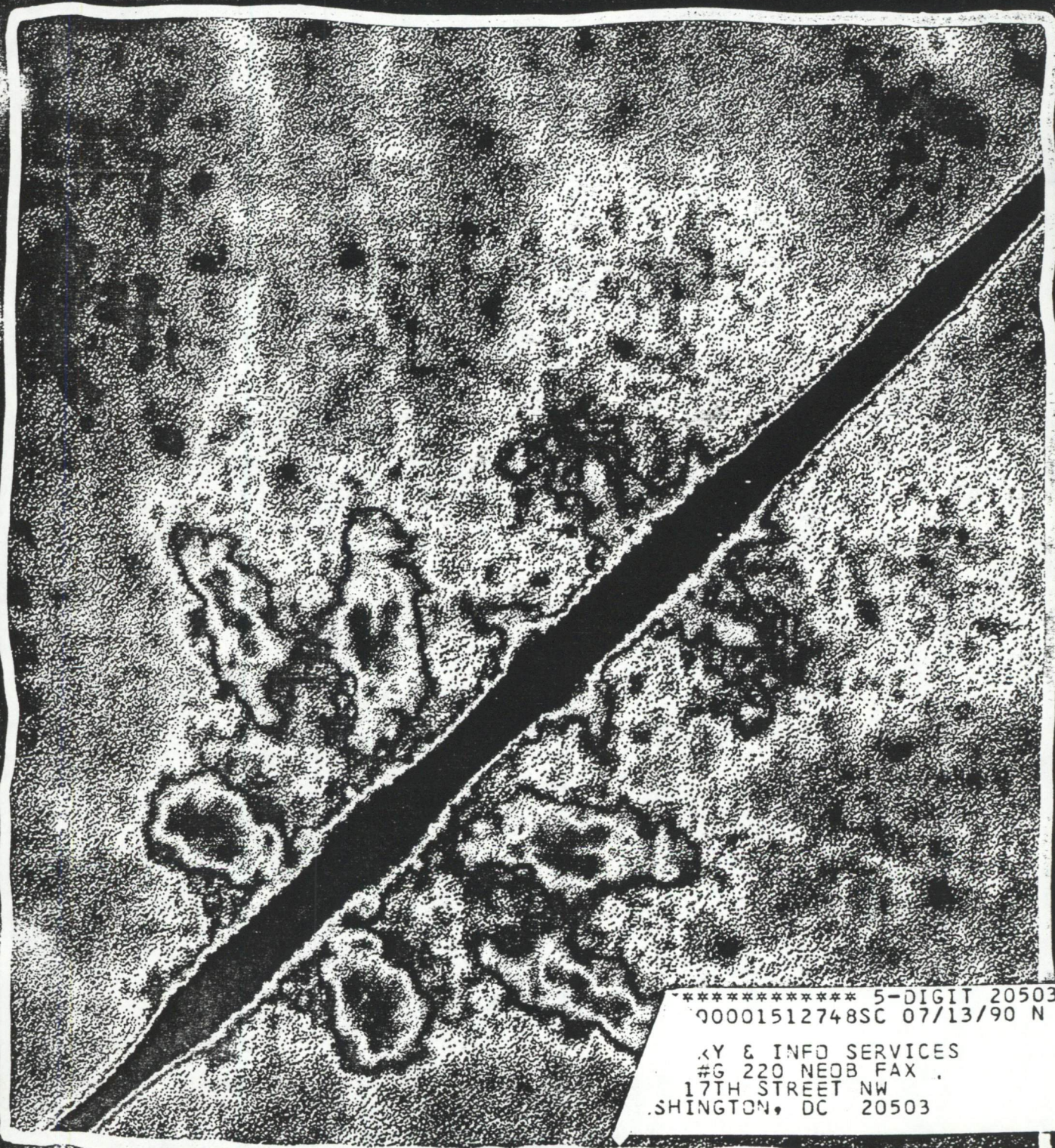
3. Should the "international trading" approach, as described in the above materials, be proposed as an integral part of the United States submission, firmly linked to the "comprehensive" approach, or should it be treated as an important and useful idea which may nevertheless be deferred for further consideration? This question is discussed more fully in the memorandum dated December 14, 1989, listed above, particularly at pp. 3-4.

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Activity in the other direction includes visits to the Soviet Union, under the same program, by a half-dozen American sociology lecturers. Among them are Neil Smelser of the University of California at Berkeley and Kohn of Johns Hopkins, who will be going to Moscow in December. Soviet universities are also soliciting American Fulbright lecturers.

Kohn adds that Cornell University has made a unique arrangement with Igor Kon, the Soviet Union's leading expert on U.S. sociology, who will have a 2-week-per-year visiting professorship. Kon, says Kohn, has managed to keep abreast of the field while working at an institute in Leningrad—mainly by obtaining review copies of American books. He cleverly managed to convey the meat of the scholarship by beginning and ending his reviews with "Marxist diatribes," says Kohn. So knowledgeable is the Soviet sociologist that when he came to the ASA convention in August 1988, he was able to identify the main accomplishments of every author to whom he was introduced.

Kohn has also been involved in initiating a series of joint conferences, which have been in the planning stage since before Gorbachev took over. IREX and the ASA are supplying funds to support five U.S.-Soviet conferences that are being held alternately in the United States and the Soviet Union. The first, in 1987, was a conference on sociology and the psychology of work, held in Vilnius. This December there will be a conference in Moscow on public opinion research.

All this cross-fertilization—indeed, the blossoming Soviet interest in sociology generally—is regarded as good news both for the discipline and for U.S. Sovietologists in particular. Shelley notes that "academic positions for sociologists trained in Soviet studies have gone unfilled in recent years" and expects that to change.

Further, William V. D'Antonio, head of the ASA, says he hopes eventually to see U.S. students doing graduate work in the Soviet Union.

For its part, the ASA is looking toward bringing over another crop of Soviet students next year, this time including political scientists and economists, with the cooperation of the American Political Science Association and the American Economics Association. "Soviets are acknowledging that American sociology is where it's at," says D'Antonio. Shelley agrees. She reports that the United States—where sociology is a heavily quantitative field—was chosen as the destination for the 17 students because "French sociology is seen as too qualitative and German sociology too philosophical."

■ CONSTANCE HOLDEN

# Global Warming: Blaming the Sun

*A report that essentially wishes away greenhouse warming is said to be having a major influence on White House policy*

A SLIM, UNREFEREED REPORT that many scientists have dismissed as biased and misleading is said to be at least partly behind the White House's recent temporizing on climate change.

And that is causing consternation among climatologists and other greenhouse experts, who are dismayed that this 35-page document by the George C. Marshall Institute, a Washington, D.C., think tank—rather than one of the massive, carefully researched and reviewed expert reports of the past several years—seems to be holding sway in the upper echelons of the Administration.

The report, "Scientific Perspectives on the Greenhouse Problem," is by three prominent scientists—William A. Nierenberg, director emeritus of Scripps Institution of Oceanography; Robert Jastrow, founder and former director of the Goddard Institute for Space Studies; and Frederick Seitz, president emeritus of Rockefeller University and past president of the National Academy of Sciences. The trio's other major foray into public policy was a vigorous defense of the Strategic Defense Initiative a few years ago.

Summing up the abundant uncertainties that surround greenhouse models and predictions, the authors say it is too soon to take any actions to reduce greenhouse gases. And by their reckoning, there is little need to. They argue that there is no evidence that the modest temperature rise of 0.5°C that has occurred this century is correlated with emissions of greenhouse gases, and they predict that decreased solar activity in the next century will lead to a cooling trend likely to offset any greenhouse warming. All of this is couched in ample caveats, but the underlying message is that the entire problem has been overblown.

Several scientists are up in arms. Steve Schneider of the National Center for Atmospheric Research, for one, has denounced

the report as a political document. Nearly 6 months after its release, he is still arguing about the report's scientific basis with Nierenberg, via letters.

"Noisy junk science," says Jerry Mahlman, director of the National Oceanic and Atmospheric Administration's Geophysical Fluid Dynamics Laboratory, where one of the major greenhouse models was developed.

A number of other respected climate researchers have suggested that the National Academy of Sciences review the study. The Academy is likely to weigh into the ruckus in some way—a couple of committees are looking at the report—though it will stop short of giving the document a formal review.

At the Environmental Protection Agency, Alan Hecht, deputy assistant administrator in the office of international activities, says he has "real problems" with the study and recently passed a critique of it onto EPA administrator William K. Reilly. As part of this informal review, Hecht asked Schneider for his comments on the report; Schneider's less-than-flattering letter is now circulating in the scientific community and on Capitol Hill, where Senator Albert Gore (D-TN), for one, is concerned.

The report does have its scientific supporters, including meteorologists like Jerome Namias of Scripps, and Richard Lindzen and Reginald Newell of Massachusetts Institute of Technology—distinguished scientists whose major work is largely outside the greenhouse field. On 23 September, Lindzen and Namias wrote to President Bush extolling the merits of the Marshall report and citing its conclusion that "current forecasts of global warming for the 21st century are so inaccurate and fraught with uncertainty as to be useless to policy-makers."

The message apparently has gotten



**High-level proponent.** William Nierenberg, one of the authors, briefed White House officials.

Scripps

through, if not to Bush then to his chief of staff John Sununu, who, it is widely believed, is quite taken with the report. Says Schneider: "Sununu is holding the report up like a cross to a vampire, fending off greenhouse warming."

Just what impact the report has had on Administration policy is difficult to pin down, and Sununu's office is mum on the subject. But it has been widely reported that Sununu tried to block EPA head Reilly from attending an international meeting on climate change at The Hague in early November. At that meeting, the United States refused to commit itself to cutting emissions of carbon dioxide.

Nierenberg, for his part, has been working hard to get the message into the White House. He personally briefed senior Administration staff, including representatives from the White House Office of Cabinet Affairs, the White House Office of Policy Development, the Council of Economic Advisers, and the Office of Management and Budget.

"I was impressed with the report," says Juanita Duggan, special assistant to the President in the cabinet affairs office. "Everyone has read it. Everyone takes it seriously. We have a coherent policy in the federal government that is not inconsistent with the Marshall Institute report."

"It is well worth listening to," adds Paul Roelling, a senior analyst in the White House Office of Policy Development. "They are eminent scientists. I was impressed."

But White House Science Adviser D. Allan Bromley, who was not yet in place when the report was released, seems to be distancing himself from it. "It has a distinguished group of authors, but there is no general consensus on the details and it has not been peer-reviewed," he said in a statement to *Science*.

All the critics concede that the first part of the report is a good description of the scientific uncertainties surrounding predictions of greenhouse warming. And everyone, not surprisingly, agrees with the report's plea for \$100 million for more research.

Where the report veers from the mainstream is with the assertion that the warming trend of the past century was probably caused by increased solar activity and not by an accumulation of greenhouse gases—and that, ipso facto, the greenhouse warming next century will be small, perhaps 1°C.

The basis of the report is an analysis of this 0.5°C warming trend, which, the authors point out, does not follow the curve of rising emissions of greenhouse gases. In-



**Leading opponent.** A critique of the report by climatologist Stephen Schneider has been widely circulated.

stead, they look for natural causes to explain the rise and find that solar variation mirrors it rather well. The authors' underlying assumption is that if they can break the connection between that 0.5°C rise and accumulating greenhouse gases, then all bets for future warming are off.

No such luck, says Schneider, who thinks they are setting up a straw man. "Could the sun have done it? Sure," he says, adding that a variety of natural phenomena could explain the temperature rise of the last century. But that, he adds, says nothing about the future greenhouse warming.

"There are uncertainties, but I can't think of any combination of them that could conspire to make the problem go away," says NOAA's Mahlman. Hypotheses are fine, he adds, "but to advise the White House on the basis of this type of argument? Give me a break. That is not responsible."

The reason people are worried about greenhouse warming, Schneider, Mahlman, and others say, is not because of the 0.5°C temperature rise during the past century but because emissions of carbon dioxide, chlorofluorocarbons, and methane are clearly increasing. And it is dead certain that if enough of these greenhouse gases are released into the atmosphere, where they trap heat, global temperatures will rise. The only question is how much, and by when.

Then the Marshall Institute pulls out another card. After analyzing the historical record of solar activity, which can be inferred from carbon-14 in tree rings, the authors predict that solar activity will decrease in the next century, leading to a mini Ice Age that will offset any greenhouse warming.

Preposterous, say solar physicists like John Eddy of the University Corporation for Atmospheric Research in Boulder, who calls their extrapolation "very shaky" at best. We simply don't have the ability to predict future solar activity, he says.

Curiously, Eddy was one of the sunspot

experts Jastrow consulted in writing the report. "Bob Jastrow would call me at work and at home on Saturday and Sunday. I would say 'No, no, you can't make that prediction.' I was shocked when I saw what came out."

Jastrow says the emphasis his colleagues are putting on the solar variability discussion is a "distorted" reading of the report, maintaining, along with Nierenberg, that the solar variation hypothesis is just a minor part of their argument.

"Then why did they put it in?" snaps a senior Academy official.

Their bottom line, Jastrow insists, is simply that no scientific conclusion can be drawn about the future greenhouse warming, "and we have time to find out." They assert that with \$100 million for supercomputers, answers to these questions will be forthcoming in 3 to 5 years, so why not wait before taking precipitous policy action?

"No one in his right mind would say that," counters Hecht at EPA, who, along with everyone else *Science* spoke with, says it will take a decade or more to address these questions.

In 25 years, Mahlman adds, "Congress will still be asking us questions we can't answer. I don't care if you pour \$100 billion at the problem."

The biggest gripe people have with the report is that the authors, in summoning uncertainty to their cause, fail to acknowledge that it cuts both ways. Explains Schneider: "What we don't know is just as likely to make it worse as better."

Solar variability is a case in point. Schneider offers a counter scenario to that in the Marshall Institute report: That during the past 100 years, solar energy output was decreasing rather than increasing. And without that natural cooling, which masked the greenhouse signal, the earth's temperature would have warmed up twice as much. "It's pure speculation," he adds, but since no one really knows what the sun was doing 100 years back, "it is just as likely as theirs." Moreover, says Schneider, if the earth warms up 2° to 4°C, as models usually predict, "it will swamp anything the sun has done in the past 100 years."

John Perry, a meteorologist and staff director of the Board of Atmospheric Sciences and Climate at the National Research Council, agrees. "If the report had just said, in an evenhanded way, 'don't rely on the models because there are hellacious uncertainties,' we all would have applauded. But the way it comes across is that all the uncertainties are on the downside. I don't think that is very democratic."

■ LESLIE ROBERTS



U.S. Department of Justice

Environment and Natural Resources Division

Office of the Assistant Attorney General

Washington, D.C. 20530

September 12, 1990

MEMORANDUM

TO: Members of the Task Force on Climate Approaches

FROM: Dick Stewart *DS*  
Assistant Attorney General

SUBJECT: Draft Task Force Interim Report on Research and  
Analysis to Support the Comprehensive and Incentives  
Approaches

As promised, attached is a draft of the interim report the Task Force will present to the DPC subgroup on global change. Please review it at your earliest convenience. We appreciate the comments you have made on the outline distributed August 24, and we have made every effort to incorporate them here. We would especially appreciate your thoughts on whether any relevant items or information have been omitted, and on suggested relative priorities for the tasks identified.

We will review this draft report at the meeting of the Task Force at 10:00 a.m. tomorrow, Thursday, September 13, at the Department of Justice, Room 2603.

A brief proposed agenda for the meeting is also attached. We look forward to seeing you tomorrow morning.

9/12/90

Comprehensive/Incentives Approach Task Force

September 13, 1990, 10:00 a.m.  
Dept. of Justice, Room 2603

Proposed Agenda

1. Consideration of draft Task Force report
  - A. Directions and content, including "policy context"
  - B. Priorities and timing of tasks, in light of importance of each task and in light of upcoming conferences, workshops, and international meetings
  - C. Agency activities to undertake tasks
2. CEES GC-MARS Research: draft report from GC working group
3. OECD activities
4. Other matters

9/12/90

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Interagency Task Force on Climate Approaches

**Interim Report:  
Research and Analysis to Support the  
Comprehensive and Economic Incentives Approaches**

September 24, 1990

Introduction

Since November 1989 the Administration has developed new approaches to the design of potential climate change policy, the "comprehensive" and "economic incentives"<sup>1</sup> approaches. These approaches were initially suggested by the United States to the Intergovernmental Panel on Climate Change (IPCC) by letter in December 1989, and were presented more fully through an "Informal Seminar" for the IPCC Response Strategies Working Group (RSWG) officers in February 1990, accompanied by a booklet of Discussion Papers that have since been widely distributed. The new approaches have been reflected in U.S. positions in the IPCC and now in the IPCC report itself, and in several speeches, including the President's April 18 closing remarks to the White House Conference on Science and Economics Research relating to Global Change, and his July 11 news conference following the Houston Economic Summit meeting.

The discussion to date has largely been of a conceptual nature. Work must now be done on the practical workings of these approaches, and to the research and analysis that would be needed to assess their utility and to support their implementation. This Task Force was organized in May 1990 to specify, encourage, and coordinate this work. The Task Force is an interagency effort chaired by DOJ and involving representatives of numerous agencies, including CEA, CEES, CEQ, DOC/NOAA, DOE, DOI, DOJ, EPA, NASA, NSF, OPD, OSTP, State, USDA, USTR, Treasury, and WH Counsel. This "Interim Report" is provided to identify the

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<sup>1</sup>The "economic incentives" approach was originally focused on emissions trading, but has since been broadened to encompass other market-based economic instruments, including emissions taxes.

research and analysis needed, the current Administration efforts in that direction, and the further work required. Work is needed in several scientific, economic and institutional research areas that bear on or underlie these approaches, including efforts to quantify sources and sinks of multiple greenhouse gases and fill gaps in information on those sources and sinks, to quantify the relative environmental impacts of these gases, to compare the cost-effectiveness of these approaches and their alternatives, and to develop institutional arrangements that could translate these approaches from concept to practicality. In light of the plethora of upcoming discussions, workshops, conferences, international meetings, ministerial conferences and full negotiations -- including the first session of negotiations on a framework convention on climate change, to be hosted by the United States in February 1991 -- prompt attention to these topics is needed to prepare U.S. representatives for effective participation and to assess choices the U.S. may need to make in responding to others' proposals or putting forward its own.

### **Policy context**

These approaches address the "how to" question -- how to design any policy that might be adopted to respond to potential climate change. Their principal aim is to improve the cost-effectiveness of any proposed policy choice. They do not address the larger cost-benefit question of "how much" policy action should be taken -- what level of social investment, if any, is warranted by risks of potential climate change. The work of this task force does not imply that a choice has been made to implement some policy action.

Furthermore, the utility of these approaches is not limited to the design of emissions limitation policies. The "comprehensive" and "economic incentives" concepts are "approaches" or heuristics that offer insight into any discussion of response strategies for potential climate change, whether the strategy is pursuing scientific research, promoting new technology, enumerating "no regrets" measures,<sup>2</sup> or designing

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<sup>2</sup>"No regrets" measures have been defined as those policies which are justified on other (non-climate) grounds (or, more precisely, those policies which are justified in the face of uncertainties about predicted climate change so great that the present expected loss due to climate change cannot confidently be said to exceed a de minimis level), yet which also help to address potential climate change. Examples include emissions-limiting steps taken for non-climate reasons, such as phasing out CFCs, afforestation, and improving energy efficiency. Other examples could include reducing landfill emissions of NMHCs and  
(continued...)

actual emissions limitations policies (whether domestic or international). The "comprehensive" and "economic incentives" approaches to potential climate change policy were originally developed in response to the piecemeal (CO<sub>2</sub>-focused), command-and-control regulatory approach then dominating the discussion in the IPCC, but the approaches apply to the full scope of policy options.

For example, a nation following a "no regrets" strategy could use the comprehensive approach to calculate the aggregate impact on net greenhouse gas emissions made by its various no regrets measures. A framework convention on climate change could take a comprehensive approach to the cooperative scientific and economic research to which the parties commit, as well as to any national emissions reporting, or to credit to be given under any future obligation for nations' current voluntary emissions-limiting activities. An economic incentives approach could be applied to adaptation measures desirable in long-range investments, such as coastal construction or water use planning.

### **Summary of the Approaches**

The two approaches are compatible, but need not be employed together. Both approaches offer the possibility of designing environmental policies that achieve goals at least cost and that maximize the possibility for diverse, innovative, flexible, and cost-effective responses.

Comprehensive approach. The "comprehensive" approach addresses all greenhouse gases (GHGs), their sources and sinks, collectively, in contrast to a piecemeal focus on CO<sub>2</sub> and the energy sector. GHGs include carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), halocarbons such as chlorofluorocarbons (CFCs) and related substances (HCFCs, HFCs), and tropospheric ozone (O<sub>3</sub>), whose precursors include oxides of nitrogen (NO<sub>x</sub>), non-methane hydrocarbons (NMHCs), and carbon monoxide (CO). Different GHGs arise from different sources and are removed from the atmosphere by different sinks. Different GHGs have different impacts on the environment; for example, each gas has a different ability to block certain radiated energy ("radiative forcing"). In order to relate the comparative environmental impacts of the various GHGs, the comprehensive approach employs a parameter or "index" that calculates the relative contribution of increments of each gas to global externalities such as radiative forcing. The comprehensive approach thereby avoids ignoring important gases (including methane, nitrous oxide, CFCs and halons, and

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<sup>2</sup>(...continued)  
CH<sub>4</sub>, reducing auto emissions of CO and NO<sub>x</sub>, and improving the drought-resistance of crops.

tropospheric ozone and its precursors) that would be omitted from a CO<sub>2</sub>-only approach, and avoids ignoring important sources and sinks that would be omitted from an energy-only approach.

As a means of developing an agenda for science and economics research, such as research on the likelihood or impacts of potential climate change, the comprehensive approach suggests the scope of the research agenda: the range of relevant inquiry, the gases and sectors relevant as inputs to economic models of GHG emissions, and the relative environmental externalities (both negative and positive) related to emissions of each gas.

As an approach to technology development, the comprehensive approach assists in identifying and comparing the relative importance of technologies and practices affecting potential climate outcomes.

As a means of enumerating "no regrets" measures, the comprehensive approach provides a metric for identifying and assessing policy actions in the climate context. It could form the basis for calculating the aggregate impact of various no regrets measures on a nation's net GHG emissions.

As an approach to emissions limitation rules or obligations, the comprehensive approach provides an environmentally coherent and least-cost design for limitations policy. A piecemeal approach, focused on one gas (e.g. CO<sub>2</sub>) or one sector (e.g. energy), would omit salient greenhouse gases, sources and sinks, and would likely induce unintended shifts of economic activities to unregulated modes that offset or even increase emissions of GHGs. The comprehensive approach cures these defects in a piecemeal approach. It also allows flexibility to choose the least-cost mix of policy options yielding the desired overall GHG limitation. And, by addressing "net emissions," it encourages sink enhancement such as through afforestation and safeguards against ocean pollution. The comprehensive approach can be applied to a variety of emissions limitation measures,<sup>3</sup> including emissions taxes and emissions trading, and including both domestic and international measures. If applied internationally, it has the additional benefit of affording each nation the flexibility and sovereignty to decide the mix of domestic policies regarding the array of gases, sources and sinks that that nation determines would best

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<sup>3</sup>In light of the relative weighting of the various GHGs according to their environmental externalities and the flexibility afforded to choose a least-cost mix of measures, it is possible that the comprehensive approach could achieve an aggregate net GHG emissions limit by restricting emissions of some gases while allowing emissions of other gas(es) to rise.

accomplish policy goals in light of its unique social, economic, cultural and institutional circumstances.

Economic incentives approach. The "economic incentives" approach similarly applies to a variety of policy options. In the emissions limitation area, it encompasses the panoply of market-based economic instruments, including emissions trading and emissions taxes, imposed to force internalization of the external environmental costs accompanying emissions. It includes the use of incentives to promote innovation in technologies and practices, and addresses adaptation as well as emissions limitation. These incentives could be applied domestically or internationally.

As one example, application of emissions trading to emissions limitation obligations would allow those emitting a substance to achieve compliance with limits on such emissions by voluntary agreements to reallocate emissions among individual emitters so long as the aggregate output did not exceed their overall limit. Thus, reductions would be obtained most at those places where reductions cost least. This could be accomplished by authorizing informal reallocations or by formally issuing "allowances" and then authorizing a market in the allowances. Experience with emissions trading in the U.S. indicates that it can achieve environmental quality goals at substantially lower cost, and therefore could be of use to nations domestically as they implement any limits on greenhouse gases. Allowing emissions trading among nations could similarly be advantageous in the context of any international limits on emissions of greenhouse gases.

Emissions taxes would in principle also produce least-cost results. In general, while emissions trading provides more certainty about the quantity of emissions limitation achieved, emissions taxes provide more certainty about the cost imposed on emitters. Imposition of international emissions taxes could raise additional institutional, political and sovereignty concerns that would not attend international emissions trading or domestic taxes.

As another example, market mechanisms could be used to encourage efficient adaptation practices. Long-range investments, such as coastal construction or water use planning, might, because of market failures or other institutional failures, be undertaken without giving appropriate weight to any climate change risks (e.g. rising sea levels or shifting precipitation). Such failures might be addressed by informational or incentive-based policies, such as requiring coastal construction to purchase subsidence insurance, or encouraging long-range water use planning to take account of potential precipitation patterns.

Research and Analysis Underlying the Comprehensive Approach

**I. Measuring and Monitoring Atmospheric Greenhouse Gas (GHG) concentrations**

Any environmental impacts resulting from GHGs would be associated with changing actual concentrations in the atmosphere, not emissions per se. The comprehensive approach underscores the necessity of gathering data on atmospheric concentrations of all relevant GHGs. Over the last decade much work along these lines has already been undertaken or accelerated, including (i) direct measurement through ground station, aerial, and satellite observation of atmospheric (tropospheric and stratospheric) concentrations of several trace gases (chiefly CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, O<sub>3</sub>, and CFCs), and (ii) sample records of past atmospheric compositions found in ice cores, tree rings, and other sites. Measuring and monitoring past, current and future concentrations, temporal and spatial (e.g. vertical) distributions, chemistry, removal, and other dynamics of GHGs will remain an essential function under a comprehensive approach.

-- Current Administration efforts:

- Under the U.S. Global Change Research Program, several CEES agencies are conducting relevant research. For example, DOE, NASA, NOAA and NSF are conducting or will soon conduct direct measurement of atmospheric concentrations and distributions of CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, tropospheric O<sub>3</sub>, CFCs, CO, NO<sub>x</sub> and NMHCs. NASA, NSF and DOI are studying sample records of CO<sub>2</sub> and CH<sub>4</sub> in ice cores and tree rings. NASA and NOAA conduct direct observations of stratospheric O<sub>3</sub> and related substances.

-- Future work:

- Ensure coverage of all relevant GHGs
- Ensure coverage of relevant temporal and spatial distributions
- Advance understanding of chemical interactions among trace gases
- Advance understanding of quantitative link between trace gases and radiative forcing
- Ensure that research called for in any framework convention addresses all relevant GHGs

## II. Impacts of GHGs: Comparative Indices

Changing concentrations of GHGs in the atmosphere are of interest because those gases may yield environmental impacts on societies and ecosystems. Different substances in the atmosphere have different environmental impacts; it goes nearly without saying that the environmental impacts of atmospheric O<sub>2</sub>, H<sub>2</sub>O, and CO<sub>2</sub> are quite varied and are believed to be fundamental to the present habitability of the planet. Incremental increases in concentrations of trace gases such as GHGs will similarly have various impacts depending on the particular gas at issue.

### (A) Radiative forcing index

In the climate change context, the principal environmental impact of GHGs under study has been radiative forcing. Radiative forcing is not the ultimate environmental impact of actual concern to societies and ecosystems; it rather serves as a useful proxy or intermediate metric for assessing the impacts of potential GHG-induced climate change, including atmospheric temperature change, changing precipitation, changing soil moisture, and sea level rise, which in turn could affect biological and other systems. Molecules of different GHGs have different radiative forcing properties, and estimates of the relative radiative forcing of incremental amounts of GHGs can provide a common metric (sometimes called "CO<sub>2</sub> equivalence") along which to compare the GHGs. A comparative parameter of relative radiative forcing, often called a "global warming potential" (GWP) index, has been developed by several scientists. The GWP index incorporates such variables as the instantaneous radiative forcing of each type of GHG molecule, its dissipation function and hence its typical residence time in the atmosphere, and the discount rate applied or the time horizon over which the forcing function is integrated.

#### -- Current Administration efforts:

- Considerable work has been done on the relative radiative forcing of many GHGs. Estimates of instantaneous radiative forcing, derived from laboratory tests of molecular properties, are well established, as are residence times for several GHGs.

Work in this area has been done by NASA, NOAA, NSF, EPA, and DOE, and has been reviewed and reported by IPCC WG I.

#### -- Future work:

- Harmonize various approaches and extending international understanding of indices.
- Improve accuracy of dissipation functions and hence of estimated residence times of GHGs. Scientific uncertainties in the current estimates remain

surrounding the residence time of CO<sub>2</sub>, due to complications in the carbon cycle and uncertainties in CO<sub>2</sub> sink removal processes. Atmospheric chemical reactions involving other gases, such as CH<sub>4</sub> and precursors to tropospheric O<sub>3</sub>, complicate estimates of their residence times.

- Incorporate indirect effects attributable to various gases' atmospheric reactions. Certain trace gases react to form other radiatively important trace gases, or react with substances that would otherwise affect GHG abundances.

- Take account of "saturation" effects. Radiative forcing by each GHG occurs within a different segment of the electromagnetic spectrum; as that segment or "band" becomes occluded, additional increments of the GHG have diminishing marginal radiative forcing impacts. Radiative forcing estimates thus depend on, and need to be expressed in terms of, projected concentrations of relevant GHGs.

- Take account of the implications that vertical and other distribution of GHGs in the atmosphere may have for calculated GWP values.

- Improve use of discount rates/time horizons. IPCC WGI expresses GWPs in three selected time horizons; analysis is needed of which horizon is appropriate for policymaking. More broadly, better understanding is needed of the scientific and economic basis for choosing different discount rates.

- Assess implications of including other relevant substances, such as anthropogenic aerosols, in the GWP index.

- Develop institutional mechanisms for adopting a consensus index and adjusting it to new research results. Because uncertainties remain in certain aspects of the index, index values may change as new scientific information is discovered. If an internationally agreed index is used as a tool for design of national policy portfolios to limit net index-weighted GHG emissions, changes in the index values could mean changes in the costs to each nation of its policy package. Mechanisms should be developed for giving advance indication of index uncertainties and likely changes in the index, incorporating new scientific information, and smoothing transitions to new index values. Such mechanisms could include objective science panels and periodic reassessments.

(B) Full environmental impacts index

As indicated above, radiative forcing is only one of the environmental impacts of trace gases, and is really an

intermediate proxy used as a common metric to compare diverse GHGs. GHGs have other non-warming environmental impacts of global and local significance, some of which may be more important than their contributions to radiative forcing. For example, CFCs and related substances deplete the stratospheric ozone layer; higher CO<sub>2</sub> concentrations increase plant photosynthesis and increase plants' water use efficiency. Optimal policy design would entail developing a comparative GHG index that incorporates the full externalities imposed by increments of each GHG. Without such a "full impacts" index, a GWP index could provide signals or incentives that yield desirable changes in aggregate GWP but undesirable changes in other impacts; in other words, significant externalities will remain uninternalized. A full impacts index would include radiative forcing (currently measured in the GWP index) and other salient non-warming global impacts of GHGs, such as the direct effects of CO<sub>2</sub> on vegetation and the ozone depletion impacts associated with CFCs and other halocarbons. Additional impacts that might be considered include the toxicity of CO, O<sub>3</sub> and other gases.

-- Current Administration efforts:

- Conceptual thinking about design of a full impacts index. (DOJ, USDA)
- Efforts to quantify direct environmental impacts of CO<sub>2</sub> enrichment, chiefly its impacts on agricultural and forestry output. (DOE, USDA, DOI, EPA, NSF)
- Efforts to quantify environmental impacts of stratospheric ozone depletion and resultant UV-B irradiance due to halocarbon emissions, such as impacts on agriculture, phytoplankton, and cancers. (USDA)

-- Future work:

- Address technical and analytic issues in a full impacts index. Whereas the common proxy or metric used in the GWP index is radiative forcing, a full impacts index would require a common metric among the various warming and non-warming impacts. One candidate for such a proxy metric is aggregate influence on global agricultural yield. (DOJ, USDA)
- Undertake preliminary design and rough quantitative estimate of a full impacts index, in order to assess the difference between the relative GHG values obtained in a full impacts index versus a GWP index.
- Improve understanding of direct environmental impacts of CO<sub>2</sub> enrichment, including the impact of CO<sub>2</sub> in concert with changes in other environmental variables such as temperature, moisture, and other pollutants. (DOE, USDA, DOI, EPA, NSF)
- Improve understanding of impacts of ozone depletion, including measuring UV-B irradiance and assessing

impacts of UV-B radiation on biological systems.  
(USDA)

- Consider whether to include additional impacts, such as toxicity.
- Use the understanding of the importance of internalizing all salient externalities to assess and compare the environmental and socioeconomic distortions that might be induced by employing a parameter limited to global radiative forcing, global agricultural yield, or other incomplete proxies.

### III. Measuring and Monitoring net GHG emissions

The comprehensive approach emphasizes attention to all GHGs, sources and sinks. Baseline data on all of these is not always currently available. In addition, much of the data that are available derives from estimates using data on inputs (e.g. fuel quantities) and knowledge of or assumptions about input-output ratios associated with technologies or practices. Better measurement, forecasting and actual monitoring of net GHG emissions is suggested by, and needed to support, the comprehensive approach.

Assessment of current and future net emissions is useful in the task of predicting the contribution of net emissions to atmospheric concentrations and hence to potential climate change, even if emissions limitations are never imposed. The ability to better monitor future emissions could also be useful in verifying the implementation of limitation actions and in assuring others' compliance with their claims and with international obligations. This is true of domestic limitations rules as well as international obligations; if a domestic GHG emissions limitation policy is to be effective and, in particular, is to employ performance standards rather than technology-based standards, it will require sound emissions monitoring techniques.

#### (A) Measuring net GHG emissions

- Current Administration efforts:
  - Numerous agencies collect and analyze data on various gases, sources, sinks, sectors, and industries, and thereby measure emissions from a variety of sources (e.g. energy utilities, mobile sources, land use, agriculture) and uptake by a variety of sinks (e.g. oceans, forests, soils, grasses).
  - Efforts are underway to assemble "inventories" of net

emissions of GHGs for many nations,<sup>4</sup> chiefly EPA's analysis of CO<sub>2</sub>, CH<sub>4</sub>, CFCs, HCFCs, N<sub>2</sub>O, CO, NO<sub>x</sub>, and NMHCs for the US and other nations.

- Data are generally adequate on US and other industrialized nations' emissions of GHGs from fossil fuel combustion (generally measured by data on fuel inputs and knowledge of typical combustion techniques), and on world emissions of halocarbons (generally measured by production, consumption and storage rates).

-- Future work:

- Ensure that measurement covers all relevant GHGs, sources and sinks.
- Improve data on other nations. Data on developing nations are particularly scant.
- Develop technologies for measuring net GHG emissions, including direct observation and remote sensing.
- Develop practical proxies or surrogates, such as fuel or fertilizer input data coupled with assumed output rates (e.g. combustion or cultivation techniques), or acreage or livestock data coupled with assumed output rates, to generate emissions factors to assist in measuring emissions. Ensure that measurement uncertainties and assumptions, and use of proxies/surrogates, do not distort policy responses.<sup>5</sup>
- Improve understanding of the processes involved in natural emissions and sink uptake, and how these activities might be influenced by climate change.
- Ensure that data presentations are comprehensive, e.g. avoid CO<sub>2</sub>-only or fossil fuels-only charts in IPCC, NES, and other reports except as adjuncts to complete GHG presentation.
- Ensure that data presentations include the scientific uncertainties involved.

(B) Forecasting future net emissions

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<sup>4</sup> Efforts outside the government include: OECD project on all gases, solicited from member states; WRI (in conjunction with UNEP/UNDP) on CO<sub>2</sub>, CH<sub>4</sub>, CFCs, all nations; Harvard Kennedy School on CO<sub>2</sub> and CFCs, many nations.

<sup>5</sup>For example, measurement of CH<sub>4</sub> emissions based on a proxy such as total acreage of rice cultivation might imply that the only option to reduce emissions is reduced rice cultivation, whereas changed practices or rice strains might accomplish the same at lower socioeconomic cost. In general, the use of proxies should not be allowed to conceal opportunities for changing the emissions factors or other assumptions from which the proxies derive.

- Current Administration efforts:
  - Use of economic models to generate scenarios of future emissions. EPA, DOE, and NSF are conducting such work, using a variety of economic models. U.S. agency work was reviewed and reported in the IPCC WGI/WGIII emissions scenarios.
- Future work:
  - Make use of forthcoming Second Generation GHG Emissions model (J. Edmonds developing for DOE), which will overhaul and expand current economic models to cover multiple GHGs, multiple sectors, and other important improvements.
  - Ensure that Edmonds model includes GHG sinks and other aspects of the comprehensive approach.

(C) Monitoring net emissions in the future

- Current Administration efforts:
  - Efforts to improve monitoring of non-point emissions, including CH<sub>4</sub> emissions from rice cultivation (EPA) and ruminant animal husbandry (EPA); and GHG emissions from biomass burning (deforestation) (EPA, NASA, USDA).
  - Efforts to improve monitoring of CH<sub>4</sub> emissions from energy systems such as natural gas transmission and fossil fuels extraction (DOE).
- Future work:
  - Use proxies/surrogates, developed for measurement of net emissions (section (A) above), to monitor emissions through monitoring of inputs, technologies and practices.
  - Expand monitoring capacity and data to cover all relevant gases, sources, and sinks: data are especially needed on non-point sources of CH<sub>4</sub> and N<sub>2</sub>O, e.g. agriculture, livestock; hydroxyl chemistry and atmospheric chemical reactions yielding tropospheric O<sub>3</sub>; non-point sources and sinks of CO<sub>2</sub>, including oceanic biota, terrestrial biota, long-term sequestration, plant lifecycles, grasses, soils, and trees, extent and effects of deforestation, and sink behavior.
  - Expand monitoring capacity and data to cover all nations. Current data generally cover industrialized nations.
  - Harmonize techniques and data among nations and analysts. For example, resolve differences among nations monitoring deforestation (Brazil is urging that only its satellites produce reliable estimates of Brazilian land use).
  - Develop monitoring technologies and capabilities, as described under "(A) Measuring net GHG emissions"

(above). Identify potential international and national methods for monitoring net GHG emissions; assess institutional, political, social, and economic constraints on such monitoring, and means to overcome such constraints

- Assess options for monitoring arrangements, including arrangements for monitoring and reporting and their relation to sovereignty concerns, e.g. voluntary or mandatory national reporting; "national technical means" of observation of other nations' activities; remote sensing; atmospheric observations; international oversight bodies (e.g. UNEP investigators); permission for on-site inspections; bilateral trade partner review under emissions trading; incentives and institutional designs to encourage development and application of accurate monitoring & reporting, for example by assuring credit for net GHG limitation actions (e.g. "no regrets" actions) upon a showing by the emitter of successful monitoring practices (see section VI below); verification and enforcement procedures and their rules, reporting and enforcement procedures, burdens of proof, forum (international or bilateral, political or scientific adjudicators, etc.).

#### IV. Evaluating current national policies and proposals

Whether or not international agreement is reached on response strategies to potential climate change, nations are already announcing their intention to restrict emissions of one or more GHGs or to expand GHG sinks. The U.S. "no regrets" policy has been articulated in qualitative form; at some point the U.S. -- or others -- may choose to present quantifications of the net GHG effects of U.S. "no regrets" measures. The comprehensive approach provides the basis for computing the aggregate impact of such diverse measures. In addition, it may be valuable for the U.S. to assess the policy claims and policy proposals being made by other nations, using the comprehensive approach, and to examine the policy opportunities that would face other nations under a comprehensive approach.

- (A) Extent and costs of net GHG limitations achieved by U.S. "no regrets" policy options within a comprehensive framework.

As described in the Introduction, "no regrets" actions are actions taken for other (non-climate) reasons but which influence net GHG emissions. One may calculate the percent limitations or reductions achieved by these policy actions using the comprehensive approach, and also calculate the marginal and total cost per policy action. This could be a first step toward assessing the marginal and total costs of

GHG avoidance from different gas/source/sink policy options and hence toward assessing the relative cost-effectiveness of the comprehensive versus piecemeal approaches.

-- Current Administration efforts:

- analysis of US policies in EPA "Comprehensive Budget" analysis (covering U.S. energy efficiency and clean energy initiatives, CFC phaseout, afforestation, landfill rules, and other policies)
- DOE/NES analysis of US energy policies

-- Future work:

- Improve basis for projecting emissions limitations achieved by current policies
- Expand to cover influence of agricultural subsidies, other relevant policy measures

(B) Analysis of net GHG limitations achieved by other nations' policies

Analysis similar to that described for U.S. "no regrets" measures above should be undertaken for the policies announced and implemented by, proposed by, or available to, foreign nations. Certain nations have suggested unilateral limits on CO<sub>2</sub> emissions (e.g. Sweden, possibly Japan), others have announced willingness to enact CO<sub>2</sub> limits if others do too (e.g. U.K., Netherlands), and others have endorsed the Noordwijk Declaration's suggestion of CO<sub>2</sub> emissions stabilization by industrialized countries by 2000.

-- Future work:

- Using a comprehensive approach, calculate the value of current policies in place in nations abroad, as described above for U.S. "no regrets" actions.<sup>6</sup> Assess how other nations would fare under a comprehensive approach.
- Include consideration of foreign nations' agricultural subsidies and other relevant policies regarding non-point sources.

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<sup>6</sup>Special attention may be due the range of CFC-substitutes to be used by each nation. Japan, for example, is apparently presenting figures that show larger reductions in radiative forcing from phasing out unit amounts of CFCs than is the U.S., suggesting that Japan may be counting on selecting CFC-substitutes with lower GWPs than those to be used in the U.S. This also suggests that the Montreal Protocol, although potentially helpful as a no regrets measure, may not by itself be sufficient to address climate concerns associated with ozone-depleting substances.

- Using a comprehensive approach, calculate the influence each foreign proposal would have on net GHG emissions and GHG concentrations.
- Include modeling of international energy markets and effect of price responses to unilateral demand reductions.

V. **Evaluating the comparative cost-effectiveness of piecemeal, partial, and comprehensive approaches.**

Advocacy of the comprehensive approach is based in part on the intuitively strong hypothesis that the marginal costs of control vary across gases, sources, sinks, and nations, so that for any assumed limitation obligation,<sup>7</sup> each nation's least-cost mix of limitation strategies would be different and all nations, regardless of their current GHG inventories, would be better off under a comprehensive approach than under an approach which placed separate limitation obligations on each gas or sector.<sup>8</sup>

This task is needed to test that hypothesis and, if confirmed, to demonstrate the value of the comprehensive approach.

- (A) Marginal costs: information and analyses needed to map full comparative cost-effectiveness functions and variations by gas, source, sink, sector, nation.

This task moves beyond analyses of specific existing policy programs and evaluates the full marginal cost functions facing policy makers and private actors.

- Current Administration efforts:  
- DOE/NES analysis for US energy sector policies and afforestation

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<sup>7</sup>As stated in the Introduction, given an assumed objective, the task is to assess the comparative costs of achieving it under different policy designs. This task does not assess the overall rationality or economic efficiency of the chosen objective.

<sup>8</sup> The aggregate shares calculated in the inventories (in Part III(B), above) do not indicate the costs of incremental limitations for each nation. Simply because a nation currently has a large share in methane, for example, does not mean that that nation would find methane reductions costlier than CO<sub>2</sub> reductions, at the margin. Economic analysis is needed to test the hypothesis of varying costs and to demonstrate the benefits to every nation of being afforded the cross-gas, cross-sector, and source-sink flexibility of the comprehensive approach.

-- Future work:

- Expand to cover all gases, sources, sinks, sectors
- Expand to cover other nations
- Assess full social costs, using general equilibrium model rather than expenditures by the regulated industry.<sup>9</sup> Make use of forthcoming Second Generation GHG Emissions model (J. Edmonds developing for DOE). Analyze costs over time, relation to innovation.<sup>10</sup>
- Include (qualitative) evaluation of non-economic costs to response options, e.g. cultural or institutional barriers to certain policies
- Assess informational, administrative, and other transactions costs of piecemeal, partial and comprehensive approaches

- (B) Use cost-effectiveness analyses to evaluating costs and benefits to the US and other nations of possible piecemeal, partial and comprehensive options that will be suggested for international policy design

This task moves beyond the analysis of current policy proposals suggested in section IV above to examine the marginal costs of policy designs, and to consider both proposed and hypothetical policy designs. It also focuses on international accords rather than national actions. This task is essential if U.S. policy makers and negotiators are to be able to assess policy proposals that inevitably be made as negotiations on a framework convention on climate change unfold.

Potential policy designs to be compared include: CO2 only, all GHGs, or all GHGs except those covered under the Montreal Protocol; sources only, point sources only, all sources and sinks, or sources and terrestrial sinks only; all sectors, or certain sectors (e.g. energy, industry, transport, agriculture, forestry).

- (C) Evaluate the environmental effectiveness of

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<sup>9</sup> The comparative impacts on macroeconomic and international variables (e.g. trade, competitiveness, economic growth) would require separate study.

<sup>10</sup> Evaluation should also address the likely economic impacts in the US and worldwide of potential future changes in the understanding of the gas-comparison index, and means to cushion adverse impacts (e.g. periodic public science reviews).

comprehensive and piecemeal approaches: propensity and impact of induced shifts in residuals

Thus far, for any given policy goal, a piecemeal (e.g. CO2-only) approach and a comprehensive approach have been assumed to yield identical results in terms of aggregated GWP (or full environmental impacts). In other words, whether a reduction in net index-weighted ("CO2-equivalent") emissions were achieved in CO2 or in a combination of gases, the overall calculated effect on the index value of concern would be the same.

But such analysis fails to account for actual economic and social responses to policy interventions. Advocacy of the comprehensive approach is based in part on the intuitively strong hypothesis that including all gases, sources and sinks ensures better effectiveness in any effort to limit contributions to potential radiative forcing (or full impacts), because piecemeal rules applying to one gas, source (or sector), or sink will engender shifts of socioeconomic activity from regulated to unregulated modes, undercutting achievement of policy goals.

-- Current Administration efforts:

- Understanding of prior piecemeal approaches in environmental regulation and their resultant shifts of residuals, including single-medium approaches, e.g. to discharges into air, land, and water; and single-pollutant approaches, e.g. to SO2.
- DOE/NES study will address CO2 and CH4 emissions from energy sector; it should consider potential GHG-related environmental effects of fuel switching, new energy sources, and sectoral shifts.

-- Future work:

- Conduct case studies of cross-gas shifts: e.g. fossil fuel switching (coal to natural gas) induced by CO2-only policies could have attendant impacts on CO2-to-CH4 emissions shifts due to CH4 leakage from natural gas transport<sup>11</sup>
- Expand cross-gas shift studies, e.g. apply coal-to-gas CO2-CH4 shift analysis to actual global GHG output and in light of likely GHG emissions/leaks from future coal and gas facilities

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<sup>11</sup> See, e.g., Rodhe, Science 8 June 1990. Using a 100-year time horizon and a CO2-equivalent GWP for CH4 of 10, Rodhe estimates that if a CO2-reduction policy were accomplished by fuel switching from coal to natural gas, a 3-6% CH4 leakage rate from natural gas transport facilities would fully offset all the CO2 reductions resulting from the fuel switch.

- Evaluate other cross-gas shifts, e.g. CH<sub>4</sub> to N<sub>2</sub>O in agriculture under a CH<sub>4</sub>-only policy
- Evaluate cross-source/sector shifts: e.g. under a transport-only policy, possible shift from fossil fuel combustion on board vehicles to electric cars powered by central utility combustion, or to use of intensely cultivated biomass fuels; e.g. under an energy-only or fossil fuel-only policy, possible shift to biomass fuels whose cultivation emits other GHGs
- Include consideration of international market responses to unilateral policy choices

(D) Evaluate the environmental benefits of a "net emissions" approach

A net emissions approach, encompassing both sources and sinks, would encourage sink protection and expansion, whereas a source-only approach would not. Sink policies encouraged could include afforestation and protection of marine phytoplankton from pollution. This task is to evaluate the side benefits of likely sink policies, e.g. reduced soil erosion, enhanced biodiversity, protected phytoplankton, and better timber management.

(E) Evaluate the environmental effectiveness of the comprehensive approach: assess implications of employing a "full impacts" index

As described above in section II.B, a full impacts index would better internalize the environmental impacts associated with GHGs. This task is to quantify the environmental and socioeconomic benefits and costs of the use of such an index.

**VI. Addressing the objection that the comprehensive approach is technically difficult or infeasible**

As discussed in the introduction, the comprehensive approach can be applied to assist in design of various policies, including research strategies, technology development strategies, enumeration of "no regrets" steps, and emissions limitation strategies. For most of these options, the comprehensive approach can be applied immediately, despite potential uncertainties, as a general guide to intelligent analysis of the scope and relative importance of policy choices.

For implementing emissions limitations, however, prompt application of the comprehensive approach might be somewhat more difficult. In principle, a comprehensive approach appears to be the most appropriate way to design any emissions limitation policy. But as indicated above, there are noteworthy gaps and uncertainties in the information on emissions of certain gases from certain sources and uptake by certain sinks. If emissions limitations were to be imposed today, a fully comprehensive approach would not be available. If emissions limitations are not needed immediately, work on the comprehensive approach can continue toward a time when limitations might be agreed. If emissions limitations are to be agreed at some point before all informational gaps are filled, a partially comprehensive approach could be employed with a mechanism for moving to a fully comprehensive approach as these gaps are filled.<sup>12</sup>

The issue for policy makers is not whether the comprehensive approach is "feasible," but whether at any point the social costs of implementing an incompletely comprehensive approach -- in terms of environmental effectiveness and economic efficiency, as described in section V above -- are outweighed by the social costs of obtaining additional information (including costs of delay). In other words, one must ask whether the marginal value of additional information (a more comprehensive approach) exceeds the marginal cost of obtaining additional information. Another way of examining the issue is to ask at what point would one know enough to proceed comprehensively; and to ask how (and at what cost) a comprehensive approach could evolve from incremental steps. Further, one would consider institutional means to incorporate incentives into any partial strategy that encourage evolution toward a comprehensive approach.

The scientific building blocks of the comprehensive approach are described above in sections I-III. In addition, consideration of the need to bridge from a partial to a comprehensive approach would include:

-- Future work:

- Assess the time and expense needed to answer scientific questions, develop proxy measurement devices, and build monitoring capabilities to achieve a workable comprehensive approach.
- Assess other constraints to employment of a fully comprehensive approach, including institutional, political, cultural and economic obstacles.
- Compare the costs of acquiring this needed information to the socioeconomic and environmental

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<sup>12</sup>Yet it must be recognized that piecemeal approaches, once adopted, generally attract vested interests who resist any efforts to expand toward a comprehensive approach.

costs (and foregone benefits) of adopting a piecemeal policy design for want of such information.

- Develop policy and institutional designs that offer incentives for needed research. For example, an emissions limitation obligation in an international agreement could be framed in a piecemeal fashion but offer the opportunity to emitters to achieve compliance through limitation actions addressing other GHGs, sources or sinks, so long as the emitter demonstrates the accomplishment. This would give emitters incentives to undertake the research needed to develop new monitoring capabilities.

- Consider intermediate approaches such as incremental or phased-in designs toward comprehensivity, and means to bridge from them to a fully comprehensive approach.

#### VII. Integrating prior and concurrent law and policies into a comprehensive approach.

Even if a fully comprehensive approach were available for use in emissions limitations at any relevant point, it is apparent that other treaties, laws and policies will already be addressing discrete GHGs, sources, and sinks. Some means would be needed to accommodate and integrate these diverse endeavors into the comprehensive approach. Several options are available for such integration. One option is to use a comprehensive approach to net GHGs in any emissions limitation protocol while varying the baseline of allowed credit according to prior treaty obligations. A related option is to incorporate in a framework convention on climate the assurance to nations, in advance of any hypothetical future protocol obligations (not yet agreed to), that they would receive credit against any such obligations for current or past (after a certain date) net emissions limitations actions, whether taken pursuant to treaties or national policies; the convention would further calculate the value of such actions according to the comprehensive approach. This would assure credit for "no regrets" measures, avoid disincentives to "no regrets" actions, and give root to the comprehensive approach, while not yet committing to emissions limitations obligations.

##### -- Current Administration efforts:

- devising means to ensure that international agreement integrates (gives credit for) "no regrets" actions, other international agreements (forestry, VOCs, GHGs covered by ozone agreements), other domestic laws and initiatives. (DOJ, EPA, State)

##### -- Future work:

- Demonstrate incentive advantages of integration

- lack of integration would yield perverse disincentives to take actions, even "no regrets" actions that are justified on other grounds, lest they be denied credit once emissions limitations are agreed.
- Address possible overclaiming (see "monitoring" and "verification," above)
- Demonstrate advantages for other nations under integrated design
- Demonstrate environmental advantages of integration
- Address issues of legal grafting presented by terms or design of other agreements, laws
- Consider possible offset model (e.g. defining any limitation obligations in terms of CO2 emissions, to satisfy those eager for CO2 limits, but authorize offsets for any verifiable limits on any GHG, source, or sink, thus effectively constructing a comprehensive approach)

Research and Analysis Underlying the Incentives Approach

As described in the Introduction, a variety of market-based incentives might be considered in the climate change context. The possible uses and advantages of these approaches are summarized in the Introduction.

I. **Emissions trading**

(A) Domestic trading

-- Current Administration efforts:

- review of past and current experience, e.g. lead phasedown, netting/bubble/offset program, CFCs trading, new acid precipitation trading scheme. Primarily EPA, DOE, CEA.
- consider application to GHGs; consider issues of implementation, e.g. informal versus formal trading; who would trade; duration of allowances; means of distributing allowances; market power; hoarding; scope of GHGs, sectors, sources and sinks; monitoring trades; etc.

-- Future work:

- Evaluate the comparative cost-effectiveness of emissions trading and command-and-control approaches

(B) International trading

-- Current Administration efforts:

- present US experience and suggestions at international discussion on application to climate

-- Future work:

- Extend analysis of above issues to international context, e.g. informal versus formal trading; who would trade; duration of allowances; means of distributing allowances; market power; hoarding; scope of trading among GHGs, sources, sinks, sectors, industries, geographical areas, stages of development; monitoring trades
- In addition, consider international institutions; trade, assistance and national income implications; sovereignty issues; cultural or ethical objections to so-called "selling the right to pollute"; trading as a decentralized,

market-based vehicle for resource and technology transfers<sup>13</sup>

- Assess informational, administrative, and other transactions costs of emissions trading and command and control policies
- Identify opportunities for cross-national trades, and hence likely trading partners (for the US and worldwide)
- Evaluate the comparative cost-effectiveness of emissions trading and command-and-control approaches

## II. Emissions fees

Fees might be employed domestically or internationally to address GHG emissions. Options discussed to date include carbon taxes based on the carbon content of energy fuels, and energy taxes. Other options include an energy sector tax that covers both CO<sub>2</sub> and CH<sub>4</sub> emissions from energy activities, using their GWP index ratings to weight the tax; and a more general multi-sector tax calibrated to the GWP index (or full environmental impacts index) rating of each gas.

### -- Current Administration efforts:

- analysis of energy sector taxes in DOE/NES
- analysis of various fees in EPA "Comprehensive Budget" analysis
- related efforts: numerous studies have used assumed taxes to examine costs of GHG limitations policies. E.g. CBO (Montgomery), Manne & Richels, Nordhaus. See CEA overview of Economics of Global Change.

### -- Future work:

- Improve assessment of tax implications. Consider international fuels market impacts; use general equilibrium models; address fiscal concerns.
- Consider variety of tax policy designs, including, carbon, energy, GWP within energy sector, etc.
- Much of this kind of consideration must be deferred to budget negotiations.

## III. Adaptation Incentives

Market mechanisms and institutional reforms could be used to encourage efficient adaptation practices. Because of current

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<sup>13</sup> In addition, consider the options for trading within regional associations such as OECD, EC, ASEAN. Evidently the EC and OECD are both considering association-wide policies.

institutional or market failures, long-range investments, such as coastal construction or water use planning, might be undertaken without giving appropriate weight to any climate change risks (e.g. rising sea levels or shifting precipitation). Such institutional or market failures might be addressed by informational or incentive-based policies, such as requiring coastal construction to purchase subsidence insurance, or encouraging long-range water use planning to take account of potential precipitation patterns. Some of these types of policies were addressed in the IPCC/RSWG RUMS and CZMS reports.

#### IV. Economic instruments in general

##### -- Future work:

- Pursue contacts with OECD regarding Environment Ministerial in January, Economic Instruments analytic workplan (experts meeting now tentatively slated for October 1990), and potential OECD Workshop on Economic Instruments.<sup>14</sup>
- Develop suggestions for economic analysis and study of economic instruments in upcoming IPCC Future Workplan discussions (tentatively slated for December or January).
- Continue to work with CEES groups, including the new Ad Hoc Economics task group, to develop economic analysis of policy proposals and designs (addressing "comprehensive approach" issues as well as "incentives" approach issues).

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<sup>14</sup> Preparing for the suggested OECD Workshop on Economic Instruments, tentatively slated for December 1990, will involve considerations of forum and cosponsorship, logistics and timing, relation to other OECD meetings, relation to other international meetings, invitees, topics to address, an October experts meeting, relation to the upcoming IPCC meeting on Future Work of the IPCC, and US presentation(s) at the December Workshop.

Possible attachments:

- February 1990 "Informal Seminar" booklet
- IPCC Overview and PMSs
- Materials on GHG indices
  - including GWPs papers
  - including papers on non-warming impacts
  - and possible design for "full impacts" index
- GHG Inventories presentation from EPA
- EPA "Comprehensive Budget" analysis of U.S. "no regrets" actions
- Papers on residual shifts, including
  - Paper on cross-media shifts
  - Paper on CO<sub>2</sub>-CH<sub>4</sub> shifts (e.g. Rodhe)
  - Paper on SO<sub>2</sub>-CO<sub>2</sub> shifts due to scrubbers policy
- NES chapter on climate ?
- CEES GC/MARS research guide for the comprehensive approach (Albritton/Watson paper)
- "Integrating ... Brainstorming" paper
- new OECD draft of Econ. Instruments workplan (not yet rec'd)
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